REVIEWS IN Aquaculture

Reviews in Aquaculture (2019) **11**, 493–514 doi: 10.1111/raq.12242

The ecosystem approach to aquaculture 10 years on – a critical review and consideration of its future role in blue growth

Cecile Brugère[1], José Aguilar-Manjarrez[2], Malcolm C. M. Beveridge[2] and Doris Soto[3]

1 Soulfish Research & Consultancy, York, UK
2 Food and Agriculture Organization of the United Nations, Rome, Italy
3 Interdisciplinary Center for Aquaculture Research, Puerto Montt, Chile

Correspondence
Cecile Brugère, Soulfish Research & Consultancy, Stillingfleet, YO19 6SH York, UK.
Email: cecilebrugere@gmail.com

Received 10 September 2017; accepted 29 January 2018.

Abstract

Over a decade ago, the ecosystem approach to aquaculture (EAA) emerged from discussions between the Food and Agriculture Organization (FAO) of the United Nations and international aquaculture experts on how to move aquaculture development towards greater sustainability. The purpose of this review is to critically examine the use and mainstreaming of the EAA in aquaculture development to date and consider its possible evolution in the next decade. We systematically searched citations of key EAA publications in the academic and related literature for the period 2007–2016 and analysed all relevant FAO publications and project documents. We assessed the lessons learnt from the past decade of EAA experiences, the opportunities the EAA has created and the links between the EAA and the new development agenda. Our review suggests that mainstreaming the EAA in planning processes has raised awareness of the usefulness of holistic and participatory approaches in aquaculture and helped to steer the sector towards greater sustainability. However, the approach has had varying degrees of resonance and uptake with different user groups. The emphasis on spatial planning that has developed as part of the EAA implementation efforts, and close links between the EAA and initiatives such as 'blue growth', constitute significant opportunities for the future of the approach, although its ability to tackle increasingly complex governance issues may be limited. Thus, it is now opportune to reconsider the EAA's *raison d'être*, taking into account ongoing developments within and outside the aquaculture sector.

Key words: blue growth, ecosystem approach to aquaculture, ecosystem-based management, policy, spatial planning.

> "What is needed for the future is an approach which makes use of the experience available, adds to the existing know-how through continued research efforts, elaborates and refines guidelines, and creates appropriate frameworks for further development... Aquaculture production is in great demand, but it must not be achieved without due regard to safeguarding our basis of survival." Bilio (1993) p.v.

Introduction

More than 20 years after Bilio's remark on the future of aquaculture, and just over a decade ago, the ecosystem approach to aquaculture (EAA) emerged from discussions between the Food and Agriculture Organization (FAO) of the United Nations and aquaculture experts around the world (the mission of FAO is to achieve food security for all and to make sure people have regular access to enough high-quality food to lead active, healthy lives). These discussions were focused on ways to move the planning and management of aquaculture towards greater sustainability and were stimulated by reflections around, and the positive experience of, the ecosystem approach to fisheries (EAF; FAO 2003; Garcia *et al.* 2003). The EAF was devised as a tool to support the implementation of the FAO Code of Conduct for Responsible Fisheries (CCRF) and has helped to promote the sustainable exploitation of capture fisheries worldwide. The CCRF is an internationally agreed set of

global principles and standards to guide responsible fisheries and aquaculture practices (FAO 1995, 2010a) and is now ubiquitous throughout the fisheries and aquaculture sectors (Hosch 2009).

The rapid growth of the aquaculture sector worldwide, and the interaction of aquaculture activities with other economic sectors and natural resources users, require a responsible and integrated approach to aquaculture development, as expressed in Article 9 of the CCRF. In response to the explicit request of its member countries in 2006 to improve the management and enhance the socio-economic impacts of aquaculture (FAO 2007), FAO initiated the development of an ecosystem approach to aquaculture production and invited a number of recognised aquaculture experts to a workshop in the Baleares Islands in May 2007 to discuss and define what such an approach would entail. This was the starting point for the EAA as it is presently defined (Soto *et al.* 2008; FAO 2010a):

> An ecosystem approach to aquaculture (EAA) is a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems.

The EAA is guided by three strategic principles:

1 Aquaculture development and management should take account of the full range of ecosystem functions and services and should not threaten the sustained delivery of these to society.
2 Aquaculture should improve human well-being and equity for all relevant stakeholders.
3 Aquaculture should be developed in the context of other sectors, policies and goals, as appropriate.

The EAA builds on these principles to provide a planning and management framework for effectively integrating the aquaculture sector into local planning. The approach provides clear mechanisms for producers and government authorities to engage with one another for the effective and sustainable management of aquaculture operations and requires them to simultaneously embrace the environmental, socio-economic and governance objectives of the sector.

From 2007, the FAO Fisheries and Aquaculture Department dedicated substantial efforts to promoting the EAA among its member countries. Regional meetings were held to describe and explain the EAA, expert meetings were convened, technical guidelines were published, and FAO-funded EAA implementation projects were piloted in several countries in Central America, Chile, Kenya, Malawi, Philippines and Zambia. Five FAO milestone publications were produced during this time: Soto *et al.* 2008 (report of the FAO Baleares workshop that launched the EAA); FAO 2010a (CCRF Technical Guidelines No. 5, Supplement 4 on the EAA); Aguilar-Manjarrez *et al.* 2010 (report of an expert workshop on spatial planning using the EAA); Brugère *et al.* 2010 (guidance on aquaculture policy and governance aligned with the principles of the EAA); and Ross *et al.* 2013 (report of an expert workshop on site selection for aquaculture development). Together with the documentation from EAA-related initiatives implemented at a national level, these publications point to the vast amount of energy and thinking that went into the operationalisation, refinement and appropriation of the EAA by a wide range of stakeholders.

The purpose of this review is to critically examine the use and mainstreaming of the EAA in aquaculture development 10 years after its inception and to consider its evolution and future in the next decade in the context of a new world order shaped by the international community's commitments to the sustainable development goals and Paris Agreement on Climate Change. We do this by answering the following questions:

1 How is the EAA used, where is it talked about, adopted and implemented?
2 Is there a common understanding of the EAA?
3 What can we learn from the past decade of EAA experiences?
4 What new forces and developments could the EAA link to?
5 What is the way forward for the implementation of the EAA in the next decade?

These questions are timely for several reasons. In 2015, world fish supply reached a new high of 20.3 kg *per capita* (FAO 2017a), and today, aquaculture provides more than half of the global food fish production, compared to 39% in 2004 (FAO 2016a). The growth of the sector is showing no sign of slowing down in absolute terms (Engle *et al.* 2017), and aquaculture is becoming an increasingly important player in the use of space and natural resources. The international economic, environmental and geopolitical context is also vastly different from that of a decade ago. This has implications for the sector's development patterns at a national level. Despite the heterogeneity of production systems, global aquaculture increasingly requires policy coherence and harmonisation of instruments for sustainable expansion. Answers to these questions should be of interest to researchers, policy makers in producing countries, international organisations, as well as non-state actors and civil society interested in steering aquaculture development on a course towards greater sustainability and equity. The focus of our review and analysis is on the EAA as promoted by FAO, although we acknowledge that other, related, interpretations of the EAA have emerged and have been promoted by other organisations. As our analysis is not an evaluation of FAO's work in support of the promotion of the EAA, nor an evaluation of the impact of the

implementation of the EAA per se, it should resonate way beyond the FAO's sphere of influence into the international research and development community concerned with aquaculture development.

Method

Our methodological approach was three-pronged and adopted a scoping/systematic review methodology (Arksey & O'Malley 2005; Levac *et al.* 2010). First, we conducted systematic citation searches of key FAO EAA publications in the published academic and related literature (e.g. FAO technical papers, theses, books and seminar notes) focusing in particular on the five FAO milestone publications listed above. We used Google Scholar (www.scholar.google.com) as a search engine for the period 2007 (the actual date of the FAO Baleares workshop, Soto *et al.* 2008) to 2016. This search engine was preferred over 'Scopus' and 'Web of Science' which are limited to academic publications and as such did not incorporate FAO publications. Grey literature citing these publications was not accounted for in the searches. Duplicate references and those in languages other than English, for example Chinese and German (8%), were removed from the results after screening. The citations retained were assessed and categorised in an Excel database according to the nature of the publication type, species, farming system, geographical location and topic concerned, for quantitative analysis. The prevalence of the EAA in the literature (number and context of citations) was used as an indicator of the influence of key FAO EAA promotional publications and the extent to which the approach has been embraced in research.

Second, we scoped out EAA-related information from the websites of selected international and regional players involved directly and indirectly in the fisheries and aquaculture sectors (e.g. international banks, UN agencies, NGOs, non-governmental organisations, research centres and networks) for any mention of the 'ecosystem approach to aquaculture' in their mandates, works and published materials. This was in an effort to assess the global acceptance of EAA. We gathered documents from EU Horizon 2020 projects known to incorporate the EAA. We also collected and reviewed any FAO in-house (unpublished) and published materials over the period 2007–2016, including the following: reports of the State of World Fisheries and Aquaculture (SOFIA; FAO 2008, 2010b, 2012a, 2014b, 2016a); preparatory documents and reports of the FAO Committee on Fisheries (COFI) Sub-committee on Aquaculture (FAO Committee on Fisheries 2009, 2010, 2012, 2014, 2015, FAO 2010c, 2012b, 2013a,b, 2015a, 2017c); results from the implementation surveys of the FAO CCRF (FAO 1995); FAO Fisheries and Aquaculture technical papers; FAO Aquaculture newsletters; FAO field project and EAA workshop reports; country case studies; newsletters, reports and minutes of workshops/meetings held in relation to the EAA and its implementation; and normative documents in preparation. These materials were reviewed for their treatment of the EAA and to provide a broader, complementary and contextual perspective on the ramifications of the implementation of the EAA, its evolution and relation to ongoing developments in the sector. Also assessed was the level of effort deployed by the FAO to promote the EAA and support implementation among its member countries. We also included in our analysis the feedback received from experts and staff who worked in the field, encouraging the practical implementation of the EAA. This ensured that the experience gained in implementing the EAA at a national level was represented in our analysis.

Third, we carried out a systematic citation search for the 'ecosystem approach to aquaculture' (strict terms) to assess the extent to which the concept was being mentioned in the scientific literature.

Our method aimed to encompass academic, non-academic and grey literature on the EAA. We acknowledge, however, that implementation processes at ground level are often not formally reported or published, resulting in a possible underestimation of implementation efforts and results, but it is beyond the scope of this research to formally evaluate and report on the outcomes of these implementation efforts.

Moreover, the analysis contained in the paper does not try to establish causal relationships between the promotion and implementation of the EAA and any changes that may have been observed in the development of the aquaculture sector since 2007. As determined by Hosch (2009) and the FAO Office of Evaluation (2012) in their analysis of the impact of the CCRF implementation, there are too many influencing variables and a before–after impact analysis is currently not practically possible. We also recognise that many positive actions in the sector predate the EAA: aquaculture development was influenced by the CCRF's principles or by other documents, for example Agenda 21 (UN 1992), and by industry-driven codes, such as the Federation of European Aquaculture Producers' code of conduct (FEAP 2008) and the principles for responsible shrimp farming (FAO/NACA/UNEP/WB/WWF 2006), or by national legislation, such as that passed or revised in the 1990s to protect mangrove habitats from the building of shrimp ponds below the high-tide mark (e.g. India's Coastal Regulation Zones, cited in Brugère 2006). Nonetheless, by considering the influence of the EAA through a number of measurable indicators – such as citation numbers – and complementing this with a qualitative analysis and reflection on its uptake and relationship with other developments and global trends, we were able to determine

the contribution of the approach to the trajectory of the development of aquaculture and establish a basis for a discussion on its future in the next decade.

