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The lack of alternative income sources: The case of ornamental fishing in the Inirida fluvial confluence, Colombian Amazon

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ABSTRACT: In this paper we present a case study of the impoverished ornamental fishing situation in the Inirida Fluvial Confluence (IFC) in Colombia. For this purpose fieldwork was conducted to obtain primary data from fishermen in the zone. The results indicate that effort applied to create different economic activities have no significant impact on the income of fishermen. Community Agreements for Responsible Fishing (CARF) could be an effective policy for management of the resource; nevertheless, their establishment can bring a loss of livelihoods when there are no clear alternative income sources, and may be incompatible with poverty alleviation objectives. Due to this, alternative sources of income should also be promoted in policy-making.

KEYWORDS: Inland fisheries, Natural Resource Management, Rural Development.

La falta de fuentes de ingresos alternativos: el caso de la pesca ornamental en la Estrella Fluvial de Inírida, Amazonas Colombiano

RESUMEN: En este documento se presenta el caso del empobrecimiento de la pesca ornamental en la Estrella Fluvial de Inirida (EFI) en Colombia. Para esto, se realizó un trabajo de campo con el fin de obtener información primaria de los pescadores de la zona. Los resultados indican que el esfuerzo aplicado a diferentes actividades económicas no tiene relación significativa con los ingresos de los pescadores. Los Acuerdos Comunitarios para la Pesca Responsable podrían ser una política efectiva para el manejo del recurso; sin embargo su establecimiento podría ocasionar una pérdida de medios de subsistencia cuando no hay fuentes certeras de ingresos alternativos, lo que puede ser incompatible con la mitigación de la pobreza. Por esto deberían promoverse también las fuentes alternativas de ingresos en la elaboración de política.

PALABRAS CLAVE: Pesquerías continentales, manejo de recursos naturales, desarrollo rural.

JEL classification/Clasificación JEL: Q22, I25, J15.

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1. Introduction

Although the problematic of deterioration affects both marine and inland fisheries, the main efforts for their protection have been focused on the former (Allan *et al.*, 2005).

In the case of small-scale fisheries, this problematic is no doubt complex. On the one hand, some authors state that main reasons for degradation of fishing resource are caused by the open access, common property nature of the fisheries (Hardin, 1968; Pearce, 1982; Copes, 1989), and the seeking of rent-maximizing equilibrium for offsetting opportunity costs and investments (Gordon, 1954). As a consequence, rent dissipation is common and the fishermen fall into a poverty trap caused by competition.

On the other hand, some authors state that degradation of resources in small-scale fisheries is caused by the lack of opportunities for obtaining direct incomes from alternative economic activities (Anderson 1980; Smith 1979; Smith, 1981; Panayatou, 1988; Cunningham, 1993). Particularly in developing countries, small-scale fisheries are usually located in rural remote areas, with very few alternative employment opportunities (Smith, 1979; Panayotou, 1988). Due to this, fishing could be the only economic activity for providing income and food to local populations (Bailey and Jentoft, 1990). In any case, there is a global consensus, that the status of fish stocks is worsening rather than improving and catch weights are declining despite the increase in total fishing effort (FAO, 2014).

In the case of Amazon inland fisheries, Sirén (2006) indicates that these different causes for explaining the resource degradation are not necessarily mutually exclusive and instead may interact with each other. Besides these causes, some other pressures can also be attributed such as the market, new fishing gear, and the destruction of aquatic ecosystems (Smith, 1985; Pinedo and Soria, 2008). Despite the high productivity of Amazonian fisheries, their scarcity periods are more frequent every day (Castro and McGrath, 2010).

This research focuses on the components that define the income of inhabitants of Inirida Fluvial Confluence (IFC) located in the Colombian Amazon. For this purpose, the hypothesis that the population relies on small-scale inland ornamental fishing[1] due to lack of more profitable alternatives is adopted (Smith, 1979). Failure to diversify economic activities to secure their livelihoods is assumed (Vedeld *et al.*, 2012)[2].

For developing this analysis, we test whether alternative livelihood sources generate significant income for local inhabitants and identify whether mechanisms for pro-

[1] According to FAO (2014) ornamental fishing and aquaculture species can be considered as ones captured and kept alive for decorative and pet purpose. Zuluaga and Franco-Jaramillo (2014) based on the United Nations Commodity Trade Statistics Database estimate that the world value of exported decorative fish was USD 142,734,000 million during 2012. According to Ajiaco-Martínez *et al*. (2012), South Asian countries are the main providers with 85 % of the market share, whereas the remaining 15 % is distributed between Brazil, Colombia and Peru.

[2] Particularly Vedeld *et al*. (2012) state that households tend to diversify their sources of income when options outside their main agricultural activities (i.e. fishing) are more profitable.

tecting the resource are found outside the fishing sector by creating alternative or supplementary livelihood sources (Kooiman, *et al.*, 2005; Allison and Horemans 2006).

