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Mobile App-Based Regional Bamboo Resource Assessment: Manabi Province, Ecuador

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The International Bamboo and Rattan Organisation, INBAR, is an intergovernmental organisation dedicated to the promotion of bamboo and rattan for sustainable development.

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1. Introduction

Bamboo is a renewable resource that has 1642 identified species worldwide. In Ecuador, there are 47 species grouped into five genera as follows: *Arthrostylidium*, three species; *Aulonemia*, five species; *Chusquea*, 33 species; *Guadua*, three species; and *Rhipidocladum*, three species. Eleven of these species are endemic, while around 10 species have been introduced, mainly from Asia, including *Bambusa tulda* (from India), *Bambusa ventrician*, *Dendrocalamus asper* (giant bamboo), *Dendrocalamus latiflorus*, *Dendrocalamus longispiculata*, *Dendrocalamus oldhamii*, *Melocanna baccifera*, *Phyllostachys aurea*, *Phyllostachys nigra* and *Phyllostachys pubescens* (moso bamboo from China).

In Ecuador, bamboo is a resource that is sustainably managed for the livelihoods of rural populations. This resource is part of their agricultural production units, contributing to the diversification of their income sources. Bamboo significantly helps mitigate climate change because of its carbon sequestration ability, helping control water flows, reducing erosion and stabilising slopes. Ecuador's bamboo forest is habitat for flora and fauna. Bamboo timber can replace wood in many ways; thus, bamboo forests help reduce the pressure on natural forests. These virtues of bamboo explain why it is important for the survival of the families involved in this activity, which represents 0.5% of the country's total gross domestic product (Estrategia Nacional del Bambú, 2018-2022, Lineamientos para un desarrollo verde e inclusivo (National Bamboo Strategy 2018-2022, Guidelines for a Green and inclusive development); Ministry of Agriculture and Livestock, Bamboo Sectorial Table, INBAR; Quito – Ecuador, 2018).

The socio-economic values of bamboo in Ecuador are understood by Afro-Ecuadorians, indigenous people and mestizos, especially in rural areas. Bamboo is an economically growing sector. The trade balance of bamboo products during the last two decades has been positive. In 2017, the trade value was about USD 217 million, representing 2% of the agricultural products exported. It is a significant source of employment in rural areas,

with a direct influence on 12% of the total agricultural employment. Bamboo production generates income for its producers and is also used for self-consumption (construction material for housing, farm infrastructure and agricultural practices) as it is an important activity for around 503,000 rural people (ibid.).

As a product of participatory work between the public sector and civil society in activities related to bamboo from different areas, in 2018, the National Bamboo Strategy for 2018–2022 was developed. In this strategy, it was proposed to develop a roadmap for strengthening the sector through its value chains. Part of this strategy includes an estimation of the existent area with the different species of bamboo, revealing an approximate presence of bamboo of 600,026 ha at a national level—of which approximately 15,000 ha are harvested. The estimation of this area is the result of systematically gathering different sources of secondary information and official statistical and cartographic information, which reveals data at a national level. It is worth recognising that this surface includes different bamboo species that are found in Ecuador as natural stands or as plantations (mono or associated with other species). In addition, bamboo in Ecuador grows spontaneously between crops on riverbanks and/or on mountain flanks, joining with the typical vegetation of each zone. According to the 2018 assessment, it is estimated that the canton of Santa Ana has 10,226 ha of bamboo, distributed amongst 4459 farms. Meanwhile, in the canton of Portoviejo, there are 9509 ha in 4179 farms.

To strengthen the initial estimates of information obtained from the analysis developed in the National Bamboo Strategy, it is necessary to pursue fieldwork for validation. Precise information is crucial due to the potential for an increase in resource demand, which is directly related to bamboo housing construction as part of the social housing programmes like Casa para Todos, carried out by the Ecuadorian government. To be able to accurately manage the resource and respond to a potential rising demand for bamboo, it is important to gradually validate the exact surface area and location of bamboo for better planning at local levels.

In this context, the International Bamboo and Rattan Organisation (INBAR) promotes policy progression to encourage the production and sustainable management of bamboo. INBAR has developed a series of instruments to strengthen the knowledge of bamboo and rattan as a beneficial resource. One such instrument is the Bamboo Survey and Monitoring System (BSMS), consisting of a set of mobile and online applications to facilitate the generation of geo-referenced information regarding bamboo distribution and diversity in a given area. This system was developed by the Global Assessment of Bamboo and Rattan (GABAR), a flagship programme of INBAR.