How is the EAA used, where is it talked about, adopted and implemented? Results from the systematic and scoping reviews

Impact and influence of FAO publications on the promotion of the EAA

Of the five milestone FAO publications that directly and indirectly promote the EAA, Soto *et al.* (2008) is the most cited (Fig. 1a). This is not surprising because it is the first document to describe and cement the concept of an EAA. Whilst non-academic, non-FAO publications (e.g. monographs, books, reports, and theses including in languages other than English, such as Spanish, Portuguese and French) constitute a sizeable share of the citations (37%), the concept of the EAA as promoted in Soto *et al.* (2008) has also found its way into academic literature. Thus, 52% (56) of the citations of Soto *et al.* (2008) were found in 37 academic journals (including one in the Spanish language), the three most frequent being *Reviews in Aquaculture* (six papers), *Ocean and Coastal Management* (five papers) and *Marine Pollution Bulletin* (three papers). This denotes a stronger emphasis on the application of the EAA in marine and coastal environments than in freshwater ones. Figure 1b shows the number of citations of Soto *et al.* (2008) in relation to the topics the approach used (conceptually or practically). Although the number of topics the EAA is cited in relation to aquaculture development in general terms is large (17 in total), Fig. 1b highlights (i) the conceptual value of the EAA in guiding the overall development of the sector (general topics are those that most frequently cite Soto *et al.* 2008); and (ii) its importance in solving practical problems of aquaculture development such as helping to decide which production systems should be selected and where they should be developed (e.g. for spatial planning purposes). The stronger emphasis on technico-ecologico-biological issues than socio-economic and institutional ones is also reflected in the number of citations of Soto *et al.* (2008) in relation to the EAA scales of implementation (Fig. 1c). Of the three spatial scales the EAA encompasses (farm, watershed, global), the farm scale is the most frequently cited (often in relation to the production of specific commodities). The watershed scale is second, most often in relation to spatial planning. The global scale, which explicitly refers to markets, gets the fewest mentions. The geographical areas where the EAA was used or guided research (conceptually or practically) are important aquaculture production areas (Fig. 1d); 62% of the European experiences citing Soto *et al.* (2008) occurred in the Mediterranean Sea.

Taken together, these results show that the EAA's greatest impact on aquaculture research has been on spatial planning, including site selection and carrying capacity, at the watershed and farm scales. The two citations of the FAO Technical Guidelines No. 5 (2010a) are also in relation to these aspects of aquaculture development. The fact that this document is only cited twice, however, suggests the rather low penetration of this type of publication, which is typically aimed at governments and non-academic institutions, in the scientific community. Technical guidelines aside, the limited number of citations of Brugère *et al.* (2010) in relation to the place of EAA in aquaculture policy and governance indicates an overall lack of (perceived) relevance and applicability of the EAA in this domain.

Our analysis of the frequency of citations or mentions of the EAA in the work and publications of selected international and regional development players in fisheries and aquaculture (Table S1) suggests that uptake of the EAA is relatively low and the EAA is not playing its anticipated role in guiding the work, strategies and interventions of these organisations in relation to aquaculture development. The exception is when FAO is directly engaged on issues of aquaculture sustainability, as is the case, for example, with the International Fund for Agricultural Development (IFAD) that regularly works and liaises with FAO in the design and implementation of its projects. Three points are, however, worth noting now:

1 IUCN's ecosystem-based approach to the management of aquaculture and ecosystems signals a (re)interpretation and adaptation of the concept.
2 The EAA features prominently in the work of three influential platforms in Asia (Network of Aquaculture Centres in Asia-Pacific (NACA)), Africa (New Partnership for Africa's Development (NEPAD)) and the Mediterranean (General Fisheries Commission for the Mediterranean (GFCM)).
3 The EAA is mentioned in relation to broader topics such as the blue economy and climate change adaptation (FAO 2011).

Our analysis of FAO published and in-house documentation shows that over the period 2007–2016, the FAO expended substantial efforts on promoting the EAA among its member countries and building the capacity to implement it, with, on average, four EAA-related events held per year to do this. Of the 46 EAA-related events it supported over this period, 18 (39%) had a spatial planning focus and 12 (26%) jointly addressed the EAA and the EAF (Tables 1 and 2 and Tables S1–S7). The EAA was presented and discussed in field projects, workshops and meetings in 26 countries. In Central America, Nicaragua was the country that was visited and assisted the most. In addition, the principles of the EAA were explicitly adopted in the design of

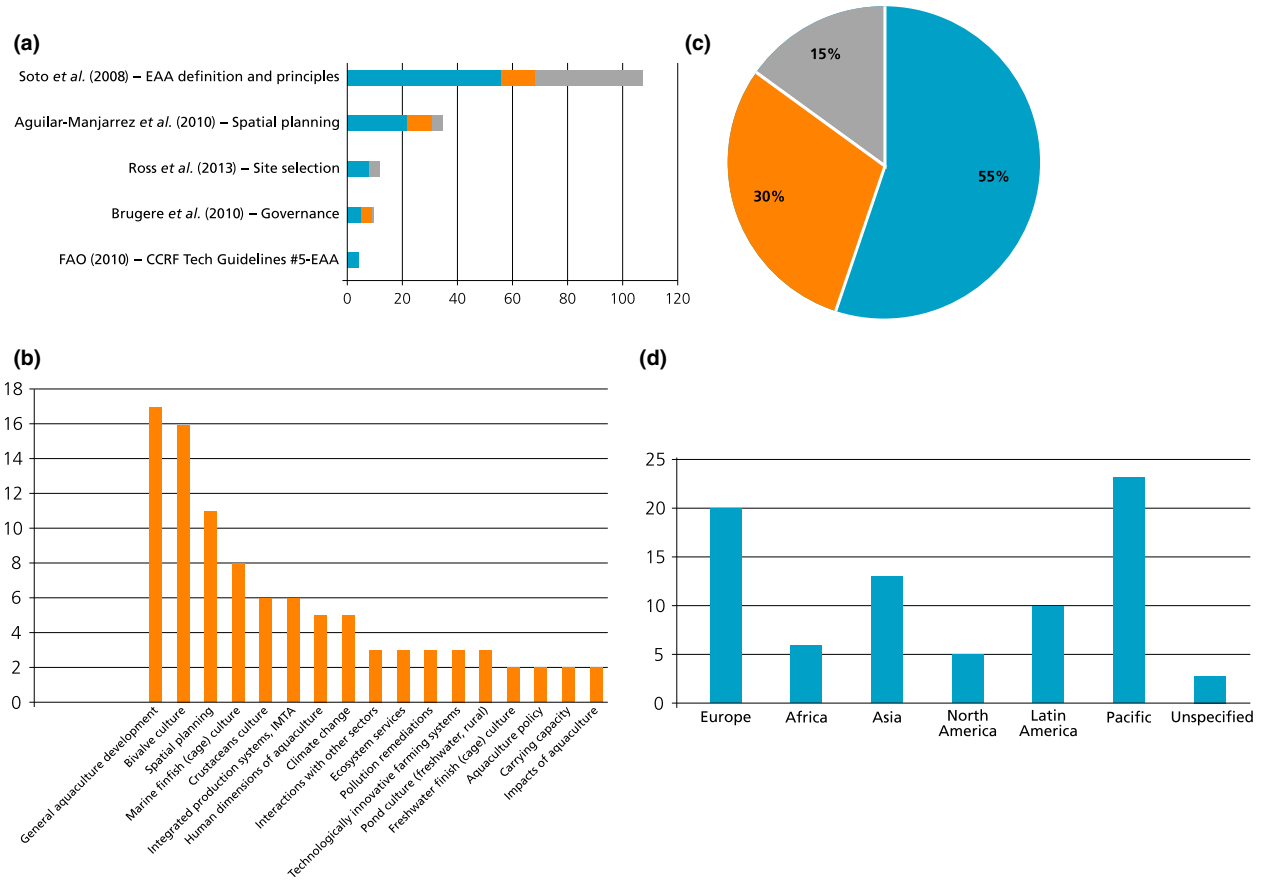

Figure 1 (a) Number of citations of FAO publications on the EAA. ■, Journals; ■, FAO publicatins; ■, Others. (b) Number of citations of Soto *et al.* (2008) in relation to topics. *Notes:* General aquaculture development: relates to aquaculture's role, trends, sustainability. Spatial planning: includes coastal management, GIS, zoning, habitat suitability. Human dimensions of aquaculture: includes vulnerability, resilience, perceptions, farmers' decisions. Climate change: includes adaptation, "green economy". Interactions with other sectors: includes capture fisheries, hydroelectric dams. Pollution remediation: includes remediation and control of pollution within and outside the sector, eutrophication remediation. Technologically innovative farming systems: excludes IMTA (included elsewhere), includes recirculation systems, aquaponics. (c) Frequency of citations of Soto *et al.* (2008) by EAA 'scales' (percent). ■, Farm scale; ■, Watershed scale; ■, Global scale. (d) Number of citations of Soto *et al.* (2008) in relation to geographical areas.

three regional projects financed by the European Commission and involving FAO: in the Mediterranean ('Developing site selection and carrying capacity guidelines for Mediterranean aquaculture within aquaculture appropriate areas' – ShoCMeD); the Black Sea ('Indicators for Sustainable Development of Aquaculture and Guidelines for their use in the Mediterranean' – InDAM) – both through the General Fisheries Commission for the Mediterranean (GFCM 2012); and one across Europe (EU H2020 'AquaSpace' – Making Space for Aquaculture project, Aguilar-Manjarrez 2016; Aguilar-Manjarrez *et al.* 2016). All three projects involved multiple academic and non-academic partners and EAA capacity-building activities formed part of these projects. A detailed evaluation of the outcomes of these initiatives is yet to be carried out. Although it may appear as if the geographical location of these projects was selected on an *ad hoc* basis, in fact the target countries where they were implemented are all emerging or mature aquaculture-producing countries with a high risk of intersectoral conflict between aquaculture and other resource users. These projects have in common that (i) they were/are primarily concerned with spatial planning issues, from the 'farm' to 'watershed' scales of Soto *et al.* (2008)'s EAA, although the Turkish aquaculture 'roadmap' (Soto *et al.* 2009) encompassed institutional issues and amounted to a development strategy for the sector; and (ii) they were/are participatory in nature, engaging a large number of stakeholders (producers and government officials). This notwithstanding, the extent to which the EAA fully informed the development of the InDAM

indicators, and the concepts of allocated zones for aquaculture (AZA) and allowable zone of effect (AZE) elaborated under the SHoCMed project, is unclear (GFCM 2012).

The EAA in the scientific literature

The broader systematic search for the 'ecosystem approach to aquaculture', regardless of the authorship, yielded 445 citations in total. Of these, non-English language citations were excluded, along with those that simply cited the EAA in passing (e.g. 'an ecosystem approach has been recommended. . .') or those that listed the authors of the EAA without making much use of it in the text of the paper itself. Thus, a net total of 239 references used the EAA as a concept or principle, applied or as a tool, or both. Of these, most were in academic journals (67%) and in equal part in FAO publications (excluding FAO publications on the EAA itself, e.g. Soto *et al.* 2008) and other non-academic outlets (books, teaching materials, theses, etc.) (16%) (see Tables S1–S7). The geographical scale of the references to the EAA is mostly global and closely aligned with main production centres, as indicated previously (Fig. 2a). A closer look at the number of publications per year shows a rapid rise until 2013, indicative of the inspiration and thrust generated by the approach, followed by a steady decline since, with the number of publications in 2016 equal to that of 2009, only 2 years after the launch of the EAA (Fig. 2b). There are, however, signs that the recently released publication of Aguilar-Manjarrez *et al.* (2017) on using the EAA to guide aquaculture zoning is reversing this trend.

Table 1 Type of FAO-supported event and EAA-related topic discussed over the period 2007–2016

Topics	Number of events
EA to mariculture	1
EA to offshore aquaculture	2
Workshop EAA only	4
Workshop EAA/EAF	12
Workshop EAA/spatial planning	18
Workshop climate change/EAA–EAF	2
Conference aquaculture–fisheries interactions	1
Meeting or conference EAA and/or spatial planning	4
Aquaculture as a business	1
Total events	46

Table 2 Geographical distribution of FAO-supported EAA-related and capacity-building activities held over the period 2007–2016

Continents	Number of countries where events were held
Africa	6
Latin America	5
North America	7
Asia	7
Europe	7
Total countries	26

Is there a common understanding of the EAA?