This research attempts to provide a contribution to the literature regarding the activity of inland ornamental fishing, thus reducing the absence of scientific evidence and generating input for enhancing institutional response in the zone[3]. The remainder of this document contains section 2 where the context of the fishermen population in IFC is explained. Section 3 presents a theoretical model for explaining the behavior of fishermen. Section 4 presents the empirical analysis and findings. Finally, in section 5 some conclusions and final remarks are made.

2. Context of case study

This section presents the population on whom this research is conducted, and for whom it is proposed to apply the Community Agreements for Responsible Fishing[4]. This section provides a broad insight of the social and economic characteristics of the studied communities based on primary sources of information and experiences collected and published by Zuluaga and Franco-Jaramillo (2013) and Zuluaga and Franco-Jaramillo (2014) during their research in these communities. This research was carried out in the indigenous communities of Yuri, Santa Rosa, La Ceiba and Almidon, located in Inirida's rivera, and Playa Blanca located in Atabapo's rivera. These communities belong to the IFC of Orinoco hydrographical basin, and to the municipalities of Inirida in the department of Guainia, and Cumaribo in the department of Vichada. These two departments are located in the northeast Amazon, along the frontier between Colombia and Venezuela.

2.1. Economic activities[5]

According to Agudelo *et al*. (2011), in the Colombian Amazon, 52 % of the regional production of fish is based on small-scale artisanal fishing. On the one hand, 335 of captured species are considered ornamental, and represent 50 % of this commodity exported from Colombia (Ramírez-Gil and Ajiaco-Martínez, 2001)[6]. During 2005, royalties from the exportation of these species were estimated at around USD $7,000,000 (INCODER, 2008; in Mancera-Rodríguez and Álvarez-León, 2008).

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[3] According to Ajiaco-Martínez *et al.* (2012), for this activity there is an absence of scientific evidence regarding the biology of species and many institutional deficiencies that foster difficulties for controlling and monitoring the users of the resource.

[4] Section 2.2 explains the definition and basis of these Community Agreements for Responsible Fishing.

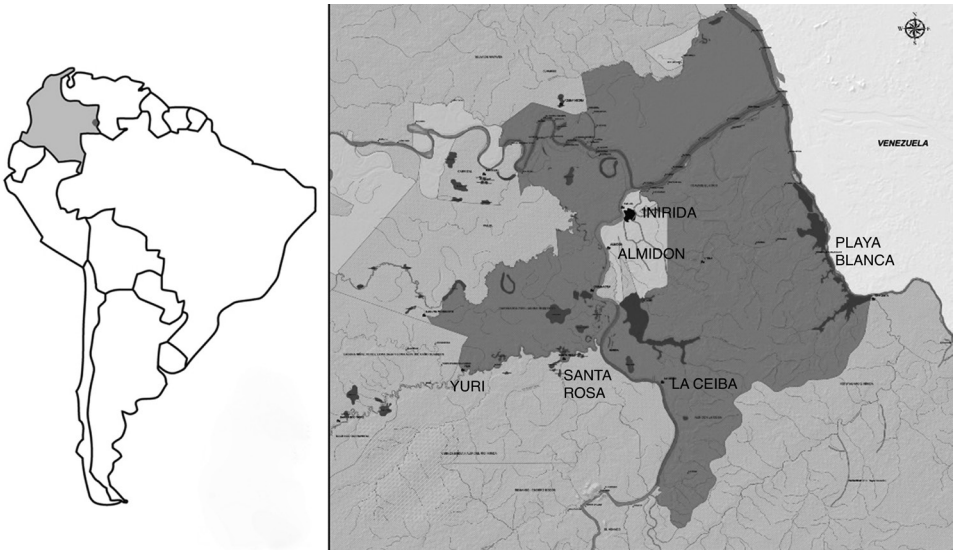
[5] Due to the importance the economical, ecosystem and biodiversity, the IFC has been declared as objective for wetland protection since 2004 (Londoño-Calle, 2012). In July 8, 2014 the IFC was declared Ramsar wetland of international importance. Thus, the IFC becomes the sixth Ramsar site in Colombia and the first in the Orinoco-Amazon region in South America.

[6] Zúñiga (2010; in Zuluaga and Franco-Jaramillo, 2014) argues that 90 % of this resource is harvested directly from their natural stock and are mostly managed by indigenous communities in the Amazon.

However, this practice faces a progressive decrease due to overfishing among other causes (Zuluaga and Franco-Jaramillo, 2014), although users' perception recognizes no such decrease (Ajiaco-Martínez *et al.*, 2012). Moreover, according to local inhabitants and researchers in the zone, the prices of this commodity have remained constant over the past 10 years due to the bargaining power of local buyers. On the other hand, 132 species are destined for local consumption or marketed inside the communities (Lasso *et al.*, 2010).

MAP 1

Inirida Fluvial Confluence



Source: Geographical Institute Agustin Codazzi (2011).

Other economic activities are performed such as small-scale agricultural harvesting of land crops called Conucos; non-timber fiber processing and manufacturing; and gold mining in some communities. The latter activity is poorly documented due to political and environmental problems involved, thus locals recognize it as profitable, but infrequent.