To substantiate the tool in Latin America, contributing to the generation of on-field information related to bamboo distribution in Ecuador, a pilot operative was proposed for using the INBAR Global Survey mobile application in the province of Manabí. This province has the greatest presence of bamboo in Ecuador, specifically in the cantons of Portoviejo and Santa Ana. These locations were selected not only because of the existing presence of bamboo but also for the cultural use of the resource by its inhabitants and its potential for resilience within the local economy, as is the case of the “latilleros” (people who fabricate bamboo laths) in the parish of San Placido (Portoviejo) and the Guadua stands at La Lucha (Santa Ana).

In the environmental field, bamboo in these two cantons serves as a protective barrier along riverbanks. Furthermore, in the mountainous regions of these cantons, bamboo regulates water flows and stabilises the slopes of the basin of the Poza Honda dam—which supplies water for human consumption for 750,000 people in the province of Manabí. Moreover, according to the most recent Survey of Living Conditions published by the National Institute for Statistics and Censuses (INEC) in 2015, over 90% of the population in most parishes included in the study area live in poverty. This extreme poverty condition is due to unsatisfied basic needs, as can be observed in Table 1.

Table 1. Poverty conditions due to unsatisfied basic needs at the parish level in the cantons of Portoviejo and Santa Ana, Manabí province, Ecuador.

Parish	Not Poor	Poor	TOTAL	% Poor
LA UNION	0	6,453	6,453	100.00
CHIRIJOS	0	2,362	2,362	100.00
RIO CHICO	221	11,084	11,305	98.05
SAN PLACIDO	221	7,449	7,670	97.12
ALHAJUELA	121	3,633	3,754	96.78
ABDON CALDERON	551	13,600	14,151	96.11
HONORATO VASQUEZ	363	5,515	5,878	93.82
CRUCITA	1,084	12,939	14,023	92.27
SANTA ANA DE VUELTA LARGA	5,266	16,937	22,203	76.28
PORTOVIEJO	93,906	126,608	220,514	57.41

Source: Survey of Living Conditions, INEC (2015).

To develop the anticipated fieldwork, in February, a proposal for the implementation of the pilot was offered to several local entities related with bamboo, encouraging them to be involved with our inter-institutional work. As a result, the following institutions provided technical and logistic support: the Decentralised Autonomous Municipal Government of Portoviejo, Decentralised Autonomous Municipal Government of Santa Ana, Ministry of Agriculture and Livestock (MAG), Ministry of Environment (MAE) through the Unique System for Environmental Information, Secular University Eloy Alfaro of Manabí (ULEAM) and Higher Technical Institute Paulo Emilio Macias (ITSPEM). Fieldwork was carried out from 18 March to 5 April 2019.

2. Methodology

2.1 Capacity-building

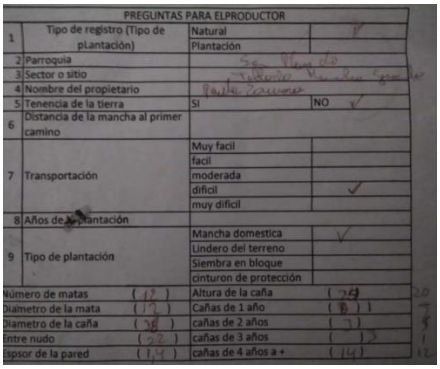
Members from the different participating institutions engaged in a theoretical and practical workshop, referring both to the use of the mobile application and the relevant guidelines for identifying representative bamboo species from the Ecuadorian coastal region. The workshop lasted 14 hours and was held in the parish of Honorato Vásquez, in the canton of Santa Ana, where it was possible to use the application. Whilst in the Botanical Garden of Portoviejo, practical exercises of bamboo identification species were performed. The workshop instructor's team was formed by an MAE expert, a former INBAR fellow and two INBAR technicians (see Annex 2).

2.2 Materials and equipment

(a) Prints of app screenshots in Spanish

An A6-size plasticised notebook detailing screenshots of the application translated into Spanish was given to the teams to avert any confusion over the information to be collected during the fieldwork.