These results do not suggest a completely uniform understanding of what the EAA is, what it entails and what it can be used for. The adoption of, and impact that the EAA guidelines and documents *per se* have so far achieved – measured through the prevalence of EAA citations throughout the literature – needs to be distinguished from the evolution of the interpretation and use of the EAA as a guiding principle. Thus, there is a gap between those who use the EAA to conceptualise the development of the sector – usually in relation to general considerations on aquaculture development at the global level – and the practitioners, who, whilst adopting the concept, have found a practical entry point to its operationalisation: spatial planning and related biophysical considerations of carrying capacity and zoning to deliver the EAA (Aguilar-Manjarrez *et al.* 2017).

There is thus some uncertainty among users whether the EAA should be treated in conceptual terms, as a guiding principle or strategy, or in practical terms, as a tool, for example when an agreed-upon EAA management plan has to be elaborated. The 56 citations of Soto *et al.* (2008) in

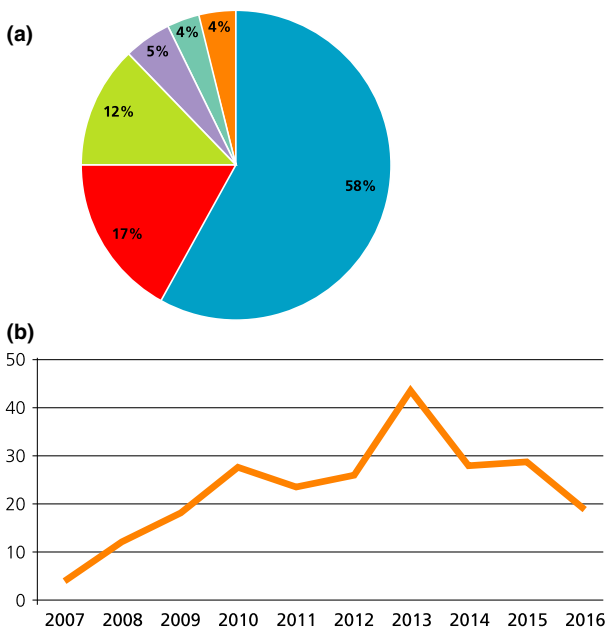

Figure 2 (a) Frequency of mentions of the 'ecosystem approach to aquaculture' in the literature in relation to the region of application. ■, Global; ■, Asia; ■, Europe; ■, Africa; ■, North America; ■, Latin America. (b) Number of publications referring to the 'ecosystem approach to aquaculture' in the literature over the period 2007–2016.

the academic literature do not deal with EAA 'implementation' as such. They refer to the EAA as a conceptual guide for the movement of the sector towards greater sustainability or use some of its contents to examine issues related to the development of a particular farming activity (e.g. integration of a production system within an ecosystem). The holistic, integrative and participatory remit of the EAA intended to promote multisectoral dialogues and stakeholder participation. This has been achieved in part with, for example, the incorporation of the EAA principles in policies at a national level, in some countries (Mannini *et al.* 2010), although it is difficult to say whether this shared understanding is because of the approach itself or as a result of the broader imperative to include stakeholders' interests in international development agendas that have occurred concomitantly (Bäckstrand 2006). Yet, in practice, the efforts to mainstream the EAA in policy making have been sectoral (i.e. focused on the fisheries and/or aquaculture sectors) and the EAA has fallen short of facilitating interaction with other users of resources, in spite of the fact that it involves multiple aquaculture and non-aquaculture interests. This shortcoming is, however, not unique to the EAA. Integrated coastal (zone) management (ICM/ICZM) has similarly generally failed to facilitate serious long-term integration, coordination and interaction, simply because this is very difficult – politically, institutionally and technically (GESAMP 1996, 2001; IWICM 1996; Scialabba 1998). Integration is more demanding and needs more complex information, more interested parties are involved, and more political perspectives are included, making this type of decision-making process costly.

There also seems to be some ambiguity regarding what the EAA means in practice: on the one hand, it is seen as an umbrella encompassing a number of 'tools' (aquaculture assessment tools (AATs)) to support the planning and management of the sector's development; on the other hand, it is seen as a tool itself (Miao *et al.* 2013). However, in Asia, the EAA, as a tool itself, is reported as either never used or applied only through *ad hoc* projects (Miao *et al.* 2013).

The degree of use of the EAA to guide research and aquaculture developments at farm and watershed levels is a sign of its relevance at these scales. Plans that have emerged from this are typically spatial in nature and are indicative of the evolution of the use of the approach for spatial planning purposes. Whilst they are relevant at local scales because they emphasise land and water use and production issues, these plans do not encompass broader policy and economic issues relating to the governance of the sector. The general lack of reference to the EAA in aquaculture policy and governance (e.g. Hishamunda *et al.* 2014) illustrates the difficulty in linking the EAA to governance matters. The ways in which the EAA can help to address the issues that occur across the three EAA 'scales' are also uncertain. In fact, the mismatch between administrative and ecological boundaries complicates the application of the EAA in policy making and was highlighted as a thorny issue at the outset (Bermúdez (2008) in Soto *et al.* 2008). This difficulty has continued to limit its relevance for policy making.

In the end, the lack of common understanding of the EAA may stem from its name and the disciplinary perspectives from which the term 'ecosystem' is interpreted. Despite efforts to portray and promote the EAA as a holistic approach to aquaculture management, the term 'ecosystem' has introduced an ecological, biological and, to a lesser extent, technological bias to the understanding of the approach. The consequence has been a stronger relevance and emphasis of the application of the EAA at farm scale, at the expense of the other – higher – scales it should also encompass, as was shown in the analysis of the citations (Fig. 1c).

What can we learn from the past decade of EAA experiences?

What challenges has the EAA been facing?

Although no targets were set at the outset of the EAA, after 10 years its adoption appears to be less than that had been anticipated, based on our methodology. Our review of all FAO's EAA sources suggests several threats or challenges to its implementation, as listed in Table 3. Evidence from FAO-supported field projects on the EAA in different countries confirmed that institutional and human capacity issues stand out as the most salient constraints. These echo the constraints and issues that were reported in the operationalisation of the EAA by Mannini *et al.* (2010) and in the application of AATs by Miao *et al.* (2013). In more general terms, the type of constraints facing the implementation of the EAA are legislative and regulatory issues;

Table 3 Threats and challenges to the implementation of the EAA (order of priority varies within and among different countries/regions) developed in Nicaragua and further validated in different countries

1	Competing development objectives
2	Difficulties with interagency cooperation
3	Ecosystem and administrative boundaries
4	Equity issues
5	Insufficient awareness
6	Insufficient knowledge
7	Lack of or limited technical and human capacity and resources (including monetary)
8	Limited stakeholder participation
9	Poor governance and regulation
10	Unregistered or illegal farms

ineffective interagency integration and coordination; financial constraints; lack of human resources; and ambiguity in the perceived benefits of these approaches by administrators and producers alike (Miao *et al.* 2013).

What are the impediments to the uptake and implementation of the EAA?

The key impediments of the EAA, which are constraining its uptake and implementation, can be synthesised in terms of scope, autonomy, behaviour change and internal features of the approach.

Scope

In line with the ICZM tradition, and despite the exception of a handful of FAO-supported EAA (and EAF) projects targeting freshwater ecosystems (e.g. Lake Malawi: Department of Fisheries, Ministry of Agriculture and Food Security 2014), the EAA has been promoted mainly in coastal and marine ecosystems. Freshwater production systems, from which the bulk of global aquaculture production comes, received less attention in relation to the planning and management framework that the EAA provides to integrate aquaculture in local planning and better coordinate human activities. More efforts are needed in this regard, especially from the perspective of aquaculture management areas under the EAA (Aguilar-Manjarrez *et al.* 2017). Furthermore, the high-level and intersectoral ambition of the EAA is not matched by the reality of where it is applied. As said above, aquaculture cuts across different scales, from local production systems to the global marketplace, which are not necessarily matched by the administrative, institutional and legal frameworks currently in place (Bermúdez 2008). This is a major hurdle to the implementation of the approach. Although there is emerging evidence that the EAA has brought together stakeholders operating at different scales (e.g. production and policy making, and producers of different sizes and intensities) and enabled the overcoming of trade-offs and diverging interests and development objectives (e.g. Nicaragua: FAO 2014a), more work is required to achieve the EAA's ambition to 'create the enabling environment necessary for the sustainable production and governance of aquatic ecosystems' (FAO 2014b: 208) and further its role in progressing towards the greater good of 'food for all': human well-being, equity and environmental protection through aquaculture for sustainable development.

Autonomy

Another noticeable impediment is the continuous need for the direct engagement of FAO in countries and organisations to promote the adoption of EAA among its member countries and partner organisations. Whilst it is likely that international organisations partnering with FAO are promoting the same holistic vision of aquaculture development encapsulated by the EAA, they do not do it in the same terms as the FAO's EAA. This suggests that these organisations have yet to sufficiently build the confidence of potential users to change their current approaches and that FAO's EAA has not sufficiently captured the imagination of potential users at all levels of planning so that it is mainstreamed in national policies and strategies, and in the mandates and agendas of these organisations. Experiences of piloting the EAA also suggest that there is a tendency to underestimate the length of time during which 'hand-holding' is required to build the necessary capacity and momentum to integrate the EAA in the *modus operandi* of the sector. For example, the FAO has put much effort into raising awareness about the worth of the approach and in training aquaculture officers and researchers in developing countries on what the EAA entails, but the extent to which this has translated into, for example, the submission of technical cooperation project proposals to FAO for follow-up, the elaboration of a development plan based on the EAA or the use of spatial planning tools to allocate production licences is unclear and, in most instances, would require additional financial/technical support from FAO or another donor.

Behaviour change

In instances where the use of EAA became relatively advanced, as was the case in Nicaragua, it was a lengthy process and the benefits achieved emerged slowly. Changes in human behaviour and in the 'philosophy' of planning are typically slow to occur and those required to mainstream and implement the EAA are no exception (Soto & Aguilar-Manjarrez 2009). Signs of changes in practices, notably in terms of integrating consultations and opening participation in planning processes to a wider range of stakeholders, have begun to be observed, but the evidence remains anecdotal.

Internal features of the approach

The relative complexity of the EAA and the holistic thinking it requires to integrate biophysical findings with social, ecological and governance aspects are still not fully embraced owing to limited institutional and human capacity. The cross-sectoral nature of the approach challenges institutions that typically work and budget independently without consulting with other sectors. The institutional and legal vacuum that continues to surround the development of the aquaculture sector in most countries and the voluntary nature of the EAA provide an easy way out for those reluctant to engage in integrated planning and development processes. Many countries have elaborated their own aquaculture development policies, but they still lack an accompanying implementation plan and regulations

specific to targeted aspects of the EAA, such as the use of alien species; the use of environmental impact assessments; regulations related to fish stocking and welfare; environmental capacity of recipient water bodies; and prevention and mitigation of escapes and aquaculture zoning (results of the CCRF implementation survey 2015). Individual capacity to implement the EAA itself, that is conceptual and technical knowledge of some of its tools, such as risk assessment (for ecological, social and governance issues), social impact assessment and life cycle analysis or carbon footprinting studies, is often lacking (Miao *et al.* 2013; with reference to Asian countries). Similarly, although recognising the high quality of the EAA Technical Guidelines (FAO 2010a) and that they 'may serve as a good didactic tool', a recent, unpublished internal FAO evaluation of these guidelines concluded that they 'still remain too theoretical with most actions depending on national capability for implementing them, which is unfortunately low in most developing countries'. These capacity gaps should, however, not preclude countries from using the EAA; once identified, they can be included as priorities to fill in a subsequent EAA implementation plan.

The unknown costs of operationalisation, as well as unquantified and unpredicted returns from using the EAA, either as a concept or as a tool, are problematic, as is the means of funding the approach, especially given its intersectoral scope. Once FAO support is withdrawn, much uncertainty remains regarding the pursuit of EAA-based work to further the development of the sector (cf. experiences in Nicaragua and Turkey).