Ramírez-Gil and Ajiaco-Martínez (2001) estimated that there were 194 fishermen in the IFC. For 2010, the World Wildlife Foundation (WWF) estimated an approximate number of fishermen in these communities which has been summarized in Table 1 below:

TABLE 1

Population of fishermen in study zone

Community	Families	Approximate count of fishermen	Distance to Urban Zone (Km)
Almidon	8	16	6.20
Santa Rosa	12	40	25.13
La Ceiba	28	28	26.91
Yurí	83	180	36.04
Playa Blanca*	16	15	-

* The accurate distance of Playa Blanca to urban zone is not available; nevertheless, locals consider this community as the furthest from urban municipality.
Source: WWF Colombia (2010).

2.2. Community Agreements for Responsible Fishing

The creation of the Community Agreements for Responsible Fishing (CARF) has been motivated for controlling the increasing human pressure and market demand for fish, which threatens the biodiversity of the IFC and compromises the local food security, nutrition, and equitable development of the local people. CARFs are based on the model proposed by Conservation International (2007), promoted by the National Authority for Aquaculture and Fisheries (AUNAP for its acronymin Spanish) of the Ministry of Agriculture of Colombia and executed by WWF. They began their formulation in 2012 by identifying different fishing sites, objective species, and socioeconomic implications/effects of the fishery.

In a broad sense, the CARF aims at the regulation of fishing gear and intensity of effort, delimitation of territory and access to fishing areas. Basically a CARF will limit access to prior natural capital for obtaining livelihoods in communities located in IFC. Then, local communities will receive little income, but substantial costs related to resource access restrictions. However, because CARFs are yet not applied there is no clear understanding of their overall impact and how the impacts differ in different contexts, at individual or household levels; i.e. perceiving whether protection is effective by imposing legal constraints rather than offering economic opportunities (Shemweta and Kideghesho, 2000). Therefore, the evaluation of CARF impacts on livelihoods is beyond the scope of this investigation.

There have been relatively few studies that evaluate the impacts of programs aiming at creating protected areas and conservation incentives on livelihoods (Thapa, 2013). Nevertheless, their findings show that they are believed to play an important role in the alleviation of poverty by supplying ecosystem services, developing ecotourism, and providing conservation benefits for social and economic development (Fortin and Gagnon, 1999; Brockington and Igoe, 2006; Ferraro and Hanauer, 2011); However, these benefits have not been found to offset the costs involved by the creation of protected areas (West *et al.*, 2006), and their establishment also brings adverse

effects on neighboring communities mainly through displacement, a reduction in food security, and a loss of livelihoods (Brockington and Schmidt-Soltau, 2004; Cernea and Schmidt-Soltau, 2006)[7].

Therefore, it has been argued that local impacts of establishing resource protection policies can lead to sub-optimal results, especially when faced with a limited set of opportunities for obtaining additional incomes, which should also be targets for governance reform. Due to this, small-scale fisheries management is also about creating opportunities instead of merely solving problems (Kooiman *et al.*, 2005; Allison and Horemans, 2006). In consequence, any agreement should contain governance reform aiming at providing small-scale fishermen with a set of opportunities and capabilities to improve their livelihoods and diversify them in order to utilize their household assets more fully, thus enhancing the possibilities for development (Vedeld *et al.*, 2012).

3. Theoretical framework

3.1. Determination of fishermen's income

This analysis is based on the theoretical model proposed by Anderson (1980) with a slight modification, which does not alter the main conclusions. First, lets assume that all the arguments that define the income of a fisherman are expressed in terms of the income received by ornamental fishing I_O and a supplementary activity I_A, which in the case of IFC are commercial activities such as selling agriculture products, non-timber manufactures, and fish-food marketing.

$$I = I_0 f(L) + I_A f(L) \quad [1]$$

In this model, incomes depend on the effort applied to the activity plus the opportunity that incomes involve, expressed as a psychic return to the activity defined as *worker satisfaction bonus* (*WSB*). Assuming an open-access equilibrium in a two-activity model, the net real income is equal in both industries [2].

$$I_0 + WSB_0 = I_A + WSB_A \quad [2]$$

In this case, there will be no incentive for agents to change activities [2]. Furthermore as Anderson (1980) states, as *WSB* seems to be less variable than monetary incomes, it is probably the latter that drives the fishery to equilibrium. Then, the reason for explaining why fishermen remain in the activity is because fishing provides

[7] A closer experience in La Pedrera, located in the Colombian Amazon shows that conservation agreements applied during 2007 ensured the recovery of the fishing resource during 2009 to 2010 (Mora *et al.*, 2010). Although communities involved in the program experienced a decline in revenue due to the implementation of these agreements (Moreno-Arias and Moreno-Arias, 2010).

a total net income higher than the other activities due to a rent earned from the fish stock [3].

$$I_0 + WSB_0 > I_A + WSB_A \quad [3]$$

In the contrary case, it can be assumed that fisherman will leave the fishing activity and reduce the pressure on the resource [4].

$$I_0 + WSB_0 < I_A + WSB_A \quad [4]$$

As a final remark, Anderson (1980) concludes that optimal management of the fishery can increase net fishing income, but it seems to be based on a confusion of wealth and income effects.