(b) Field form



PREGUNTAS PARA ELPRODUCTOR

1	Tipo de registro (Tipo de plantación)	Natural	
		Plantación	
2	Parroquia		
3	Sector o sitio		
4	Nombre del propietario		
5	Tenencia de la tierra	SI	NO
6	Distancia de la mancha al primer camino		
7	Transportación	Muy facil	
		facil	
		moderada	
		dificil	✓
		muy dificil	
8	Años de la plantación		
9	Tipo de plantación	Mancha domestica	✓
		Lindero del terreno	
		Siembra en bloque	
		cinturon de protección	

Número de matas	(17)	Altura de la caña	(24)
Diametro de la mata	(13)	Cañas de 1 año	(8)
Diametro de la caña	(36)	cañas de 2 años	(3)
Entre nudo	(32)	cañas de 3 años	( )
Espsor de la pared	(1,4)	cañas de 4 años a +	(14)

Aiming to reduce the time of on-field information gathering, INBAR generated a printed form with the required dendrometric data. Consequently, whilst one member of the group collected relevant information on the form, another organised an onsite walking tour for mapping polygons or poly-lines (points made directly in the application using a mobile device). The information registered on the form included the height and diameter of culms, length of internodes and number of stems per stand, as well as the information provided by the producer regarding land legalisation, the age of bamboo stands and so on. Later, this information was consolidated within the BSMS to complete the process for each stand.

(c) Identification cards

Identification cards were provided to each participant of the fieldwork to facilitate better access to bamboo producers and generate confidence in the work to be done. The identification cards included logos of participating institutions, as well as their names and national identification numbers.

(d) Mobile devices

The participating groups had smartphones with Android operating systems. Fortunately, INBAR's Global Survey application had previously been downloaded and tested for use with Android operating systems.

(e) Drones

Two drones were used for aerial surveying of geo-referenced aerial photographs. These drones are especially useful for areas that are difficult to access and/or for areas with extensive bamboo surfaces.

(f) Tools

To better facilitate the relevant fieldwork, working groups were equipped with machetes, 20-m-long measuring tapes, raincoats, calibrators, chalk and non-disposable water bottles.

(g) Vehicles

There were three vehicles suitable for the fieldwork; two were provided by INBAR and one by the MAG.

2.3 Fieldwork team conformation

The participants who engaged in collecting on-field information were trained on how to use the app, and they were distributed in three field survey teams. Each team had two ULEAM or ITSPEM students, at least one technician of a municipal Decentralized Autonomous Government (GAD), and a MAG or INBAR technician (Annex 1). Of the three teams, two had drones. The participants were organised into three teams based on their place of residence and the areas needing to be covered.

Prior to the fieldwork, a meeting was held to coordinate with all the members of the three teams to give security indications for the field. Then, the members were distributed to corresponding brigades, and leaders were assigned for each team. To ensure quality performance, an instant messaging group was established with all the participants of the pilot, including the facilitators of the workshop, to maintain permanent accompaniment and quickly resolve any technical or logistic concerns or difficulties that could have arisen during the fieldwork.

2.4 Designation of survey sites

Based on the preliminary information of the two cantons to be surveyed from the National Bamboo Strategy, a meeting was held with technical staff from each municipal GAD to gather available information regarding the presence of bamboo in their territories. Gathering and consolidating the information regarding the territories being surveyed enabled the teams to identify the sectors where the presence of bamboo was more abundant at the parish level (Annex 7, Map 1). The following parishes were selected in the Portoviejo canton: Abdon Calderon, Alhajuela, Chirijos, Crucita, Portoviejo, Pueblo

Nuevo, Rio Chico and San Placido. The parishes selected in the Santa Ana canton were as follows: Ayacucho, Honorato Vásquez, La Union and Santa Anta de Vuelta Larga.

Once these areas were well defined, geo-referenced data of roads and populated areas of both cantons (Portoviejo and Santa Ana) were included to more accurately determine the optimal routes for gathering information (Annex 7, Map 2). To register each area, two meeting points, both in Portoviejo, were established. The two meeting points were located where the members of each brigade would arrive at the beginning of the day, as well as where the teams would finish at the end of the day. Every day, the fieldwork surveys began at the furthest points of the two acknowledged meeting points and advanced inward as conditions allowed.