The spatial focus of the EAA and the deliberate adoption of spatial scales in the EAA definition are now proving to be a constraint in relating the approach to the changes the aquaculture sector has undergone globally and to the shift in focus from the production of specific commodities to the consideration of trade and exchanges of knowledge and products through entire value chains. The notion of value chains was not found in relation to the EAA in our searches of the literature, nor present in Soto *et al.* (2008) and FAO's technical guidelines (FAO 2010a), suggesting that if the EAA 'made sense' at physical scales at the time of its launch, it is not gaining much traction in relation to value chains and to the global product and trade scales that now dominate the sector. The EAA implementation plan of the Government of Nicaragua is the only exception in this regard, having undertaken a value chain analysis to ensure that equity issues along the shrimp value chain could be addressed by specific actions of the plan (Escoto 2011). In one sense, the EAA has been superseded by the 'value chain approach', which is simply another way of recognising that one cannot consider aquaculture production in isolation from the broader social and economic context. In fact, value chains are arguably implicit – if not explicit – in the EAA. But, as with spatial planning, value chains have gained prominence because they offer a clear and practical entry point to address much broader aquaculture development issues. In many ways, the value chain approach is simpler to grasp and has immediate meaning and relevance for practitioners.

Positive outcomes from and advances in the EAA: examples from real-world cases of promotion and implementation of the approach

The CCRF prepared the ground for the EAA by introducing the principles of sustainable development from the 1992 United Nations Conference on Environment and Development and Agenda 21 (UN 1992) in fisheries. In a similar manner, the EAA has been instrumental in raising awareness of the importance of these principles and placing them at the heart of aquaculture planning and the work of those supporting and acting for the development of the sector. The holistic approach to aquaculture development the EAA advocates is what makes it unique compared to other food production sectors. For example, the EAA touches on inseparable planning and management issues and uniquely captures interactions between aquaculture and capture fisheries at multiple scales (Soto *et al.* 2012a,b).

In practice, the promotion and implementation of the EAA have taken a range of forms and led to a range of positive outcomes. Real-world examples of FAO's technical assistance on EAA have strengthened aquaculture planning in many government and local institutions (Table S2). For example, in Malawi, Nicaragua and Turkey, key stakeholders, including government, changed their way of planning by considering environmental, socio-economic and governance objectives and by better understanding the trade-offs that occur between different spatial and temporal scales. Nicaragua, for instance, underwent an in-depth iterative and participatory engagement process with stakeholders that cut across multiple institutions and levels of administration over a 3-year period to prepare EAA management plans for aquaculture development in sensitive zones. These are being progressively implemented. In Central America, a roadmap for the implementation of the ecosystem approach to shrimp fisheries and aquaculture has been prepared to strengthen fisheries and aquaculture planning, resource allocation and management (Gumy *et al.* 2014). In Chile, there is good technical capacity and the situation for EAA implementation is very promising. For example, the country's Fisheries and Aquaculture Law is being reviewed to include the EAF and EAA and a new policy that will guide aquaculture development over the next 20 years is being prepared, using the EAA as its

main reference. The EAA and the EAF have also been used to design climate change adaptation strategies piloted in fishing and aquaculture communities. Finally, the larger number of references citing Soto *et al.* (2008) with regard to the usefulness of the EAA to aquaculture development in the Mediterranean Sea also exemplifies the value of the approach in semi-enclosed and heavily used marine environments.

The spatial focus of the EAA in response to planning challenges has stimulated the development and wider use of a number of methodologies and tools in support of the more considerate and responsible expansion of aquaculture. Examples include 'zoning', supported by the use of geographical information systems (GIS) for the selection of suitable aquaculture sites and delimitation of suitable aquaculture management areas (AMAs) (Aguilar-Manjarrez *et al.* 2010; Ross *et al.* 2013). GIS is now routinely used in places where the EAA is promoted (Corner & Aguilar-Manjarrez 2017). There are many examples of aquaculture zoning around the world, covering, for example, marine fish cages (Indonesia, Turkey), fish farming in cages in freshwater reservoirs and lakes (Brazil) and shrimp ponds in Mexico. In the Mediterranean, the concept of allocated zones for aquaculture (AZA) promoted by the GFCM is widespread (Sanchez-Jerez *et al.* 2016). Aquaculture management areas or clusters are a new concept in most countries, but are currently gaining ground (e.g. in Chile, Hainan Island in China, India, the Philippines and Scotland, the United Kingdom of Great Britain and Northern Ireland).

The EAA also stimulated the application of the concept of sustainability to aquaculture development. The literature abounds with examples where, although not labelled as such, it is effectively an EAA that is being used to consider the development of the sector and its relations with the wider environment (e.g. Saenger *et al.* 2013; Kasozi *et al.* 2016). The profile of integrated multitrophic aquaculture (IMTA), which is a direct application of the principle of integration of the EAA at a farm level, is increasing (Barrington *et al.* 2009).

What new forces and developments could the EAA link to?

Evolution of the global context and of development discourses

The international economic and geopolitical context has changed significantly since the launch of the EAA. Aquaculture output now exceeds that of capture fisheries (FAO 2016a) and is playing an ever-increasing role in global food production. The food and nutrition security of more than 7 billion people – 2 billion of whom live in countries affected by instability, conflict and violence (World Bank 2017) – is now at stake (Godfray *et al.* 2010). Incomes and demand are growing on a par with inequality in well-being, especially for the youth and women (UNDP 2016). Climate change is adding pressure and altering the functioning of social–ecological systems, challenging production patterns and calling for the urgent adaptation of the sector and of producing countries to these growing threats (Cochrane *et al.* 2009). The Rio+20 Conference in 2012 and subsequent adoption of the sustainable development goals (SDGs) by the international community in 2015 have renewed countries' commitments to sustainable and inclusive development, with the corresponding Agenda 2030 shaping the actions to be undertaken by all actors in all sectors (UN 2015). Achieving sustainable food production, rural development, integrated water resource management and fair food supply chains will depend primarily upon improved policy, planning, regulation and implementing institutions – the critical issues faced by aquaculture development itself (Hambrey 2017). In relation to this, the 'blue economy' concept, which emerged from the Rio+20 Conference, emphasises the three pillars of sustainable development – economic, social and environmental – in relation to aquatic environments. In response, the FAO launched the Blue Growth Initiative (BGI) in 2013 with the support of regional fisheries bodies and its member countries (FAO Committee on Fisheries 2014, FAO 2015b). It is designed around sustainable capture fisheries and aquaculture, livelihoods and food systems, and economic growth from aquatic ecosystem services. 'Blue Growth aims to optimize revenues from sustainable use of aquatic resources while minimizing ecosystem degradation and enhancing social benefits (FAO 2015b). The BGI brings support and focus to enhance the implementation of the CCRF and of both the EAF and the EAA (FAO Committee on Fisheries 2015, FAO 2016b). At the same time, new strategies, such as the European Marine Strategy Framework Directive (EC 2010), have been promoted at a regional level, setting the objectives and establishing the means to maintain or enhance the good environmental status of marine waters.

Concepts and approaches that had been used in specific contexts for some time have also started to take centre stage in international discourses on development, poverty alleviation and sustainable food production and, by extension, have begun to be used in relation to aquaculture and its contribution to these goals. This is the case, for example, of 'value chains' (e.g. M4P 2008), 'ecosystem services' (e.g. MA 2005), 'ecosystem-based management' (e.g. Agardy *et al.* 2011), 'resilience' (e.g. Folke 2006; Folke *et al.* 2010) and more recently still, 'landscapes' (FAO 2017b), which are all linked directly and indirectly to aquaculture and seafood production more generally.

Relationships between the EAA and current development discourses and concepts

Connections with the sustainable development goals

Almost all the SDGs, and many associated targets, are relevant to aquaculture development. Equally, the EAA contributes significantly to many of the SDGs and targets (Hambrey 2017), as shown in Table 4. The principles of the EAA mirror those of the SDGs, and the approach should, in principle, be a perfect tool to support their realisation. However, in practice, the shortcomings of the EAA in relation to governance, cross-scale interactions, capturing human dimensions, such as poverty alleviation and equity, and addressing trade-offs between objectives are likely to weaken its role in creating the enabling environment that the sector requires to make its full contribution to the SDGs.

Table 4 Relevance of aquaculture development to the achievement of the sustainable development goals (SDGs)

No.	Sustainable development goals (text shortened)	Relevance of aquaculture
1	End poverty in all its forms everywhere	**
2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	***
3	Ensure healthy lives and promote well-being for all at all ages	*
4	Ensure inclusive and quality education for all and promote lifelong learning	*
5	Achieve gender equality and empower women and girls	**
6	Ensure availability and sustainable management of water and sanitation for all	**
7	Ensure access to affordable, reliable, sustainable and modern energy for all	**
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	***
9	Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	**
10	Reduce inequality within and among countries	*
11	Make cities and human settlements inclusive, safe, resilient and sustainable	*
12	Ensure sustainable consumption and production patterns	***
13	Take urgent action to combat climate change and its impacts	**
14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development	***
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss	**
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	*
17	Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development	**

Low (*), medium (**), high (***)
Source: Hambrey (2017).

Connections with Blue growth

The FAO's BGI, currently in development, adopts a more explicit value chain approach to (fisheries) and aquaculture. Owing to the fact that suppliers, retailers and consumers are direct actors in blue growth, their consumption choices can tip (or not) the balance towards greater sustainability (FAO 2015b). However, there are in fact no differences between the principles underpinning the EAA (and EAF) and the BGI.

The BGI, as defined by FAO, is closely aligned with the EAA because it articulates the three guiding principles of the EAA by promoting resource efficiency, decent work, energy efficiency and innovation across the value chain (Jacqueline Alder, pers. comm., 2017). However, such alignment can also be a sign of redundancy. Indeed, the idea of decoupling economic growth from environmental degradation, which is embodied in the BGI (Hambrey 2017) and which provided a new impulse in the thinking around how to achieve 'sustainability', is only very loosely alluded to in the EAA, making it seem outdated by comparison. Although the BGI is broader in scope than the EAA – which is relevant to islands and non-islands, marine and landlocked areas – to date the focus of the BGI has been narrower because it has been primarily directed at small island developing states (cf. SDG target 14.7 and the recently endorsed Blue Growth Charter by island nations [Cabo Verde, May 2017] (see also Table S3 on BGI)). Even though a number of projects are in the pipeline in African and Asian non-island countries, nonetheless this has been disappointing.

The 'blue growth agenda' that FAO is helping its member countries move towards (FAO 2015b), and the more generic focus of the BGI on both capture fisheries and aquaculture – echoing the CCRF – is likely to lead to a dilution of the momentum created by the EAA in establishing a place among the concerns relating to capture fisheries that usually dominate discussions. Furthermore, the conclusions and recommendations of the GFCM workshop on 'Blue Growth in the Mediterranean and the Black Sea: developing sustainable aquaculture for food security', held in Bari, Italy in late 2014 (FAO 2017c), raise doubts about whether the BGI, in substance, will amount to more than a repackaged EAA.

This notwithstanding, there is a lot in the engaging name of 'blue growth' to attract the attention of policy makers,

planners, economists, environmentalists and the media. The BGI also represents an opportunity to enhance awareness of the economic importance of aquatic (marine and freshwater) ecosystems for productive and non-productive uses, as well as resource use efficiency, equity and conservation, and the design of management systems to sustain a strong and resilient blue economy. As such, either the BGI could become a new conduit for the principles and influence of the EAA, or it could bury it. Already, 'blue growth/economy' initiatives are springing up (Patil *et al.* 2016; Stobberup *et al.* 2017).

Connections with value chains

It is only relatively recently that the concept of 'value chains' has made its way into the development discourse. Previously, the concept was more commonly used in the context of manufacturing. In 2007, value chains in aquaculture and fisheries were hardly talked about. Today, the concept has been embraced as a way of thinking and bringing distributional equity considerations to the analysis of supply chain efficiencies, placing greater emphasis on the roles and responsibilities of post-harvest stakeholders, including consumers. The importance of taking into account the sustainability of supply chains is something the EAA, at its inception, had 'sensed' (cf. global market scale of the approach in Soto *et al.* 2008) but inadequately captured. Given the direction taken so far by the EAA, and its current biophysical focus, it may prove difficult to incorporate value chain dimensions in its implementation. However, the BGI provides a framework to attempt to make that change.