3.2. Sustainable livelihoods and diversification

According to Ellis (2000), livelihood diversification is a phenomenon that characterizes rural household survival strategies. The author argues that livelihood diversification should be considered as an objective for long term policy making for reducing poverty in low income economies, and not as merely a transient phenomenon reflecting disequilibrium in labor markets in the process of development thus ensuring the survival of rural economies and reducing the vulnerability of peoples' livelihoods.

Different motivations for livelihood diversification are seasonality, risk, labor markets, credit markets, asset strategies, and coping behavior (Ellis, 2000). These determinants are mediated through social relations and institutions, and shaped by interactions with the physical environment, and by changes in the economy over time due to liberalization policies. Thereby the role of diversification in reducing the intensity of poverty promotes a process of continuous adaptation for avoiding labor market failures and for attaining a better income distribution in rural economies.

As a conclusion, Ellis (2000) argues that having diverse alternatives income sources can make the difference between sustainable livelihoods and extreme poverty.

4. Empirical analysis

This section presents the analysis of the data collected during August 2014. The information is obtained from 45 male fishermen through a semi-structured survey. This section also presents a brief descriptive analysis of the information and the statistical estimations.

4.1. The Data

This sample takes into account only artisanal ornamental fishermen from 5 communities located inside the IFC. These fishermen also perform alternative activities for obtaining income.

TABLE 2

Sample of fishermen

Community	Fishermen	Average size of household
Almidon	8	6.0
Santa Rosa	12	3.6
La Ceiba	8	6.4
Yuri	14	4.4
Playa Blanca	3	5.3
Total	**45**	**5.14**

Source: Own elaboration.

The survey collected data related to average weekly income from ornamental fish sales, commercializing fish-food and non-timber manufactures, and working for other employers. The latter activity entails full or part time waged-occupations that provide income by selling labor inside or outside the communities. Data regarding the weekly hours destined to different activities were also obtained[8].

TABLE 3

Economic activities of sample fishermen

Activity	Average weekly income ($)	Average weekly hours	Principal activity	Supplementary activity
Ornamental Fishing	127,200	49.86	32	13
Fish-food	75,000	37.06	1	10
Conucos	37,500	33.68	12	16
Non-timber manufactures	25,000	43.5	-	4
Working for other	75,000	40	-	2
Full-income	231.000	-	-	-

1 The exchange rate by the date for dollar was 1,880 COP/USD. For euro was 2,450 COP/€.
Source: Own elaboration.

[8] Previous interviews, focus groups, and communication with local leaders in the zone were performed before conducting the survey.

Data collected also contains information about mobilization, indicating whether the fisherman powers the boat using oars or an outboard motor. The variable '*tv* ownership' indicates the richest households. The variable *ow* indicates whether fishermen are owner-operators of their vessels, then distinguishing between returns of labor and capital. Cunningham (1993) states that if a fisherman is capitalist rather than a laborer, he finds it difficult to leave the fishery. Regarding the education of fishermen, it is observed that everyone has some level of schooling. Variable *dhs* indicates whether a fisherman has attended any level of high schooling[9]. Particularly in this zone, the schooling coverage in every community is up to 5 grades of elementary school. In order to continue with formal education, inhabitants of the communities have to travel up to the urban area of the municipality of Inirida. For this purpose they have to travel by water transport, which entails a high cost. This is one reason of the high abandonment of high school by fishermen. Information about family composition was also collected; the variable *cs* indicates whether a fisherman is married or not. This variable indicates when fisherman is the head of household. Finally, *fpa* indicates when fishing is the principal activity of the fisherman. This variable contains information about self-recognition in the activity, and most important, this variable tries to obtain information about the bargaining power of the fishermen when faced with the local buyers. Table 4 summarizes this information.

TABLE 4

Socio-economic characteristics of sample

Variable	Definition	Quantity	Percentage of sample (%)
tv	Television ownership	25	55.56
r	Row mobilization	32	71.11
ow	Vessel ownership	34	75.56
dhs	High-schooled fishermen	24	53.33
cs	Civil status	36	80.00
fpa	Fishing as principal activity	32	71.11

Source: Own elaboration.

4.2. Estimations

In order to measure the relation between the effort and the average income of the livelihood of a fisherman, an OLS model was estimated with the information obtained from the survey. This estimation considers the weekly average income obtained from fishing and alternative activities as a dependent variable. As independent variables, it considers *f* as the weekly hours exclusively applied to ornamental fishing

[9] Formal elementary schooling in Colombia takes 5 years. High schooling takes 6 years. Technician tertiary schooling entails up to 3 years of schooling. Tertiary professional is up to 5 years for obtaining a Bachelor Diploma.