2.5 Data collection

The field survey was initiated on 18 March and operated through 5 April 2019. The work was conducted Monday through Friday, comprising 15 full working days. Once the teams arrived at the survey site, the leading delegate of the corresponding parish council was contacted to determine the most efficient ways to reach the locations of bamboo stands. On some occasions, the delegates offered themselves as guides during the fieldwork.

When arriving at farms needing to be registered, the team leader would discuss the mission with the owner of the bamboo stand, explaining which institutions were involved with the work and what the registration process involved. Once the owner gave his authorisation, the information was collected both on a form and in the system as indicated previously. The average time between arriving at the location and filling out the necessary information was around 50 minutes. Furthermore, it took approximately 20 minutes to go from one farm to another.

When the conditions for fieldwork and travel were more optimal, it was possible to conduct two surveys per team, increasing the number of registered farms per day. However, for the locations that were difficult to access due to extremely dense vegetation, rivers,

estuaries, topographic factors, high elevations or other circumstances, drones were employed for geo-referencing photographs of the centre of the particular bamboo stands (Annex 3, Image f); in bamboo stands larger than 1 ha, a flight route was planned to collect a mosaic of photos to create an orthomosaic of the surface registered at a later stage in the office (Figure 1). During the daily surveys, the battery life of each drone allowed the teams to take an average of 10 photos per day.

At the end of the day, the information collected on mobile devices by each team was uploaded to the GABAR database once they had access to internet. The GABAR database has an online browser called INBAR Bamboo Survey Manager, in which one can observe the registered bamboo on a reference map, select and perform some statistical calculations of the information and generate reports for each record (Annex 4 and Annex 5, Images a and b).

2.6 Data processing

Whilst the teams were working in the field, the information that had been previously loaded into the system was monitored to identify possible errors and any confusing information. This exercise informed the field teams and allowed them to obtain feedback when necessary whilst simultaneously improving the process.

At the end of the survey, all the uploaded information was downloaded and analysed on Excel, and erroneous data were removed. For example, information regarding wrong species (*Bambusa balcooa*, not present in Ecuador, the first on the drop-down list of species), incorrect names of farm owners and test points raised during the training workshop were deleted. The data of farms with unknown owners were consolidated.

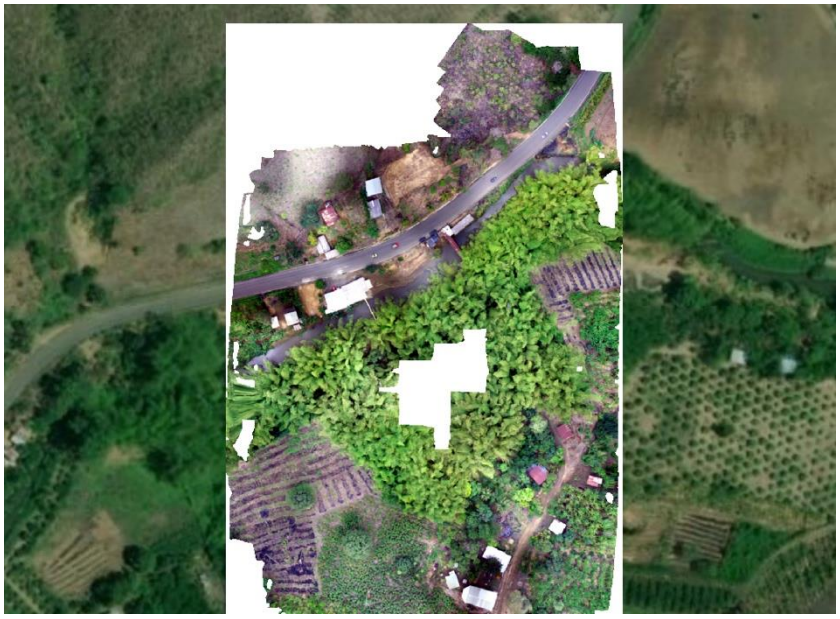


Figure 1. Orthomosaic map created from images obtained with the drone on a Gustavia angustifolia stand.

The geographical information was downloaded from the BSMS and sent to MAG, MAE and INBAR technicians to be processed. The information contained different cartographic entities (points, lines and polygons). The files were converted to shapefile (shp) format and analysed using geographic information systems.