Connections with the concept of resilience

The concept of resilience has been in use for several decades, and its social and ecological dimensions are fully incorporated in the EAA (Soto *et al.* 2008; FAO 2010a). Resilience is also strongly emphasised by the SDGs and, as such, is an articulating point between the EAA and the SDGs (Hambrey 2017). Social, ecological and economic resilience to withstand and recover from shocks and trends is a characteristic that aquaculture systems should strive to achieve so as to maintain the contribution of the sector to food security, livelihoods and economic growth (FAO 2010a). Resilience, as encapsulated by the EAA, also relates to the idea that physical and socio-economic environments within which aquaculture systems operate can sustain a certain degree of change, but have limits beyond which degradation (ecological and/or social, e.g., conflicts) will be such that the aquaculture system itself and the social–ecological system it is embedded in, will be far less resilient (Hambrey 2017). The reaching of this tipping point is precisely what the EAA is intending to avert.

Connections with the concepts of landscapes and ecosystem services

The concept of landscape has been used relatively recently. It encompasses a range of holistic planning approaches that strive to integrate the needs of all stakeholders and support ecosystem services and resilience in a broad area and are in many ways very similar to the ecosystem-based approaches detailed below. The concept of integrating food and fish production with the maintenance and enhancement of other ecosystem services is beginning to attract interest from the scientific and development communities. Working at 'landscape level' means recognising that farmers, pastoralists, those who depend on forest resources and fisher folks live in a social–ecological system that consists of a mosaic of natural and/or human-modified ecosystems, often with a characteristic configuration of topography, vegetation, land use and settlements that is influenced by the ecological, historical, economic and cultural processes and activities of the area. As a result, the scale of a landscape approach is large and system-wide and necessitates the integration of different sectors, different levels of governance and the involvement of multiple stakeholders (FAO 2017b). Although the position of the EAA in relation to a landscape approach is yet to be defined, the EAA (with ecosystem in its name) would seem to provide a specific (aquatic) ecosystem, if not sectoral complement to a landscape approach. Both approaches provide an opportunity to reconsider in a positive light the relationship of aquaculture – until now mostly seen in negative and disruptive terms – with the delivery of regulating, supportive and cultural ecosystem services, and the manner in which fish production itself can enhance these (Brugère *et al.* 2015).

Connections with ecosystem-based management

In contrast to the EAA, ecosystem management and ecosystem-based management (EBM) do not have a single, widely accepted, definition (Christensen *et al.* 1996; Long *et al.* 2015). EBM, which stems from the Convention on Biological Diversity (UNEP 2000), is described with a rationale similar to ICZM but applied to any ecosystem and recognises the growing impact of human activities on these (FAO 2016a). The definition of the EAA essentially reiterates that of EBM as proposed in the Convention on Biological Diversity (Soto *et al.* 2008), and the EAF has been acknowledged as a sector-specific interpretation of EBM (Bianchi & Skjoldal 2008; Long *et al.* 2015). However, the recent downgrading of the EAA to a sectoral management approach under the multisectoral umbrella of EBM (FAO 2016a) signals a significant departure from the initial, ambitious and holistic remit and aspirations of Soto *et al.* (2008) for the EAA.

To ensure that equity and human rights issues in aquaculture retain enough attention, the EAA needs to renew itself or find its 'unique selling point' under the EBM umbrella. Many of the 15 principles that underpin EBM approaches in marine environments (Long *et al.* 2015) are shared with the founding principles of the EAA (marked hereafter with *: consider ecosystem connections*; appropriate spatial and temporal scales*; adaptive management; use of scientific knowledge; integrated management*; stakeholder involvement*; account for dynamic nature of ecosystems; ecological integrity and biodiversity*; sustainability*; recognise coupled social–ecological systems; decisions reflect societal choice*; distinct boundaries; interdisciplinarity*; appropriate monitoring; acknowledge uncertainty). These offer an entry point for a reinterpretation of the EAA in line with renewed thinking around sustainability and natural resource management rhetoric. Other principles, less frequently cited but nonetheless very important in the context of the EAA, deserve equal attention (Long *et al.* 2015): cumulative impacts, explicit acknowledgement of trade-offs, effects on adjacent ecosystems, commitment to principles of equity, long-term objectives and use of incentives.

It remains to be seen what impact EBM, which is gaining momentum in relation to aquatic resource management (FAO 2016a), will have on the governance of the aquaculture sector – an aspect that the EAA has not addressed well. The potential interactions of EBM with existing and upcoming approaches and philosophies of resource use and management discussed above are also becoming increasingly tangled, raising larger questions about the necessity of a plethora of approaches and the long process of operationalising them. Perhaps, the question should not be how to keep the approaches distinct, but how to ensure that tools and principles are embedded and sustained in the new approaches.

What is the way forward for the implementation of the EAA in the next decade?

An uncertain future?

In the midst of these concepts, approaches and commitments, all of which affect the development trajectory of aquaculture (and other economic sectors), the role of the EAA has become blurred. Complementary or aligned with some, embedded in others, the EAA has lost some of its visibility and some of the traction and interest it generated a decade ago, and it is becoming superseded by broader and more holistic approaches (e.g. EBM and blue growth). Consequently, it is now difficult to differentiate what constitutes the unique selling point of the EAA when compared to these approaches. From a sectoral perspective, the EAA, and the suite of spatial planning tools, local initiatives and positive outcomes it has generated (e.g. Nicaragua's EAA management plans), constitute remarkable advances. This may be where the most probable use of the EAA in the future will lie. But the EAA was meant to facilitate integration with other sectors, and in the face of new (or renewed) and more holistic approaches that better lend themselves to the handling of governance issues, it is losing ground.

As they co-evolve, at times symbiotically, at others competitively, these various approaches are likely to create confusion among policy makers and practitioners in the aquaculture sector – including the very farmers and their associations they are meant to enlighten and guide. Increased awareness of the advantages and changes proposed by the different approaches might help to clarify their differences and their respective uses. The problems of integration and complexity are not particular to the EAA, but they are common to the successive sustainable development agendas that have been set since the 1972 Stockholm Declaration (Hambrey 2017). Establishing a clearer association between high-level goals of sustainability, the purpose of the various approaches proposed to achieve them and the tools available or designed to support them (e.g. spatial/GIS-based planning and modelling tools) will be essential, but not sufficient on its own. Creating the right enabling environment is essential for ensuring that aquaculture continues to develop sustainably and contributes to the SDGs (Hambrey 2017). The EAA on its own lacks the institutional traction to do that. National-level initiatives in small island developing states promoted under the BGI umbrella may be better suited to trigger the changes in governance that are required at higher levels to simultaneously achieve greater aquaculture production, resilience and overall improved integration with other economic sectors (e.g. tourism, capture fisheries and mining) within an accepted or minimal level of social and/or environmental disruption.

Despite these obstacles, the EAA looks set to continue to be adopted, thanks in part to the priority and explicit support given to the approach by FAO member countries and requests that FAO continue its efforts to disseminate tools and guidance on the EAA (FAO Committee on Fisheries 2012, FAO 2013b, 2015a). Another reason to be positive about the future of the EAA is the adoption by the European Commission of the European Union (EU) of the EAA through a number of regional aquaculture research initiatives, signalling the endorsement of the principles of the approach as a means to finding solutions to the challenges faced by aquaculture and to guide the development of the sector in Europe (e.g. EU AquaSpace and EcoAqua projects – Aguilar-Manjarrez 2016; Aguilar-Manjarrez *et al.* 2016; Haroun *et al.* 2016). The momentum should be enhanced through country-led monitoring, evaluation and communication especially at the ground level.

Over the past 10 years, the EAA has steered the 'blue revolution', that is the remarkable emergence and fast development of aquaculture as an important and highly productive activity (Costa-Pierce 2008) in the right direction, most notably with regard to spatial planning and stakeholder participation. And, with the increased availability of remote sensing applications and digital technologies that may be used to plan the development of aquaculture operations in space or resource-constrained settings (e.g. Aguilar-Manjarrez *et al.* 2010; Corner & Aguilar-Manjarrez 2017), the coherent framework the EAA has provided for the utilisation of spatial analysis tools is likely to become more useful than ever. The recent release of Aguilar-Manjarrez *et al.* (2017) to guide aquaculture zoning, site selection and area management and the momentum this is gaining are signs of the growing importance of this particular aspect of the EAA. But, as Aguilar-Manjarrez *et al.* (2017) point out, this should not be at the expense of human and institutional issues arising out of aquaculture development. Using the EAA as the umbrella under which all stakeholders can be brought together to discuss the various issues affecting the development of aquaculture activities in particular areas, and to rationalise planning processes, should also be pursued. However, fragmentation still characterises many countries: multiple agencies are in charge of a variety of decision-making processes (e.g. delivering licences) and controls; different production systems need to co-exist but are at different levels of development and maturity; space has to be shared by a number of economic sectors; data need to be shared and harmonised for monitoring activities and their impacts; and trade-offs and conflicts arise from sectoral decision-making. Such fragmentation calls for horizontal and vertical cross-scale institutional and stakeholder interactions, in particular where semi-enclosed aquatic ecosystems are concerned (FAO 2017c).

Additional considerations for the EAA

The global and local context in which the EAA has evolved over the past decade has changed, and the EAA is showing its limitations in relation to this. FAO (2016a) signalled a very important change in the way the EAA was portrayed, perhaps because of a realisation – or inevitable evolution – of this fact. Regardless of whether the EAA is narrowed down to a sectoral approach under the auspices of EBM (also denoting a return to 'ecosystems' and a stronger environmental focus) or whether it is broadened to become part of the multisectoral integrated planning and management encapsulated in the blue growth concept, new considerations need to gain more prominence. These include climate change and small-scale producers.

Climate change adaptation

Adaptive planning and management is of general relevance to aquaculture systems which need to continuously adjust and adapt to changing markets, competition, input costs and supply, capital and labour, but it particularly resonates with the need of the sector to adapt to climate change (Cochrane *et al.* 2009; Curtis *et al.* 2011; Santos *et al.* 2016). The strong link between the EAA and climate change adaptation has been recognised (FAO 2010a), but the management flexibility it requires is still insufficiently accounted for in the EAA guidance (FAO 2010a) and national fisheries and aquaculture policies, strategies and plans are still not 'adaptive' enough in nature, that is they do not include mechanisms for regular and frequent review and adaptation according to evolving circumstances. Despite this limitation, more recent efforts to promote the EAA at a country level have emphasised the inclusion of climate change analyses in national fisheries and aquaculture policies, strategies and plans. The commitments of countries to the Paris Agreement on Climate Change now require them to prepare national adaptation plans (Karttunen *et al.* 2017), which should allow for increased visibility of aquaculture (and fisheries) in adaptation planning and for mainstreaming climate change concerns and adaptation in aquaculture (and fisheries) development and management. This should provide a clearer avenue for developing climate change adaptation options for the aquaculture sector that are compliant with the principles of the EAA, are informed by hazard identification, risk characterisation and assessment, and followed by risk management throughout the value chain (Bueno & Soto 2017). Some blue growth practices/programmes will contribute to climate change adaptation (Jacqueline Alder, pers. comm., 2017).

