



# Assessment of a fisheries legal framework for potential development of an ecosystem approach to fisheries management in large rivers

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**Abstract** Most small-scale fisheries of large floodplain rivers are still managed under conventional top-down regulations that limit the application of an ecosystem approach to fisheries (EAF) due to inappropriate legal frameworks. Using the Parana–Paraguay River fisheries (Argentina) as an example, this study examines the extent to which existing provincial legislations can be prepared for the adoption of an EAF. An Ecosystem Fishing Legal Approach (EFLA) framework is proposed based on different criteria across an environmental–ecological, fishing, social, economic and institutional template. Policy Component Scores (PCS) and an Integrated Policy Legal Index (IPLI) were applied to assess the degree of compliance by current provincial legislations to EAF implementation. Cluster analysis was used to recognise the potential for articulating a legal framework at a basin scale. The EFLA framework, which provided an accurate picture of how provinces were poorly prepared to adopt an EAF for the Paraguay–Parana fisheries, and represents a suitable tool that can be adapted and extended to other basins around the world.

**KEY WORDS:** Argentina, large floodplain rivers, Parana River, small-scale fisheries.

## Introduction

Large floodplain river fisheries are mostly small scale and play a critical role in providing food, livelihoods, food security and poverty alleviation (Béné *et al.* 2007). They represent complex socio-ecological systems (Berkes *et al.* 2001; Janssen *et al.* 2007; McClanahan *et al.* 2009) in which the human component is called upon to play a critical role (De Young *et al.* 2008).

In South America, the largest fluvial continent in the world, deterioration of floodplains, agricultural and cattle development, fishing pressure, water diversion, pollution and particularly damming are challenges to the maintenance of fisheries in a sustainable state (Barletta *et al.* 2010). Conflicts in freshwater fisheries are commonplace, as there are different objectives and priorities among user groups even in the same fishery or basin (Welcomme 2016). Most fluvial fisheries still exhibit

low management performance or are still managed under a conventional approach. This approach assumes centralised management agencies, with enforcement of top-down regulations at species or stock level, which are focused on limiting mesh size, minimum length of catch, closed seasons or places and access. This top-down approach, however, is not effective in maintaining small-scale fisheries at sustainable levels on a long-term basis due to its rigid application, and has been blamed for the deterioration of subsistence fisheries in many South American large rivers (e.g. Petrere *et al.* 2004; Soria & Rodríguez 2008; Baigún *et al.* 2013). Legal measures should go beyond fisheries norms and incorporate social, economic, ecological and institutional criteria. An enhanced vision should consider social equity and the improvement of living standards for the most vulnerable stakeholders (Witbooi 2006; Soria & Rodríguez 2008; Khalilian *et al.* 2010; Sowman *et al.* 2014).

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The need to ensure artisanal fluvial fisheries sustainability as a valuable aspect of livelihoods is challenging managers to adopt an ecosystem-oriented perspective (Barletta *et al.* 2010, 2016). Recently, the ecosystem approach to fisheries (EAF) has been proposed as a new way to overcome limitations of conventional management that focus solely on the fishing and biological aspects of the system (FAO 2003, 2009; Garcia *et al.* 2003). Central to the EAF concept is the need to consider the human component, the use of environmental resources and the conservation of biodiversity, habitats and ecological processes (Charles 2001; De Young *et al.* 2008). EAF also strives to balance a diversity of objectives with the planning, development and management of fisheries, in a manner that addresses the multiple needs and desires of societies benefiting from the full range of goods and services provided by ecosystems (FAO 2003, 2009; Garcia *et al.* 2003; Garcia & Cochrane 2005). Therefore, this approach takes a broader perspective by considering the interactions between fisheries and ecosystems, encompassing the socio-economic environment, the related stakeholders and the institutional framework (De Young *et al.* 2008).