and *oa* as the weekly hours applied to commercializing alternative commodities, fish-food included. These weekly hours also contain the time for traveling to the urban market in Inirida. Additionally, some other variables are taken into account such as rowing for transport *r*, which takes the value of 1 if a fisherman moves using rowing, 0 if using an outboard motor. The ownership of vessel is indicated by the variable *ow*, which takes the value of 1 if a fisherman owns the vessel, 0 otherwise. The variable *dhs* defines the schooling of fishermen; this variable takes the value of 1 if a fisherman has received any kind of secondary schooling, 0 otherwise. Civil status *cs*, which is a dummy variable, takes the value 1 if a fisherman is the head of household, 0 otherwise. Dummy variable *fpa* takes the value 1 if fishing is a principal activity for the agent, 0 otherwise. Finally, controls for the activities *ff*, *ch*, *nm*, and *w*, and distance to urban market expressed by the communities *sr*, *lc*, *y*, and *sr* are applied to identify differences on income. These descriptors are presented in Table 5.

TABLE 5

Descriptors of income composition

Variable	Descriptors	Expected sign
f	Weekly effort on fishing	+
oa	Weekly effort on other activities	+
r	Row boats (mode of transport)	-
ow	Vessel ownership	+
dhs	Some high-school experience	+
cs	Civil Status	+
fpa	Fishing as principal activity	+
ff	Fish-food	-
ch	Conucos	-
nm	Non-timber manufactures	-
w	Working for others	-
sr	Santa Rosa	-
lc	La Ceiba	-
y	Yuri	-
pb	Playa Blanca	-
Constant		+

Source: Own elaboration.

Descriptors such as *sr*, *lc*, *y*, and *pb* are presumed to exhibit lower incomes compared to Almidon due to those fishermen living in Santa Rosa, La Ceiba, Yuri, and Playa Blanca which are further from urban market buyers and subject to local buyers with greater bargaining power. The results of this estimation are presented in Table 6.

TABLE 6

Income composition in IFC

Variable	Description	Coefficient	
f	Weekly effort on fishing	-831.99	(929.01)
oa	Weekly effort on other activities	-682.19	(804.81)
r	Row boats	-48836.43**	(23590.04)
ow	Vessel ownership	37571.8*	(21551.61)
dhs	High-schooled Fishermen	34059.37**	(16697.51)
cs	Civil Status	36951.73**	(18310.22)
fpa	Fishing as principal activity	51612.44**	(25431.5)
ff	Fish-food	-21608.16	(55641.45)
ch	Conucos	-626.49	(52079.14)
nm	Non-timber manufactures	-1932.45	(63226.39)
w	Working for others	34988.72	(54672.89)
sr	Santa Rosa	8812.15	(28923.09)
lc	La Ceiba	22645.15	(20018.72)
y	Yuri	-30448.32	(21971.93)
pb	Playa Blanca	-6395.41	(32601.53)
Constant		97986.61**	(47156.81)

[a] Weekly income *i* as independent variable. R^2=0.3132, F=0, n=90. Test regarding normality exhibits no statistical evidence to reject the normality of errors. Problems of heterosckedasticty are corrected in the estimation. Tests are presented in the Appendix.
*Significance at 10 %. **Significance at 5 %. ***Significance at 1 %.
Source: Own elaboration.

Table 6 shows that neither *f* nor *oa* exhibit significant statistical relationship to the income of fishermen[10]. One of the reasons for explaining the non-statistical relationship between the income and the effort applied to fishing is the dynamic of distribution. The fishermen are paid once the commodity arrives at the final buyer having no control over the supply chain and the species that arrive alive; thus facing the total mortality of the commodity[11]. Moreover, the different activities represented by *ff*, *ch*, *nm*, and *w*, provide non-statistically significant higher incomes than ornamental fishing in IFC[12].

[10] In order to deal with the analysis of the effect of effort on performance in terms of income, interactions within variables such as *f*ow* and *oa*ow* were estimated, though they are non-statistically significant.

[11] The estimation of mortality is 2.2 % in capturing, 1.7 % during community buying, and 1,2 % to urban buyers. Nevertheless, this mortality varies from 0,7 % up to 16 % depending on species and season (Ramírez-Gil and Ajiaco-Martínez, 2001).

[12] Inhabitants declare that trading manufactured and agricultural products, and other related activities do not provide enough income to inhabitants of IFC communities.

This result presents some evidence to consider that IFC households rely on fishing due to lack of more profitable alternatives outside the fishing activity. According to authors such as Townsley (1998), Bailey and Jentoft (1990) and Panayotou (1988), fisheries constitute a last resort for rural households when there are few alternative sources of income, or access to other economic activities. As a consequence they are often unlikely to subsist by other activities rather than fishing (Dunn, 1989). Besides, according to Payne (2000), MacKenzie (1979), Bailey (1988) and Cunningham (1993), both marine and inland small-scale fisheries tend to include non-skilled, poor, and landless people; thereby fishermen rely for their livelihood only on fishing, which is maintained as their principal activity (Bailey, 1988; Vedeld *et al.*, 2012).