The visibility of small-scale aquaculture producers

No particular consideration is given to small-scale aquaculture producers in the EAA guidelines (FAO 2010a), but most aquaculture producers are small-scale and they have been the focus of all EAA implementation exercises and pilots (Table S2), either directly or through the representatives of their associations. Yet, the conditions under which they produce, access and use resources and technologies, benefit (or not) from incentives and other mechanisms (e.g. certification schemes), get organised and impact on the environment, local food security and global value chains deserve greater attention. In this regard, the internationally agreed Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (FAO 2015c) recognise the unique role, contribution and characteristics of small-scale fishers. Similar attention is amply deserved by small-scale aquaculture producers and should

Table 5 Key questions and pointers for answering them in support of the reinvigoration of the EAA

Key questions	Pointers
Perceptions	
What are aquaculture stakeholders' perceptions of the EAA?	Most people understand the EAA to be focused primarily on 'ecosystems', without realising that human, social and governance aspects are integral to it. How should such gaps in understanding across different communities of users be closed? Long *et al.* (2017), for example, showed that the priorities of fishers were not always aligned with those of planners promoting marine EBM and the EAF. A similar methodology to the one Long *et al.* (2017) developed could be used to identify users' perceptions of EAA and develop a common understanding
Contents	
What new or renewed contents should be included in the EAA?	If the EAA principles still apply, emerging issues, or those issues inadequately recognised to date, should be considered so as to maintain and enhance the EAA's appeal and relevance at wider scales. These include the need for greater adaptation (i.e. adapting the EAA to local circumstances and adapting planning and management systems to emerging learning, problems and threats) and intergenerational and transboundary issues (e.g. inclusive and equitable growth and access to resources, regional cooperation, transboundary issues such as trade and disease)
Adoption	
Which strategies could be used to ensure the adoption of the EAA?	There are different paths and models for sustainable development, as well as a range of situations and priorities in each country. These should be considered individually. The overarching principles of the EAA or blue growth are useful, but the international organisations supporting these approaches should also focus on initiatives that can be targeted and adapted to local capacities and realities (i.e. national priorities and institutional, human and financial capacities). There is general support for the pursuit of the EAA on behalf of national governments (FAO 2013a,b, 2016b; FAO & World Bank 2015; Aguilar-Manjarrez *et al.* 2017), but this needs to take into account the new focus on blue growth and EBM. FAO and international partner organisations will need to clarify what these approaches entail in practical terms and how they could be harmonised or consolidated to pursue efforts towards sustainable aquaculture development and its contribution to the SDGs and targets
Funding	
How should the EAA be funded at a national level, through which incentives and mechanisms, and how should EAA guidance and tools be maintained over time?	The lack of funding for the regular updating and adequate maintenance of freely available tools was found to threaten the continuity of EBM (Curtice *et al.* 2012). Funding in support of the implementation of the EAA is required over long timescales and funding mechanisms capable of sustaining the approach need to be identified. Long-term funding – over at least 5–10 years – is needed to see the implementation of the EAA translate into positive impacts
Positioning	
How should the EAA's objectives be positioned in relation to high-level commitments and visions for world development?	Coherence, synergies and harmonisation should be sought to overcome the current multiplicity of approaches. Whether the EAA should be promoted as a concept or as a planning tool should be part of the discussions on the essence of the approach. The position of the EAA *vis-à-vis* the EAF should also be reconsidered: these approaches are usually referred to together, yet they are at very different stages of development. What can be learnt from the EAF experience, including from its 'toolbox'? Should synergies between EAF and EAA be strengthened (Soto *et al.* 2012a,b; Soto & Bianchi 2014) or, on the contrary, should the EAA be more distinct?
Relevance to governance	
How should the relevance of the EAA for the governance of the aquaculture sector be increased?	The FAO's *Common Vision for Sustainable Food and Agriculture* (COAG 2016), concerning agriculture, forestry, fisheries and aquaculture – especially principle 5 on governance mechanisms – provides useful guidance for aquaculture planning and management and is meant to 'encourage more effective and coherent action within aquaculture and across other agricultural sectors in implementing the 2030 Agenda' (FAO 2017d)
Partnerships	
What roles should partnerships play in a renewed EAA?	Public–private partnerships (PPPs) were advocated to foster aquaculture development by FAO's member countries (FAO Committee on Fisheries 2014). What this means in practical terms and how it would support the implementation of the EAA remain to be discussed. The extent to which the promotion and implementation of the EAA could be influenced through closer partnerships between FAO and its key partners (e.g. NACA) could also be explored, as was achieved with the CCRF (Hosch 2009)

Table 5 (continued)

Key questions	Pointers
Impact	
How can the impact of the EAA on the sustainability of aquaculture operations across scales, as well as the resonance and relevance of the approach, be better monitored and evaluated?	Improvements in the CCRF questionnaire survey could provide an entry point for this process. The redesigned and updated CCRF questionnaire that has been sent to FAO member countries since 2013 to monitor their implementation of the code now includes questions of relevance to the EAA – such as ecosystem functions, carrying capacity, climate-related risks and zoning. These may provide valuable insights into the gaps and needs of countries to fully embrace the EAA. The way in which devolved aquaculture administrations in the United Kingdom of Great Britain and Northern Ireland are handling their responses to the CCRF questionnaire sets a useful example for other countries (Seafish 2017). How to adequately address the weaknesses and needs identified in the returned questionnaires, and over what periods of time, is the next question
Spatial planning	
How might the impact of spatial planning under the EAA be evaluated?	Ongoing work under the EU AquaSpace project to review current approaches to spatial planning under the EAA in marine and freshwater environments in Europe, the Mediterranean, the Black Sea and North America could provide a useful basis to answer this question (Aguilar-Manjarrez *et al.* 2016)
Communication	
Would it be strategic to make the EAA more than a planning tool? Could it also be a communications tool?	This would be possible if its principles were more explicitly incorporated into existing certification systems, thus taking those certification schemes already aligned with the CCRF one step further. Could it become a vehicle for the public to regain confidence in the sector and improve perceptions of it (cf. Froehlich *et al.* 2017)? Recent FAO initiatives relating to the potential of group certification of aquaculture products, for example products originating from specific aquaculture management zones designed and managed according to the principles of the EAA (Aguilar-Manjarrez *et al.* 2017), could serve as a starting point in this regard. In addition, the documenting of public perceptions of aquaculture, and the public's acceptance of it (Bacher 2015; FAO 2016c) in the context of improved spatial planning, should be pursued

be conveyed in a renewed EAA. The International Year of Artisanal Fisheries and Aquaculture (IYAFA) planned for 2022 could create the impetus to do so and consolidate the links between the EAA and small-scale aquaculture (FAO 2016d).

Avenues for a reinvigoration of the EAA

In the light of our findings, we suggest that it is now opportune to initiate a process to review and reconsider the EAA's *raison d'être*, taking into account its strengths, weaknesses and the opportunities and threats created by developments within and outside the aquaculture sector that are discussed above. FAO should take the lead in this process, and this paper could be a starting point for wide stakeholder consultation and FAO and partners' discussions. To this end, Table 5 identifies, in addition to the considerations of climate change and small-scale producers, key questions to raise and provides pointers for answering them and enabling the reinvigoration of the approach in the forthcoming years.

Conclusion

The CCRF prepared the ground for the introduction of the EAA. As both a process and a concept, the EAA has brought the broad principles of sustainable development to the attention of the aquaculture sector. By focusing more intently than the CCRF on the three interlinked dimensions of sustainability (economic, environmental and social), the EAA triggered improvements in the management of aquaculture in relation to ecosystems. Whilst in practice, the EAA has enabled considerable progress in zoning and spatial planning (see Aguilar-Manjarrez *et al.* 2017), it has not been used by decision-makers and planners to embrace and address the more complex institutional issues that also shape the development of aquaculture. The recent portrayal of the EAA as one of the tools of EBM is unlikely to remedy this.

Although times have changed since the inception of the EAA, it has acted as a springboard for the emergence of other approaches and ways of thinking. 'Blue growth' is a prime example of this and undoubtedly adds value to the CCRF, EAF and the EAA itself. The EAA launch and early evolution were largely as a result of the work, efforts and expertise of a few individuals within FAO. Whilst the concept of blue growth/blue economy has greater corporate and media appeal and may be more attractive to decision-makers and policy makers than ecosystem-based management (which lends itself to conservation practitioners and conservation-oriented organisations), it will need to generate buy-in and produce incentives for implementation at the national level if it is to stand the test of time. The EAA itself, on the other hand, and particularly in its spatial applications, may retain the interest of researchers, aquaculture developers and producers. Despite their often

divergent interests, bringing these communities together is fundamental for the sustainable development of the sector, but finding common ground among a multiplicity of approaches and concepts is likely to be challenging. Rationalising them into broader development frameworks such as blue growth is even more challenging, but appears to be the ineluctable next stage of action.

Whilst the momentum of spatial planning should grow over the coming decade, spatial planning tools should strive to account for changes that will occur simultaneously at local and global levels and the resulting impacts on ecosystems and resource uses. It would be essential for a revitalised EAA to build in considerations for flexible and adaptive management under a range of scenarios. This would allow the EAA to retain some relevance at local planning levels, thanks in particular to the ethos of participation implicit in the approach. However, its relevance to the improvement of the governance of the aquaculture sector at higher levels is questionable – other, non-sectoral approaches for institutional analysis and development (e.g. Ostrom 2005, 2011) may be better suited to address the institutional issues the sector is facing in most countries.

Acknowledgements

This study was commissioned by the FAO Fisheries and Aquaculture Department. The authors wish to thank John Hambrey (Hambrey Consulting Ltd) and Jacqueline Alder (FishCode Manager, FAO) for their valuable comments on an earlier version of the manuscript and Claire Attwood, for editing assistance. The authors are also grateful for the support of Uwe Barg (Aquaculture Officer, FAO), Zachary Foco (FishCode Programme specialist, FAO) and Zhiyi Zhang (Aquaculture intern, FAO) for gathering literature of relevance to the study. The views expressed in this information product are those of the author(s) and do not necessarily reflect the views or policies of Food and Agriculture Organization of the United Nations.

References

Agardy T, Davis J, Sherwood K, Vestergaard O (2011) Taking steps toward marine and coastal ecosystem-based management – an introductory guide. UNEP Regional Seas Reports and Studies No. 189. UNEP, Nairobi.

Aguilar-Manjarrez J (2016) *Horizon 2020: Promoting Sustainable Aquaculture*. FAO Aquaculture Newsletter 54, p. 26. FAO, Rome.

Aguilar-Manjarrez J, Kapetsky JM, Soto D (2010) The potential of spatial planning tools to support the ecosystem approach to aquaculture. Expert Workshop. 19–21 November 2008, Rome, Italy. FAO Fisheries and Aquaculture Proceedings No. 17. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/012/i1359e/i1359e.pdf

Aguilar-Manjarrez J, Massa F, Bacher K (2016) Workshop on aquaculture zoning, site selection and area management: Assessment of policy management issues. FAO Aquaculture Newsletter 55, pp. 28–29. FAO, Rome.

Aguilar-Manjarrez J, Soto D, Brummett R (2017) Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture. Full document. Report ACS113536. FAO, Rome and World Bank Group, Washington, DC. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i6992e.pdf

Arksey H, O'Malley L (2005) Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology* **8**(1): 19–32.

Bacher K (2015) *Perceptions and Misconceptions of Aquaculture: A Global Overview*. GLOBEFISH Research Programme, Vol. 120. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-bc015e.pdf.

Bäckstrand K (2006) Democratizing global environmental governance? Stakeholder democracy after the World Summit on Sustainable Development. *European Journal of International Relations* **12**(4): 467–498.

Barrington K, Chopin T, Robinson S (2009) Integrated multitrophic aquaculture (IMTA) in marine temperate waters. In: Soto D (ed.) *Integrated Mariculture: A Global Review*. FAO Fisheries and Aquaculture Technical Paper No. 529, pp. 7–46. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/012/i1092e/i1092e00.htm

Bermúdez J (2008) Legal implications of an ecosystem approach to aquaculture. In: Soto D, Aguilar-Manjarrez J, Hishamunda N (eds.) *Building an Ecosystem Approach to Aquaculture*. FAO/Universitat de les Illes Balears Expert Workshop, 7–11 May 2007, Palma de Mallorca, Spain. FAO Fisheries and Aquaculture Proceedings No. 14, pp. 67–78. FAO, Rome. [Cited 24 January 2018.]. Available from URL: http://www.fao.org/docrep/011/i0339e/i0339e00.htm

Bianchi G, Skjoldal HR (eds) (2008) *The Ecosystem Approach to Fisheries*. CABI, Oxford.

Bilio M (1993) Foreword. In: Pullin RSV, Rosenthal H, Maclean JL (eds.) *Environment and Aquaculture in Developing Countries*, pp. v–vi. ICLARM-GTZ, Manilla.

Brugère C (2006) Can integrated coastal management solve agriculture–fisheries–aquaculture conflicts at the land-water interface? A perspective from New Institutional Economics. In: Huong CT, Tuong TP, Gowing JW, Hardy B (eds) *Environment and Livelihoods in Coastal Tropical Zones: Managing Agriculture–Fishery–Aquaculture Conflicts*, pp. 258–273. CGIAR Comprehensive Assessment Series, CABI International, Oxon.