The application of EAF to fresh waters, particularly large river systems, remains poorly understood and is barely developed. The main constraints to its use frequently derive from the lack of an appropriate legal framework (Baigún *et al.* 2016; Barletta *et al.* 2016). Management policies should be adaptive or flexible to adopt new paradigms, such as a multidimensional perspective to envision fishery resources as ecosystem services (Baigún *et al.* 2016), which in turn should be managed using an ecosystem-based perspective. The Parana Basin (Argentina) is a well-known case, with well-developed recreational and artisanal fisheries (Barletta *et al.* 2010), but a conventional management approach has encouraged an intensive fishery for export based on sabalo, *Prochilodus lineatus* (Val.), since 2000. This management goal promoted conflicts with recreational anglers, local artisanal fishers and other stakeholders due to uncontrolled fishing pressure observed in 2004 and 2005, when the resources became severely overexploited (Baigún *et al.* 2008, 2013). Moreover, the authorisation for an intensive fishery for export ignored the key ecological role of this species in recycling nutrients and organic matter (Quirós & Baigún 1985; Taylor *et al.* 2006; Winemiller *et al.* 2006), demonstrating that decisions, management measures and information in large river systems should consider attributes other than catch-effort data and financial profit. Management problems related to transboundary migratory target species are also common in rivers of South America (e.g. Delfino & Baigún 1985; Petrere 1985; Ruffino & Barthem

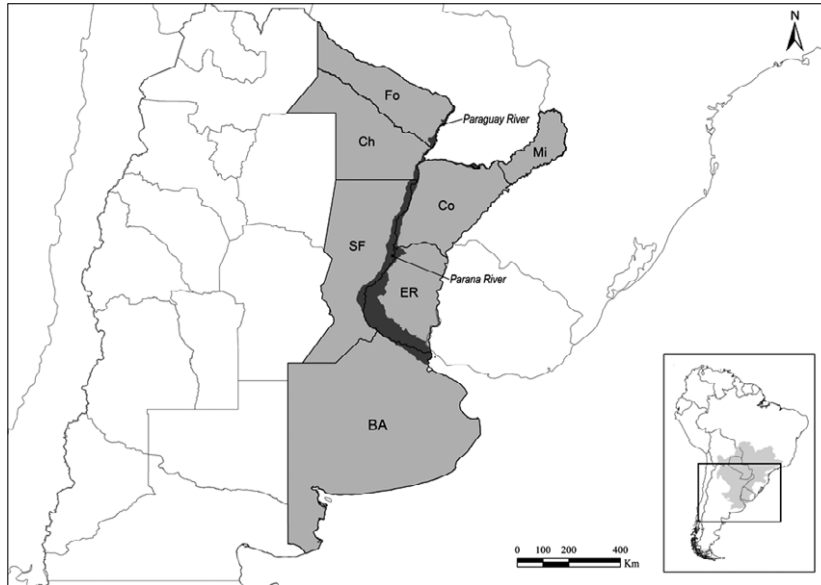
1996; Barthem & Goulding 1997; Valbo-Jørgensen *et al.* 2002; Carolsfeld *et al.* 2004; Petrere *et al.* 2004; Quirós 2004) and Asia (Warren *et al.* 1998; Baird *et al.* 2001; Baran *et al.* 2007), particularly when fishing regulations are not fully articulated along the basins or rivers. This can severely affect fish life cycles, as was observed in the upper Parana River (e.g. Agostinho *et al.* 2007; Baigún *et al.* 2007; Oldani *et al.* 2007). These scenarios show why legal frameworks under conventional management approaches are unable to cope with the complexity of small-scale fisheries of large rivers. In this context, the identification of needs, gaps and weaknesses of legal norms becomes a critical first step to progress towards an EAF management perspective.

This study presents an approach to assessing the extent to which an existing legal framework of a large river is ready for the adoption of EAF. It is based on the assumption that the status and long-term sustainability of fluvial fisheries are closely related to the compliance with ecosystem-based criteria and with their inclusion in the fishing legal framework. The Parana–Paraguay River fisheries in Argentina (Fig. 1) is used as a study case as the provinces sharing the basin have autonomy and decision-making capacity over the resource management of their own river sections, and therefore can be comparable from a management policy perspective. Lessons learned can be extended or expanded to any transboundary basins where resource management and fisheries sustainability are threatened.

## Methods

A five-step approach – the Ecosystem Fisheries Legal Assessment (EFLA) framework – was developed to assess the degree of compliance of fishing regulations with EAF.