Regarding the non-significant difference between alternative activities income of fishermen, some possible explanations arise. According to Sachs and Warner (2001), full dependence on the natural resources tends to crowd out other economic activities that could promote economical growth. The authors define the situation as the *Resource Curse,* which is based on the criterion that a population dedicated to exploit natural capital tends to neglect other activities because the high original revenues obtained from exploitation. Table 3 shows that ornamental fishing provides, on average, almost twice the income than selling fish-food and working for other, which are activities with the higher income after ornamental fishing.

Results regarding the fishing technology indicate that those fishermen who power their boats by rowing have significantly lower incomes. In this case, it is assumed that those fishermen who have outboard motors can travel longer distances and find less exploited fishing zones, thereby capturing more fish.

The ownership of the vessel indicates that those fishermen who perform the activity as capitalists rather than laborers have incentives to earn higher incomes to recompense their opportunity costs. This is an important result considering that Panayotou (1982) argues that fishermen may continue fishing even if they earn far less than their opportunity costs. In this case, those who own a boat have an explicit opportunity for referencing whether the activity is profitable or not, thereby these owners perceive ornamental fishing as a business.

Furthermore, according to Copes (1989); Ikiara and Odink (2000); and Doulman (2004), the opportunity cost of fishing for most fishermen is very low, thereby the opportunity cost of other activities is relatively higher than fishing. In this way they rely less on other activities leaving them underdeveloped or for sporadic engagement. It is also necessary to remark on the schooling of fishermen. It means, that despite 26 fishermen having received some kind of secondary school experience, 42 out of 45 fishermen have not completed the ordinary basic schooling of 11 grades, and only 3 of them have a tertiary schooling. As an explanation it is presumed that due to schooling provided in the communities of IFC reaches only 5 grades, which means that as fishermen they have to travel to the urban zone of Inirida in order continue their schooling at a high opportunity cost; a high abandonment of schooling is plausible. Taken into account this abandonment, possible consequences are slow human capital accumulation, low skills formation, and lower specialization in technical activities. According to Gylfason (2001), populations involved in exploitation of

natural resources tend to have low schooling enrolment rates due to their reliance on the revenues from this activity. As a consequence, lower levels of growth and development are present. This is linked to findings from Sachs and Warner (2001), where populations involved in natural resource exploitation face a curse.

However, some explanations arise regarding the schooling of fishermen and why the more-schooled ones obtain higher incomes. Firstly, due to the isolation of fishing communities in IFC, more-schooled agents are not necessarily linked to alternative employment opportunities, although the concept of a *quality of life* effect promoted by educational achievement generally encourages them to obtain higher incomes (Smith, 1979). Secondly, the level of education of a fisherman is important to determine his opportunity cost and opportunities outside the fishing sector, respectively (Ikiara and Odink, 2000). Thereby, informational or educational power results in knowledge for obtaining better selling prices and sales alternatives (Smith, 1979). Thirdly, Gylfason (2001) argues that relying on natural resources brings risks. Moreover, the cost of collecting and processing information about the risks and returns for an asset might be lower for more educated individuals (Black *et al.*, 2015), More-schooled fishermen can perceive the risks associated with the full dependence on one resource, thereby being encouraged to obtain higher incomes in order to compensate for the risks involved in the primary activity.

The coefficient of variable *cs* indicates that those fishermen who are head of household obtain higher incomes than those that are not head of household. In this case, it can be presumed that those fishermen who face obligations for supporting a family are encouraged to obtain higher incomes. Nevertheless this is an assumption that requires to be proved.

The variable *fpa* includes information about the *know-how* of the activity. Considering these results, it can be asserted that those fishermen who perform the activity as their principal one, are more frequent on it; thereby they ensure better methods for avoiding fish mortality due to better techniques or equipment, proximity to the local buyer, or just because they are experienced. Moreover, this result also can provide an approximation of the bargaining power of fishermen, because those who perform the activity more frequently can ensure better payments for the quality of their catch in terms of the health of the fish.

Moreover, the estimations regarding *fpa* provide an insight into the *WSB*, which is an individual-level feeling that reflects if a fisherman's needs are being met by the activity they perform. According to Pollnac and Poggie (2008), fishing is often more than just another occupation and most fishermen have a strong attachment to it. The authors argue that fishing is an occupation that can be characterized as active, and adventurous, which satisfies the needs of the person. This explains the extent to which fishermen are willing to give it up for alternative professions (Bavinck *et al.*, 2012). Thereby fishing being a satisfactory occupation, fishermen tend to be more productive, creative and committed to this activity (Syptak *et al.*, 1999).

Regarding the distance to urban market buyers, control variables exhibit no significantly higher income over those communities located further from Almidon.

This is because fishermen inhabiting isolated communities are subject to the bargaining power of local buyers and face mortality risks of the fish. Particularly, the estimation signs for Yuri and Playa Blanca are negative, though non-significant, corresponding to that of the furthest communities.

4.3. Livelihoods diversification in IFC

Considering that diversification focuses on different income sources and their relationship to income levels (Ellis, 1998), non-fishing earnings to on-fishing earnings can be compared. For analyzing this, a dummy variable *di* is created taking the value 1 when more than 50 % of a fisherman's income is obtained from activities other than fishing. On the other hand, it takes value 0 when 50 % or less of income is obtained from other activities, i.e. when a fisherman relies 50 % or more for his livelihood on fishing. This is an approximation to diversification behavior. A probit model is estimated considering *di* as a dependent variable and some socio-economic characteristics as independent variables.