Brugère C, Ridler N, Haylor G, Macfadyen G, Hishamunda N (2010) Aquaculture planning. Policy formulation and implementation for sustainable development. FAO Fisheries and Aquaculture Technical Paper No. 542. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/012/i1601e/i1601e00.pdf

Brugère C, Lymer D, Bartley DM (2015) *Ecosystem Services in Freshwater Fish Production Systems and Aquatic Ecosystems:*

Recognizing, Demonstrating and Capturing Their Value in Food Production and Water Management Decisions. TEEB Agriculture & Food, UNEP, Geneva. [Cited 24 January 2018.] Available from URL: http://teebweb.org/agrifood/home/inland-fisheries/

Bueno P, Soto D (2017) Adaptation strategies of the aquaculture sector to the impacts of climate change. FAO Fisheries and Aquaculture Circular No. 1142. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i6943e.pdf Available at: http://www.fao.org/3/a-i6943e.pdf

Christensen NL, Bartuska A, Brown JH, Carpenter S, D'Antonio C, Francis R *et al.* (1996) The report of the Ecological Society of America Committee on the scientific basis for ecosystem management. *Ecological Applications* **6**: 665–691.

COAG (2016) Agriculture and the 2030 Agenda for Sustainable Development. 25th Session of the Committee on Agriculture, Rome, Italy, 26–30 September 2016. COAG/2016/4. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-mr022e.pdf

Cochrane K, De Young C, Soto D, Bahri T, eds. (2009) Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper No. 530. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/012/i0994e/i0994e00.htm

Corner RA, Aguilar-Manjarrez J (2017) Tools and models for aquaculture zoning, site selection and area management. In: Aguilar-Manjarrez J, Soto D, Brummett R (eds.) *Aquaculture Zoning, Site Selection and Area Management Under the Ecosystem Approach to Aquaculture (Full Document)*. Report ACS113536, pp. 95–145. FAO, Rome and World Bank Group, Washington, DC. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i6992e.pdf

Costa-Pierce B (2008) An ecosystem approach to marine aquaculture: a global review. In Soto D, Aguilar-Manjarrez J, Hishamunda N (eds.) *Building an Ecosystem Approach to Aquaculture. FAO/Universitat de les Illes Balears Experts* Workshop, 7–11 May 2007, Palma de Mallorca, Spain. FAO Fisheries and Aquaculture Proceedings No. 14. pp. 81–115. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/011/i0339e/i0339e00.htm

Curtice C, Dunn DC, Roberts JJ, Carr SD, Halpin PN (2012) Why ecosystem-based management may fail without changes to tool development and financing. *BioScience* **62**(5): 508–515.

Curtis L, Beveridge MCM, el-Gamal AR, Mannini P, eds. (2011) *Adapting to Climate Change: The Ecosystem Approach to Fisheries and Aquaculture in the Near East and North Africa Region – Workshop Proceedings*. FAO Fisheries and Aquaculture Circular No. 1066. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/014/i2146e/i2146e.pdf

Department of Fisheries, Ministry of Agriculture and Food Security (2014) *EAF/EAA Management Plan for Fisheries and Aquaculture of Lake Malombe, South East Arm and Part of South-West Arm of Lake Malawi*. Government of Malawi, Lilongwe.

EC (2010) *2010/477/EU: Commission Decision of 1 September 2010 on Criteria and Methodological Standards on Good Environmental Status of Marine Waters (Notified Under Document C(2010) 5956)*. European Commission, Brussels.

Engle CR, D'Abramo L, Ponniah AG, Slater M (2017) Global aquaculture 2050. Editorial. *Journal of the World Aquaculture Society* **48** (1): 3–6.

Escoto RM (2011) *La Cadena del Camarón de Cultivo de Nicaragua. Un Estudio de la Camaronicultura en el Estero Real Desde el Enfoque de Ecosistema de la Acuicultura*. FAO, Nicaragua.

FAO (1995) *Code of Conduct for Responsible Fisheries*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/005/v9878e/v9878e00.htm

FAO (2003) *Fisheries Management. 2. The Ecosystem Approach to Fisheries*. FAO Technical Guidelines for Responsible Fisheries. No. 4, Suppl. 2. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/005/Y4470E/Y4470E00.HTM

FAO (2007) FAO Fisheries Report No. 816. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/009/a0922t/a0922t00.htm

FAO (2008) *The State of World Fisheries and Aquaculture 2008*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/011/i0250e/i0250e00.htm

FAO (2010a) *Aquaculture Development. 4. Ecosystem Approach to Aquaculture*. FAO Technical Guidelines for Responsible Fisheries. No. 5, Suppl. 4. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/013/i1750e/i1750e00.htm

FAO (2010b) *The State of World Fisheries and Aquaculture 2010*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/013/i1820e/i1820e.pdf

FAO (2010c) The FAO Fisheries and Aquaculture Department's efforts in implementing the recommendations of the past sessions of the COFI Sub-Committee on Aquaculture. Fifth Session of the Sub-Committee on Aquaculture (SCA) of the FAO Committee on Fisheries (COFI). Phuket, Thailand, 27 September–1 October 2010. Discussion document. COFI/AQ/V/2010/2. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/meeting/019/k7584e.pdf

FAO (2011) Fisheries and aquaculture in our changing climate: adaptation and mitigation measures in fisheries and aquaculture. Committee on Fisheries, Twenty-ninth Session, Rome, Italy, 31 January–4 February 2011. Discussion document. COFI/2011/6. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/meeting/021/k9668e.pdf

FAO (2012a) *The State of World Fisheries and Aquaculture 2012*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/016/i2727e/i2727e.pdf

FAO (2012b) The FAO Fisheries and Aquaculture Department's efforts in implementing the recommendations of the past Sessions of the COFI Sub-Committee on Aquaculture. Sixth Session of the Sub-Committee on Aquaculture (SCA) of the FAO

Committee on Fisheries (COFI). Cape Town, South Africa, 26–30 March 2012. Discussion document. COFI:AQ/VI/2012/2. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/fi/static-media/MeetingDocuments/COFI_AQ/2012/2e.pdf

FAO (2013a) The FAO Fisheries and Aquaculture Department's efforts in implementing the recommendations of the past sessions of the COFI Sub-Committee on Aquaculture. Seventh Session of the Sub-Committee on Aquaculture (SCA) of the FAO Committee on Fisheries (COFI). St. Petersburg, Russian Federation, 7–11 October 2013. Discussion document. COFI:AQ/VII/2013/2. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/fi/static-media/MeetingDocuments/COFI_AQ/2013/2e.pdf

FAO (2013b) Applying spatial planning for promoting future aquaculture growth. Seventh session of the Sub-Committee on Aquaculture (SCA) of the FAO Committee on Fisheries (COFI). St. Petersburg, Russian Federation, 7–11 October 2013. Discussion document: COFI:AQ/VII/2013/6. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/fi/static-media/MeetingDocuments/COFI_AQ/2013/6e.pdf

FAO (2014a) Informe del Taller de validación del "Plan de gestión colaborativa de la pesca y la acuicultura con enfoque ecosistémico, en el Estero Real". FAO Informe de Pesca y Acuicultura No. 994/3. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i3801s.pdf

FAO (2014b) *The State of World Fisheries and Aquaculture 2014*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i3720e.pdf

FAO (2015a) The FAO Fisheries and Aquaculture Department's efforts in implementing the recommendations of the past sessions of the COFI Sub-Committee on Aquaculture. Eighth Session of the Sub-Committee on Aquaculture (SCA) of the FAO Committee on Fisheries (COFI). Brasilia, Brazil, 5–9 October 2015. Discussion document. COFI:AQ/VIII/2015/2. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/fi/static-media/MeetingDocuments/COFI_AQ/2015/2e.pdf

FAO (2015b) *Achieving Blue Growth Through Implementation of the Code of Conduct for Responsible Fisheries*. Policy Brief. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/fileadmin/user_upload/newsroom/docs/BlueGrowth_LR.pdf

FAO (2015c) *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i4356e.pdf

FAO (2016a) *The State of World Fisheries and Aquaculture 2016. Contributing to Food Security and Nutrition for all*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i5555e.pdf

FAO (2016b) Report of the FAO workshop launching the Blue Growth Initiative and implementing an ecosystem approach to aquaculture in Kenya, Mombasa. Kenya 27–31 July 2015. FAO Fisheries and Aquaculture Report No. 1145. FAO, Rome. [Cited 24 January 2018.] Available from URL: www.fao.org/3/a-i5997e.pdf

FAO (2016c) Report of the Workshop on Increasing Public Understanding and Acceptance of Aquaculture – the Role of Truth, Transparency and Transformation. Vigo, Spain, 10–11 October 2015. FAO Fisheries and Aquaculture Report No. 1143. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i6001e.pdf

FAO (2016d) Hundred and Fifty-fifth Session of the FAO Council. Rome, 5–9 December 2016. International Year of Artisanal Fisheries and Aquaculture. CL 155/LIM/7. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-mr951e.pdf

FAO (2017a) *Food Outlook – June 2017*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i7343e.pdf

FAO (2017b) *Landscape for Life. Approaches to Landscape Management for Sustainable Food and Agriculture*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/i8324en/i8324en.pdf

FAO (2017c) Regional Conference "Blue growth in the Mediterranean and the Black Sea: developing sustainable aquaculture for food security", 9–11 December 2014, Bari, Italy. In: Massa F, Rigillo R, Bourdenet D, Fezzardi D, Nastasi A, Rizzotti H, Emam W, Carmignac C (eds.). *FAO Fisheries and Aquaculture Proceedings No. 46*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i6902e.pdf

FAO (2017d) Aquaculture, the Sustainable Development Goals (SDGs)/agenda 2030 and FAO's common vision for sustainable food and agriculture. Ninth session of the Sub-Committee on Aquaculture (SCA) of the FAO Committee on Fisheries (COFI). Rome, 24–27 October 2017. Discussion document. COFI:AQ/IX/2017/5. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/cofi/30794-011acfda6d140b8ede06f0b184c8e5fd4.pdf

FAO Committee on Fisheries (2009) Report of the fourth session of the Sub-Committee on Aquaculture. Puerto Varas, Chile, 6–10 October 2008. FAO Fisheries and Aquaculture Report No. 891. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/tempref/docrep/fao/011/i0615t/i0615t00.pdf

FAO Committee on Fisheries (2010) Report of the fifth session of the Sub-Committee on Aquaculture. Phuket, Thailand, 27 September to 1 October 2010. FAO Fisheries and Aquaculture Report. No. 950. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/013/k9426t/k9426t00.pdf

FAO Committee on Fisheries (2012) Report of the sixth session of the Sub-Committee on Aquaculture. Cape Town, South Africa, 26–30 March 2012. FAO Fisheries and Aquaculture Report No. 1006. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/016/i2765t/i2765t.pdf

FAO Committee on Fisheries (2014) Report of the seventh session of the Sub-Committee on Aquaculture. St Petersburg,

Russian Federation, 7–11 October 2013. FAO Fisheries and Aquaculture Report No. 1064. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i3647t.pdf

FAO Committee on Fisheries (2015) Report of the eighth session of the Sub-Committee on Aquaculture. Brasilia, Brazil, 5–9 October 2015. FAO Fisheries and Aquaculture Report. No. 1131. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i5191t.pdf

FAO Office of Evaluation (2012) *Evaluation of FAO's Support to the Implementation of the Code of Conduct for Responsible Fisheries*. Final report. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/meeting/026/me173e.pdf

FAO & World Bank (2015) *Aquaculture Zoning, Site Selection and Area Management Under the Ecosystem Approach to Aquaculture*. Policy brief. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/documents/card/en/c/4c777b3a-6afc-4475-bfc2-a51646471b0d/

FAO/NACA/UNEP/WB/WWF (2006) *International Principles for Responsible Shrimp Farming*. Network of Aquaculture Centers in Asia-Pacific (NACA), Bangkok.

FEAP (2008) *Code of Conduct for European Aquaculture*. Federation of European Aquaculture Producers, Liège.

Folke C (2006) Resilience: the emergence of a perspective for social–ecological systems analyses. *Global Environmental Change* **16**: 253–267.