The first step compiles and analyses current fishing regulations from government agencies and official web pages belonging to provinces located in the study area. Secondly, a template assesses the compliance of each fishing regulation administrative unit (province) to EAF. This template addresses social, economic, environmental–ecological and institutional policy components, which in turn include different criteria representing measures, activities or actions that are considered compatible with EAF. The social component encompasses criteria related to fishers' social capital, needs, demands and rights. The economic component refers to criteria related to available mechanisms for improving fishers' economic well-being and resilience. The environmental–ecological component contains issues associated with habitat and species conservation. The fishing component includes concepts



**Figure 1.** Location of Parana-Paraguay basin provinces (Argentina) involved in the study (light grey area; Fo: Formosa, Ch: Chaco, Co: Corrientes, Mi: Misiones, SF: Santa Fe, ER: Entre Ríos, BA: Buenos Aires) and river areas related to artisanal fishing activity (dark grey area). Source: Authors.

related to good fishing practices and sustainable management policies. The institutional component is associated with measures, legal norms (official laws, decrees, resolutions and dispositions) and the presence of management agencies that influence fisheries functioning and governance processes.

In the third step, each province is assessed by evaluating each legal norm against the EAF template criteria. For each criterion, a value of 1 is assigned if there was at least one legal norm complying with, even partially, and 0 if there was none.

The fourth step, the EAF template of each province, is summarised by Policy Component Scores (PCS) and an Integrated Policy Legal Index (IPLI). PCS depict the degree of compliance by component (social, economic, environmental–ecological and institutional). For each province, PCS are calculated for each  $j$  component as:

$$PCS_j = \frac{1}{n} \sum X_i$$

where  $X$  corresponds to the value (0 or 1) that each  $i$  criterion adopts for the given component and  $n$  is the total number of criteria.  $PCS_j$  is 0 when no norms are found to meet any criteria and 1 when all criteria were partially or completely covered by the legal norms under analysis. For example, if 13 criteria are included in the environmental–ecological component of a given province, and only 7 were met, its corresponding environmental–ecological PCS value is 0.54.

Integrated Policy Legal Index assesses the overall preparedness for ecosystem-based management and is calculated as the average of PCS values:

$$IPLI = \frac{1}{k} \sum PCS_j$$

where  $PCS_j$  is the PCS of the  $j$  component and  $k$  represents the total number of components.

Finally, a fifth step is included to compare administrative units. A hierarchical cluster analysis based on PCS values is performed to summarise the similarity among provincial regulations, using Euclidean distance and unweighted pair-group average linkage.

## Results

A total of 457 legal norms were compiled for the Parana–Paraguay River in Argentina, including provincial laws, decrees, resolutions and dispositions currently in force. The template required to portray the general legal framework for implementing an EAF in large rivers included 62 criteria defined across environmental–ecological, fishing, social, economic and institutional components (Table 1). In the case of the Parana–Paraguay River, different degrees of compliance were observed in terms of individual criteria and by component (Table 2). Only four of the 62 criteria, all belonging to the fishing component showed all scores of 1. Criteria showing all 0s were 51%, with the highest number of all 0 cases in the economic (78%) and social (67%) components.

**Table 1.** Components and criteria template applicable to support a legal framework based on an Ecosystem Approach to Fisheries