TABLE 7

Determinants of diversification in IFC

Variable	Description	Coefficient		dy/dx	
*dhs**	High-schooled fishermen	0.727*	(0.398)	0.244*	(0.131)
ph	Household size	0.110	(0.085)	0.038	(0.029)
cs	Civil status	0.360	(0.551)	0.116	(0.165)
tv	Television ownership	0.063	(0.406)	0.022	(0.140)
*ow**	Vessel ownership	-0.746*	(0.446)	-0.272*	(0.165)
Constant		-1.249	(0.848)		

[a] Dummy of diversification *di* as dependent variable. Pseudo R^2= 0.1028, Prob > Chi^2 = 0.241, n = 45.
*Significance at 10 %. **Significance at 5 %. ***Significance at 1 %.
Source: Own elaboration.

In this analysis it is observed that those more-schooled fishermen have more probability to diversify than those that only have basic schooling. This confirms, as Ellis (1998; 2000) and Vedeld *et al*. (2012) argue, that in IFC the lack of education is a constraint inhibiting diversification and development of alternative activities for securing livelihoods. It limits inhabitants to depend on ornamental fishing.

Interestingly Ellis (2000) argues that diversification allows actors to reduce the risk involved in the seasonality of activities, i.e. fishing. In this case, those more-schooled fishermen exhibit this behavior, which entails a strategy for reducing risk represented by a smaller probability of income failure. Thereby off-fishing revenues are considered as complementary revenues, sometimes representing higher average incomes.

Moreover, owners of vessels tend to diversify less. We consider this reasonable considering the explicit opportunity cost involved in this activity. It is notable that, neither belonging to a big household, being head of household, nor the level of wealth have any statistical influence on diversifying livelihoods in IFC.

5. Discussion and final remarks

5.1. Discussion

This research focuses on the analysis of the income of fishermen in their main activity and the possible alternative activities without considering the exploitation costs. Nevertheless it considers the lower opportunity cost compared to other activities (Copes, 1989; Ikiara and Odink, 2000; Doulman, 2004). Open access equilibrium, sustainable yield, or overexploitation outcomes related to common-pool resource management are beyond the scope of this analysis. However, the understanding of strategies for secure sustainable livelihoods does not necessarily require exhaustive analysis about the evolution of labor dynamics in fishing. The results allow judgment that reducing extractive effort applied to the fishing resource proposed by the CARF is not enough to ensure effective management of the ornamental fishery and sufficient social support for fishermen in their struggle for survival and for improving their standards of living.

According to Smith (1979), households intensify efforts and pressure on fishing due to the lack of opportunities in the rural sector leading to overexploitation of resources and reduction of incomes, even though the conventional wisdom of common-pool resources findings states that open access is the mechanism that leads to the overexploitation of the resource (Hardin, 1968; Pearce, 1982). This may be due to fishing effort efficiency that seeks rent-maximizing equilibrium for offsetting capital investment (Gordon, 1954), regardless the lack of alternative opportunities. Additionally, Smith (1979) argues that as long as the resource remains open-access, long-term solutions to the dual problem of overexploitation of the resource and low fishing incomes lie outside the fishing sector in the form of alternative or supplementary income sources.

Furthermore, it is necessary to recognize that the improvement of fishermen's income is one of the objectives that authorities such as AUNAP pursue. Nevertheless fishing development is a multi-objective activity where it is necessary to adopt specific labor market supply-side measures to ensure that the value of fishermen is improved. This may be achieved through demand-side measures in communities by promoting investment and providing alternative employment opportunities (Cunningham, 1993).

5.2. Conclusions

There is evidence to state that the lack of alternative income opportunities in the IFC leads inhabitants to rely for their livelihoods on fishing (Smith, 1979; Ellis, 2000; Vedeld *et al*., 2012), and for obtaining higher incomes. The non-significant relationship of effort *f* on fishermen's income allows us to consider that reducing access to natural capital not necessarily brings a direct decrease of the income of fishermen. However because fishing provides higher incomes, fishermen have monetary incentives to remain in the activity because supplementary activities are less profitable than ornamental fishing.

Owners of vessels perceive their activity in a businesslike way and are subject to higher opportunity costs that require to be recompensed. Transport technology allows fishermen to travel longer distances and find less exploited fishing zones, thus obtaining more species for sale.

Moreover, those fishermen who perform the activity as a principal one have a higher bargaining power, by providing consistent and healthier species to local buyers. Besides, fishing being a satisfactory occupation, fishermen tend to be more productive, creative and committed to this activity, thereby ensuring higher payments for the commodity and thus higher incomes.

Finally, regarding distance to urban markets, though it is not statistically significant, it exhibits evidence that isolation provides lower income to inhabitants of IFC. This is because fishermen living in isolated communities are subject to local buyers bargaining power.