Folke C, Carpenter SR, Walker B, Scheffer M, Chapin T, Rockström J (2010) Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society* **15** (4): 20. [Cited 24 January 2018.] Available from URL: http://www.ecologyandsociety.org/vol15/iss4/art20/

Froehlich HE, Gentry RR, Rust MB, Grimm D, Halpern BS (2017) Public perceptions of aquaculture: evaluating spatiotemporal patterns of sentiment around the world. *PLoS ONE* **12**(1): e0169281.

Garcia SM, Zerbi A, Aliaume C, Do Chi T, Lasserre G (2003) The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook. FAO Fisheries Technical Paper No. 443. FAO Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/006/Y4773E/Y4773E00.HTM

GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) (1996) The contributions of science to coastal zone management. GESAMP Reports and Studies No. 61. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/contents/dc824e26-b1b7-568d-8770-1f9347ecb063/W1639E00.HTM

GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) (2001) Planning and management for sustainable coastal aquaculture development. GESAMP Reports and Studies No. 68. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/005/y1818e/y1818e00.htm

GFCM (2012) Resolution GFCM/36/2012/1 on guidelines on allocated zones for aquaculture (AZA). General Commission for the Mediterranean. [Cited 24 January 2018.] Available from URL: http://bit.ly/Resolution-GFCM-36-2012-1

Godfray HCJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF *et al.* (2010) Food security: the challenge of feeding 9 billion people. *Science* **327**: 812–818.

Gumy A, Soto D, Morales R (2014) Implementación práctica del enfoque ecosistémico a la pesca y la acuicultura del camarón en los países del sistema de integración centroamericana (SICA/OSPESCA) Taller FAO/OSPESCA, San Salvador, El Salvador, 18 al 21 de junio de 2012. FAO Actas de Pesca y Acuicultura No. 33. FAO, Rome. [Cited 24 January 2018.] Available from URL: www.fao.org/documents/card/es/c/0e1e24d3-5644-4475-8e25-6098cf470a9f

Hambrey J (2017) The 2030 Agenda and the SDGs: the challenge for aquaculture development and management. FAO Fisheries and Aquaculture Circular No. 1141. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i7808e.pdf

Haroun R, de Courtois Viçose G, Kaushik S (2016) Fostering expertise in sustainable aquaculture. Impact open access and free science reports. EU FP7 EcoAqua Project. [Cited 24 January 2018.] Available from URL: http://ecoaqua.ulpgc.es/sites/default/files/documentos/news/impact_article.pdf.

Hishamunda N, Ridler N, Martone E (2014) Policy and governance in aquaculture: lessons learned and way forward. FAO Fisheries and Aquaculture Technical Paper No. 577. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i3156e.pdf

Hosch G (2009) Analysis of the implementation and impact of the FAO Code of Conduct for Responsible Fisheries since 1995. FAO Fisheries and Aquaculture Circular No. 1038. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/tempref/docrep/fao/011/i0604e/i0604e00.pdf

IWICM (The International Workshop on Integrated Coastal Management in Tropical Developing Countries: Lessons Learned from Successes and Failures) (1996) Enhancing the success of integrated coastal management: good practices in the formulation, design and implementation of integrated coastal management initiatives. MPP-EAS Technical Report No. 32 pp. GEF/UNDP/IMP Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas and the Coastal Management Center, Quezon City, Philippines. [Cited 24 January 2018.] Available from URL: http://repository.wwf.org.my/conference/EnhancingTheSuccessofIntegratedCoastalManagement.pdf

Karttunen K, Wolf J, Garcia C, Meybeck A (2017) *Addressing Agriculture, Forestry and Fisheries in National Adaptation Plans (Supplementary Guidelines)*. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i6714e.pdf

Kasozi N, Opie H, Iwe G, Enima C, Nkambo M, Turyashemererwa M *et al.* (2016) Site suitability assessment of selected bays along the Albert Nile for cage aquaculture in West Nile

region of Uganda. *International Journal of Fisheries and Aquaculture* **8**(9): 87–93.

Levac D, Colquhoun H, O'Brien KK (2010) Scoping studies: advancing the methodology. *Implementation Science* **5**: 69.

Long RD, Charles A, Stephenson RL (2015) Key principles of marine ecosystem-based management. *Marine Policy* **57**: 3–60.

Long RD, Charles A, Stephenson RL (2017) Key principles of ecosystem-based management: the fishermen's perspective. *Fish and Fisheries* **18**: 244–253.

M4P (2008) *Making Value Chains Work Better for the Poor: A Toolbook for Practitioners of Value Chain Analysis, Version 3*. Making markets work better for the poor (M4P) Project, UK Department for International Development (DFID). Agricultural Development International, Phnom Penh.

MA (2005) *Ecosystems and Human Well-Being: Synthesis. Millennium Ecosystem Assessment*. Island Press, Washington, DC. [Cited 24 January 2018.] Available from URL: http://www.millenniumassessment.org/documents/document.356.aspx.pdf

Mannini P, Beveridge M, Curtis L (2010) Adapting to climate change: the ecosystem approach to fisheries and aquaculture in the Near East and North Africa Region. FAO Aquaculture Newsletter No. 45, pp. 14–15. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/012/al363e/al363e08.pdf

Miao W, Mohan CV, Ellis W, Brian D, eds (2013) *Adoption of Aquaculture Assessment Tools for Improving the Planning and Management of Aquaculture in Asia and the Pacific*. RAP Publication 2013/11. FAO Regional Office for Asia and the Pacific, Bangkok.

Ostrom E (2005) *Understanding Institutional Diversity*. Princeton University Press, Princeton, NJ.

Ostrom E (2011) Background on the institutional analysis and development framework. *Policy Studies Journal* **39**(1): 7–27.

Patil PG, Virdin J, Diez SM, Roberts J, Singh A (2016) Toward a blue economy: a promise for sustainable growth in the Caribbean. Main report. World Bank, Washington, DC. [Cited 24 January 2018.] Available from URL: http://documents.worldbank.org/curated/en/965641473449861013/main-report

Ross LG, Telfer TC, Falconer L, Soto D, Aguilar-Manjarrez J, eds. (2013) Site selection and carrying capacities for inland and coastal aquaculture. FAO/Institute of Aquaculture, University of Stirling, Expert Workshop, 6–8 December 2010. Stirling, the United Kingdom of Great Britain and Northern Ireland. FAO Fisheries and Aquaculture Proceedings No. 21. FAO, Rome. Includes a CD–ROM containing the full document (282 pp.). [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i3322e.pdf

Saenger P, Gartside D, Funge-Smith S (2013) A review of mangrove and seagrass ecosystems and their linkage to fisheries and fisheries management. RAP Publication 2013/09. FAO Regional Office for Asia and the Pacific, Bangkok. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/018/i3355e/i3355e.pdf

Sanchez-Jerez P, Karakassis I, Massa F, Fezzardi D, Aguilar-Manjarrez J, Soto D *et al.* (2016) Aquaculture's struggle for space: the need for coastal spatial planning and the potential benefits of allocated zones for aquaculture (AZAs) to avoid conflict and promote sustainability. *Aquaculture Environment Interactions*, **8**: 41–54. [Cited 24 January 2018.] Available from URL: www.int-res.com/articles/aei2016/8/q008p041.pdf

Santos CF, Agardy T, Andrade F, Barange M, Crowder LB, Ehler CN *et al.* (2016) Ocean planning in a changing climate. *Nature Geoscience* **9**: 730.

Scialabba N, ed. (1998) Integrated coastal area management and agriculture, forestry and fisheries. FAO Guidelines. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/docrep/W8440e/W8440e00.htm#TopOfPage

Seafish (2017) UK Submission of the FAO Code of Responsible Fisheries (CCRF) Aquaculture Questionnaire 2017. Seafish [online] Scotland, United Kingdom of Great Britain and Northern Ireland. [Cited 24 January 2018.] Available from URL: http://www.seafish.org/media/1685298/seafish_version_-_uk_fao_ccrf_aquaculture_questionnaire_2017_-_final.pdf

Soto D, Aguilar-Manjarrez J (2009) FAO Expert Workshop on "Guidelines for the implementation of an ecosystem approach to aquaculture (EAA)". *FAO Aquaculture Newsletter* **42**, pp. 8–9. FAO, Rome.

Soto D, Bianchi G (2014) Capacity development for implementation of an ecosystem approach to fisheries and aquaculture in member countries focusing on aquaculture fisheries interactions. Policy Brief. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/tempref/FI/brochure/Fisheries-flyer-Ecosystem_approach-WEB.pdf

Soto D, Aguilar-Manjarrez J, Hishamunda N, eds. (2008) Building an ecosystem approach to aquaculture. FAO/Universitat de les Illes Balears Expert Workshop. 7–11 May 2007, Palma de Mallorca, Spain. FAO Fisheries and Aquaculture Proceedings. No. 14. FAO, Rome. [Cited 24 January 2018.] Available from URL: http://www.fao.org/3/a-i0339e.pdf

Soto D, White P, Yucel G (2009) TCP/TUR/3101: Developing a roadmap for Turkish marine aquaculture site selection and zoning using an ecosystem approach to management. FAO Aquaculture Newsletter 43, pp. 8–9. FAO, Rome.

Soto D, Bianchi G, Aguilar-Manjarrez J (2012a) Implementing the ecosystem approach to fisheries and aquaculture: a case study in the Estero Real, Nicaragua. FAO Aquaculture Newsletter 49, pp. 10–11. FAO, Rome.

Soto D, White P, Dempster T, De Silva S, Flores A, Karakassis Y *et al.* (2012b) Addressing aquaculture-fisheries interactions through the implementation of the ecosystem approach to aquaculture (EAA). In: Subasinghe RP, Arthur JR, Bartley DM, De Silva SS, Halwart M, Hishamunda N, Mohan CV, Sorgeloos, P . (eds.) *Farming the Waters for People and Food*. Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand. 22–25 September 2010. pp. 385–436. FAO, Rome and NACA, Bangkok. [Cited 24 January 2018.] Available from URL. http://www.fao.org/docrep/015/i2734e/i2734e00.htm

Stobberup K, Garza Gil MD, Stirnemann-Relot A, Rigaud A, Franceschelli N, Blomeyer R (2017) Research for PECH Committee – small-scale fisheries and "blue growth" in the EU. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels. [Cited 24 January 2018.] Available from URL: http://www.europarl.europa.eu/RegData/etudes/STUD/2017/573450/IPOL_STU(2017)573450_EN.pdf

UN (1992) United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3–14 June 1992. Agenda 21. United Nations, Washington DC. [Cited 24 January 2018.] Available from URL: https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf

UN (2015) Transforming our world: the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015. A/RES/70/1. [Cited 24 January 2018.] Available from URL: www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

UNDP (2016) *Human Development Report 2016: Human Development for Everyone (web Version)*. UNDP, Geneva. [Cited 24 January 2018.] Available from URL: http://hdr.undp.org/sites/default/files/HDR2016_EN_Overview_Web.pdf

UNEP (2000) Report of the Fifth Meeting of the Conference of the Parties to the Convention on Biological Diversity. UNEP/CBD/COP/5/23. Decision V/6, pp. 103–106. United Nations Environment Programme, Geneva.

World Bank (2017) Helping countries navigate a volatile environment. Webpage (24 January 2018.). World Bank Group, Washington, DC. http://www.worldbank.org/en/topic/fragilityconflictviolence/overview.

Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article:

Table S1. Mentions of, and references to, the 'ecosystem approach to aquaculture' (strictly) or to FAO's 'EAA' in the work and publications of selected international and regional players in fisheries and aquaculture.

Table S2. List of FAO EAA-related workshop reports.

Table S3. List of FAO activities promoting the EAA (projects, training and conferences) over the period 2007–2016.

Table S4. Summary of FAO member countries' reporting of the implementation of the CCRF provisions related to aquaculture and the EAA over the period 2010–2017, based on their answers to the CCRF questionnaire circulated to them biannually.

Table S5. Results for the systematic citation search of Soto *et al.* (2008) in the academic literature over the period 2007–2016, in support of Fig. 1b.

Table S6. Results for the systematic citation search of the 'ecosystem approach to aquaculture' in the literature over the period 2007–2016, in support of Fig. 2a,b.

Table S7. List of FAO materials on FAO's Blue Growth Initiative.