<i>Fishing</i>	
1	Measures that regulate the use of inappropriate practices and fishing gears not compatible with resource conservation and responsible fishing
2	Management measures that ensure compatibility and development of subsistence, artisanal and sport–recreational fishing
3	Measures that avoid the catch of juvenile fish of target species
4	Measures that promote minimum catch sizes based on $L_{100}$ criteria or higher when overfishing evidences are detected
5	Measures that regulate maximum catch sizes to preserve old and very large individuals
6	Measures that control the use of selective gears based on mesh size, net length, net materials, hanging coefficient, etc.
7	Corrective measures to eliminate the excessive fishing effort
8	Measures that regulate the capture of bait and ornamental species
9	Mechanisms to ensure periodic collection of fishing statistical data
10	Mechanisms that ensure collection of social and economic information
11	Mechanisms that involve fishers' participation into the collection of fishery information
12	Application of precautionary measures based on preset reference levels for different fishery parameters
13	Application of precautionary measures on resources exploitation based on new methods of fishing and/or catch
14	Development of participative and adaptive fisheries management plans
15	Measures that regulate fishing effort and catch based on hydrological regime and climatic factors
<i>Environmental–Ecological</i>	
16	Measures that protect and preserve floodplains and their free connectivity and minimise river fragmentation at longitudinal and lateral dimensions
17	Measures that maintain natural hydrological cycle including dry and wet pulses
18	Measures that preserve critical habitats for migration, reproduction, growth, feeding, etc., of fish species with ecological and socio-economic relevance
19	Application of environmental impact studies (EIS) before the building of infrastructure works in rivers, lakes and wetlands
20	Mention of the precautionary approach related to measures that can promote severe environmental impacts
21	Measures that reduce to a minimum pollution, wastes and discards related to fishing activities
22	Measures that implement the creation of protected fishing areas with different categorisation and management policies
23	Development of research and decision-making policies that relate environmental trends and climate changes with fish resources management
24	Measures that preserve biodiversity and protect endangered fish species or with special categorisation
25	Measures to recover or to re-establish overfished, reduced or depleted species inhabiting the fishing areas
26	Regulations about fish culture and exotic species introduction
27	Measures for the conservation of fish assemblages structure in fishing areas
28	Measures that protect species of ecological and conservation relevance (bioengineering, key species, highly endemic)
<i>Institutional</i>	
29	Measures that ensure the creation and effective functioning of advisory fisher councils composed by the main stakeholders involved in the fishery
30	Existence of specific government agencies to regulate and manage fisheries at provincial/state/national levels
31	Mechanisms that ensure the provision of human, logistic and economic resources to guarantee the correct functioning of management agencies
32	Measures that promote the development of local institutions to improve the governance processes and to contribute in a more efficient fishery management
33	Existence of suitable mechanisms and best practices for solving disputes based on environmental and man-made impacts affecting fishing rights and fisher livelihoods
34	Measures that promote interinstitutional relationships among different agencies related to management and governance of fisheries at different levels
35	Articulation of regulatory measures and management of fish stocks among provinces, neighbouring states or basin countries in order to ensure the sustainable use of transboundary migratory resources
36	Mechanisms that ensure free access to general and specific fishery regulatory norms
37	Existence of advisory mechanisms to guarantee public participation in decision-making processes, law and management policy development
38	Measures that take allow implementing exclusive fishing rights on the resources when is needed or appropriate
39	Mechanisms that ensure access to the fishing areas for native and local communities
40	Measures that regulate the use of landing ports for commercial and artisanal fishing
41	Mechanisms that support community land and fisheries tenure, resource access and use rights
<i>Economic</i>	
42	Measures that allow fundraising to support the artisanal fishing sector
43	Administrative measures that ensure an economically viable exploitation for artisanal fisheries
44	Measures to promote regional economies related to fishing activities

(continued)

**Table 1.** (continued)

45	Measures to facilitate the access to soft loans for the development of activities related to artisanal fishing and/or aquaculture
46	Measures to guarantee fair trade of fishing products in order to assure the equitable sharing of benefits between fishers and others stakeholders
47	Measures to promote added value and strategies to optimise the use of fishing products
48	Measures to raise funds for assistance, diversification and fishers reconversion when fishery became unsustainable
49	Application of precautionary measures based on preset reference levels for different economic parameters
50	Funding and financial incentive mechanisms for environmental protection, including compensation and payment for ecosystem services
<i>Social</i>	
51	Measures to guarantee food security for fishers with scarce or no alternative resources
52	Measures that guarantee the use of traditional gears, fishing boats compatible with local fishing practices and the provision of fishing licences
53	Measures to obtain and apply fishers' ecological knowledge and traditional fishing technologies in resources management
54	Measures that take into account fishers' interests and demands, including those who are involved in subsistence, artisanal and small-scale commercial fishing practices
55	Mechanisms to solve conflicts related to the fishery management and governance processes
56	Measures to promote training of fishers in technical aspects related to fish handling, processing and conservation
57	Measures to support and preserve knowledge, culture, traditions and practices of native people and local communities
58	Measures that guarantee appropriate health and hygienic standards in landings, fish commercialisation and processing sites
59	Measures that establish controls that verify levels of harmful substances in fish for human consumption
60	Application of precautionary measures based on preset reference levels for different social parameters
61	Measures to promote gender equity and to ensure women participation in different programs for resources management and adaptation to impacts from external fisheries agents
62	Measures that guarantee special rights to vulnerable people including women, children, ethnic minority groups and native people in case of environmental impacts, climatic hazards, and loss of fishing grounds and fishing areas access