5.3. The importance of education in IFC

Several studies concur that education is a great facilitator of livelihood diversification, and somehow, the lack of education constrains finding alternative means for obtaining income. Thereby, less educated agents are more dependent on income obtained from the natural environment, i.e. fishing. Besides, lower education levels are often found to correlate to fewer available income alternatives (Vedeld *et al.*, 2012).

In this research, findings indicate that the increase of incomes related to higher schooling is not necessarily related to human capital accumulation and the substitution of effort in fishing with other activities that promote economic growth. According to Gylfason (2001), a population involved in exploitation of natural resources fully relies on the revenues obtained from these activities. Nevertheless, schooling provides information to fishermen for perceiving opportunities and opportunity costs involved in the activity, the risk involved in the activities, and the strategies for securing their livelihoods (Ellis, 1998; 2000).

5.4. Policy implications and recommendations

Although there is no understanding whether impacts of CARF will impose constraints or offer economic opportunities, it has been argued that these programs frequently lead to sub-optimal results, especially when populations face a limited set of opportunities for diversifying livelihoods.

However, protection of wildlife and the physical environment should not be seen as a critical constraint for poverty alleviation and creation of protected areas should not be expected to increase poverty. Instead of this, conservation strategies should be used as a means to sustain the environment and the resources within it (Adams *et al.*, 2004). Thus, the CARF can be an effective policy to manage the resource in the short run. Nevertheless, the entitlements provided by these agreements should include investments outside of the fishery sector to enhance the set of opportunities in education, sanitation, communication, transportation, and supplementary livelihood activities in order to strengthen the income of small-scale fishermen (Cunningham, 1993; Vedeld *et al.*, 2012); thus, ensuring a form of community development will happen, including a reduction of their vulnerabilities (Bailey and Jentoft, 1990; Béné and Friend, 2009; Kraan, 2009).

Appendix

A.1. Test for normality of error term

The test for normality exhibits evidence that errors are not distributed normally. However, considering 90 observations we can apply the Central Limit Theorem, allowing us to assume that a large and ramdom sample approaches normality regardless the shape of the population distribution.

TABLE A1

Test for normality

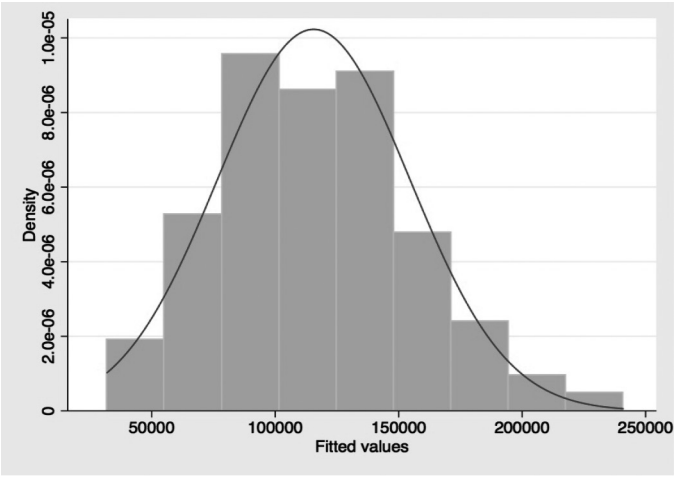
Variable	n	p- value (Skewness)	p-value (Kurtosis)	Joint	
				chi2 (2)	Prob > chi2
errors	90	0.0425	0.4329	4.75	0.0932

Source: Own elaboration.

However, the histogram of distribution of errors shows no large deviation from a normal distribution.

FIGURE A1

Distribution of errors



Source: Own elaboration.

A.2. Test for heteroskedasticity

Breush-Pagan test exhibits evidence of heteroskedasticity. For correcting this, we ran a regression controlling by clustering variable *id*, which means each fisherman. Then we corrected this problem in the regression.

TABLE A2

Breush-Pagan test

Breush-Pagan	
chi2(1)	3.5900
p-value (BP)	0.0581

Source: Own elaboration.

A.3. Test for Multicollinearity

Correlation between variables exhibits evidence of multicollinearity between effort applied to fishing (*f*) and fishing as a principal activity (*fpa*), which seems credible given that fishermen who perform the activity as a principal one are more active on it. However, given that these variable are objective of theoretical and empirical analysis, we decided to estimate the effect on income separately.

TABLE A3

Correlation matrix of variables

		f	**oa**	**r**	**ow**	**dhs**	**cs**	**fpa**
Effort on fishing	*f*	1						
Effort on other activities	*oa*	-0.8463	1					
Row boats	*r*	0.0444	0.0863	1				
Vessel ownership	*ow*	0.0570	0.0940	0.7783	1			
High-school experience	*dhs*	0.0131	-0.0184	0.0898	0.1900	1		
Civil Status	*cs*	-0.0206	-0.0302	-0.1551	-0.1961	-0.2450	1	
Fishing as principal activity	*fpa*	0.7792	-0.6535	0.3145	0.2686	-0.0031	-0.0928	1

Source: Own elaboration.

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