When components were compared among provinces (Fig. 2) the largest PCS value corresponded to the fishing component, environmental–ecological, was in second place, whereas the lowest was equally shared by the social, economic and institutional components. Santa Fe exhibited the highest scores for the fishing and environmental–ecological criteria, while values for social, economic and institutional components were almost negligible for all provinces. The average IPLI for all provinces was 0.23, ranging from 0.15 (Buenos Aires) to 0.40 (Santa Fe). The cluster analysis based on PCS values highlighted the differences among province legislations (Fig. 3). Formosa, Entre Ríos, Misiones and Chaco formed a compact group with higher similarity, closely related to Corrientes, with Buenos Aires in the same branch but more separated. Santa Fe appeared as an isolated element.

## Discussion

This study addressed a novel approach to assess whether a legal fishing framework is ready to shift from a conventional approach to an EAF one. Despite the abundance of legal norms in the study area (more than 400), PCS and IPLI values showed that the current policy frameworks in the basin are not yet suited for EAF. Template analysis based on criteria fulfilment demonstrated that provincial legislation is focused primarily on fishing characteristics, whereas ecological–environmental issues are only minor concerns. Most provinces

exhibited the typical norms related to minimum catch sizes, bans on catching juvenile fish, use of selective gears and establishment of time closures, although with different systems depending on river segment. Fishing norms considered the development of different fishing activities (commercial, recreational, scientific), the creation of protected areas, which allowed recreational but no commercial fisheries, and the regulation of the fish culture and the introduction of exotic species. Although environmental norms have been addressed by several provinces, they are not oriented to maintain the critical ecological processes that govern fish production.

Large number of 0s were simultaneously found for all provinces, indicating strong component weaknesses, exacerbated in the case of economic and social components. For instance, no norms were found relating to key issues such as fishers' participation (except for Santa Fe Province) or a precautionary approach defined by reference levels or threshold values. The use of fishers' ecological knowledge and adaptive management plans were also absent in all legal frameworks. Besides, Santa Fe was the only province that includes funding provision for fishers' assistance and guild reconversion, a functional fisheries council involving diverse stakeholders, dedicated fisheries management agencies that ensure the provision of resources to guarantee the correct functioning of management and advisory mechanisms to guarantee public participation in decision-making processes. Its legislation also presented regulations for species of ecological and conservation relevance.

**Table 2.** Compliance with required criteria under a legal framework for the implementation of an Ecosystem Approach to Fisheries in each province. (1: partial or total fulfilment, 0: non-compliance)

Criteria*	Misiones	Formosa	Corrientes	Chaco	Santa Fe	Entre Ríos	Buenos Aires
1	1	1	1	1	1	1	1
2	0	0	0	0	0	0	0
3	1	1	1	1	1	1	1
4	0	0	0	0	0	0	0
5	0	0	1	0	0	0	0
6	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1
8	0	1	0	1	1	0	0
9	0	1	0	1	1	1	0
10	0	0	0	0	1	1	0
11	0	0	0	0	0	0	0
12	0	1	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
18	1	1	1	1	1	0	0
19	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
21	1	1	1	1	0	1	0
22	1	0	1	1	1	1	0
23	0	0	0	0	0	0	0
24	0	0	1	1	1	1	0
25	0	0	0	0	1	0	1
26	1	1	1	1	1	1	0
27	0	0	0	0	1	1	0
28	0	0	0	0	1	0	0
29	0	0	0	0	1	1	0
30	0	0	0	0	1	0	1
31	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0
34	0	0	0	0	1	0	1
35	1	1	1	1	1	1	0
36	0	0	1	1	1	0	0
37	0	0	0	0	1	0	0
38	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0
40	1	0	0	1	1	1	0
41	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0
44	0	0	0	0	0	1	0
45	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0
48	0	0	0	0	1	0	0
49	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0
51	1	1	0	1	1	1	0
52	1	1	1	1	1	1	1
53	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0

(continued)

**Table 2.** (continued)

Criteria*	Misiones	Formosa	Corrientes	Chaco	Santa Fe	Entre Ríos	Buenos Aires
55	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0
58	1	1	0	0	1	1	1
59	0	0	0	0	0	0	1
60	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0
TOTAL	13	14	13	16	25	18	10

\*See Table 1 for criteria description.

Higher IPLI values in Santa Fe represented a better potential for promoting an EAF management strategy but also indicated recent improved conditions. Instead, Buenos Aires showed the lowest scores in most components. This was not surprising as the low IPLI performance can be attributed to its fisheries legislation, which is historically oriented to marine, estuarial and shallow lakes. This has promoted recurrent conflicts between fishers and authorities in the Parana River sector located in the province, while norms have remained unclear and unspecific. Policy limitations were also well reflected by the very low PCS corresponding to economic and social components.

The IPLI values were below 0.5 for all provinces, suggesting that not even one province can readily switch to ecosystem-based fisheries management without modifying and improving their legal fishing norms. In turn, the cluster analysis highlighted differences between provinces, splitting Santa Fe and Buenos Aires from the rest. Such results confirmed that fishing norms do not provide what it is needed to foster an ecosystem-based management approach, but also showed that they are not fully compatible for articulating common management policies at a basin scale.

Although this study focused on the Parana–Paraguay River provinces, the EFLA framework represents a simple but powerful tool to recognise the feasibility of moving towards an EAF implementation in other large floodplain river basins. A main advantage of this framework is its capacity to provide a comparative analysis and to assess the possibilities for developing integrated management policies at different spatial scales. This implies that such an approach is applicable to any type of administrative unit, from provincial or state scale to between countries. As IPLI can range from 0 to 1 (1 being the optimum), it allows easy identification of which provinces, states or countries need to improve

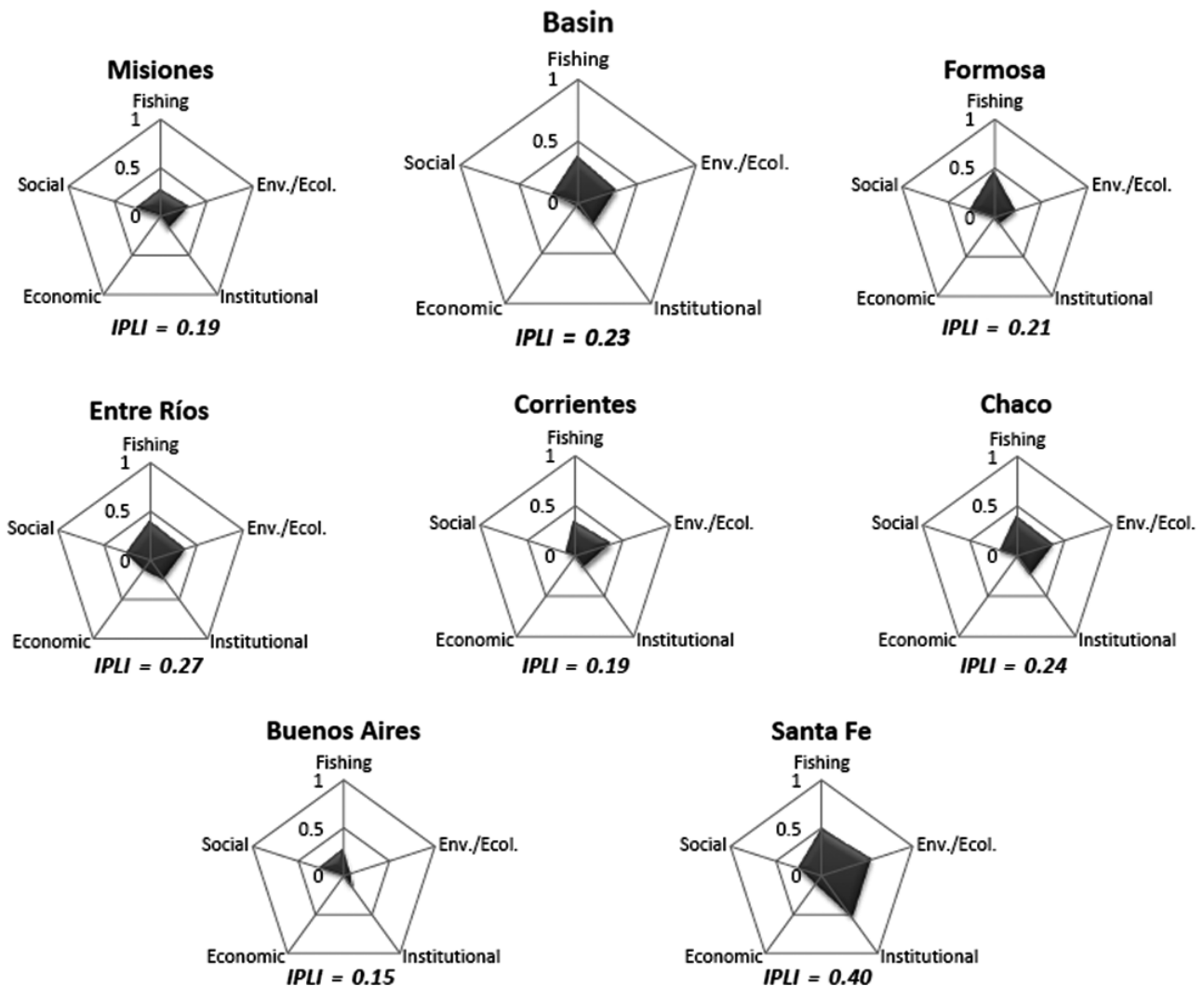
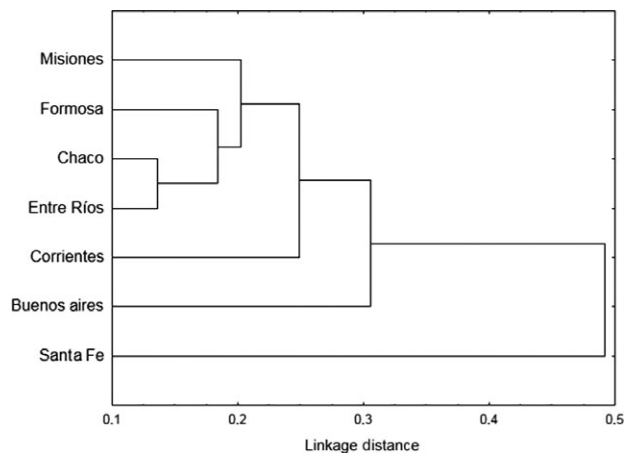


Figure 2. Estimated Policy Component Scores (PCS) and Integrated Policy Legal Index (IPLI) values for the study provinces. Source: Authors.

their legal framework by adding or modifying their norms. Low IPLI values therefore imply that there is ample room for improving the existing legal framework. On the other hand, IPLI can be enhanced by weighting the PCS according to their relative relevance across different basin sectors or management objectives. For example, in isolated sectors of the Parana Basin, the institutional and economic components could have lower importance than environmental and social ones.

Finally, an advantage of EFLA as applied to large rivers is that it helps in seeing fluvial fisheries as a multidimensional perspective shaped by cultural, social, economic and ecological processes that act at different spatial and temporal scales. The EFLA application can benefit managers to gain insight into the several main components required to support an EAF-oriented vision. This is an important property, as the implementation of EAF can fail

if criteria are not properly specified (Garcia *et al.* 2003). In this context, the template criteria raise critical concepts not considered by conventional regulations but which are strongly associated with EAF in small-scale fisheries. The empowerment of fishers, the adoption of precautionary principles and reference values, participatory governance and the recognition of the role of such fisheries in supporting livelihoods and food security for local communities who rely on fishing practices are just some pillars on which to build EAF. Stakeholder participation as a key element for framing an EAF development in small-scale fisheries (Berghöfer *et al.* 2008) is also reflected by different EFLA criteria. Certainly, periodic revision of legislation engaging stakeholders' demands can promote improvements in the EFLA framework, representing a suitable strategy to advance the evolution of fisheries management and help in the process of removing barriers,



**Figure 3.** Cluster analysis based on observed PCS similarity among provinces for each policy component. Source: Authors.

reducing tensions and overcoming conflicts (Murawski 2007). The EFLA also incorporates related mechanisms such as payment for ecosystem services (Bladon *et al.* 2014) and innovative concepts in fisheries management such as responsible governance of fishing tenure and fishing rights (FAO 2012) that also contribute to supporting an ecosystem-based management approach. As the EFLA has the advantage of being flexible, it allows fisheries management to adapt to the evolution and changes in natural, social and economic scenarios.

Ultimately, the understanding and application of the EFLA framework will provide managers with guidelines and opportunities to cope with gaps in social, economic, environmental and institutional legislation that are barely considered by conventional management practices, contributing to a better comprehensive approach to a more holistic policy decision-making perspective in large river basins.

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