3. Results

3.1 Surveyed area

Table 2 illustrates 688 bamboo registries obtained during the pilot, covering a total of 158.27 ha surveyed with the app. A total of 418 farms were visited, with an average of 0.38 ha of bamboo per farm. As a result of the fieldwork, 394 surveys were conducted in the Portoviejo canton, covering eight parishes. When comparing this information with the estimated presence of bamboo in the National Bamboo Strategy, the percentage of registered farms represents 3.3% of the total of Santa Ana canton and 6.46% of Portoviejo canton. The location with the highest number of records in the Portoviejo canton was San Placido parish, which generated 218 records in 126 farms with an average bamboo area of 0.38 ha. Moreover, in the Santa Ana canton, 294 records were registered. These records represented 79.59 ha of bamboo throughout four different parishes in a total of 148 farms—averaging 0.54 ha of bamboo per farm. The Santa Ana de Vuelta Larga parish had the largest number of records (94) in 45 farms, with an average bamboo area of 0.91 ha per farm (Annex 7, Map 3).

Table 2. Number of records, farms, bamboo hectares and average bamboo coverage per farm in the Portoviejo and Santa Ana cantons, surveyed during the pilot operation using the INBAR Global Survey app, carried out between March and April 2019, in Manabí province, Ecuador.

Canton/parish	N° of registrations	Registered bamboo hectares	N° of lands registered	Average bamboo hectares/farm
Portoviejo	**394**	**78.67**	**270**	**0.29**
Abdon Calderon	55	8.82	43	0.21
Alhajuela	3	0.53	2	0.27
Chirijos	39	5.54	36	0.15
Crucita	2	0.00	2	0.00
Portoviejo	24	4.81	19	0.25
Pueblo Nuevo	42	9.29	34	0.27
Riochico	11	1.44	8	0.18
San Placido	218	48.23	126	0.38
Santa Ana	**294**	**79.59**	**148**	**0.54**
Ayacucho	86	13.20	44	0.30
Honorato Vasquez	35	2.15	19	0.11
La Union	79	23.51	40	0.59
Santa Ana De Vuelta Larga	94	40.74	45	0.91
TOTAL	**688**	**158.27**	**418**	**0.38**

3.2 Age of *Guadua angustifolia* stems by parish

The information regarding bamboo age collected in the app is classified into the four following ranges: up to one year, referring to the plants with bamboo shoots and plants growing their first branches; up to two years, referring to bamboo stems without caulinar (stem) leaves, but nevertheless, totally green without lichens; up to three years, bamboo with lighter green culms, with the presence of lichens up to the middle of the culm; and more than three years, with mature culms or hechos (local term for mature culms), which present a dark green colour, as well as lichens that reach the base of the stems and/or culms that are over-mature or those with dried canes.

The analysis of the information obtained during the survey reflects two realities, one per canton; thus, in Portoviejo, it can be concluded that bamboo is less exploited because 35.7% of the total culms are mature or over-mature and only 18.69% of culms are up to one year. This factor is typical of an abandoned bamboo stand or a stand that is poorly managed. By contrast, in Santa Ana, the opposite can be observed. In Santa Ana, the data reflect that bamboo is better managed and exploited, with a greater number of culms up to one year, representing 24.2%, and the culms of more than three years represent 22.2% of the total number of culms in the registered bamboo stands (Table 3).

Table 3. Culm age by parish in the Portoviejo and Santa Ana cantons, registered during the pilot operation using the INBAR Global Survey app between March and April 2019, Manabí province, Ecuador.

Canton	Parish	1 year culms	2 years culms	3 years culms	more than 3 years culms
Portoviejo	Abdon Calderon (San Francisco)	356	522	645	1,114
	Alhajuela (Bajo Grande)	22	33	72	78
	Chirijos	126	121	131	107
	Crucita	18	2	12	23
	Portoviejo	135	191	239	362
	Pueblo Nuevo	187	162	153	168
	Riochico (Rio Chico)	80	87	101	110
	San Placido	1,083	1,168	1,252	1,873
	Portoviejo Totals	**2,007**	**2,286**	**2,605**	**3,835**
	Percentage by age	**18.70**	**21.30**	**24.27**	**35.73**
Santa Ana	Ayacucho	689	850	835	762
	Honorato Vasquez	179	235	233	189
	La Union	628	698	693	567
	Santa Ana De Vuelta Larga	875	866	859	658
	Santa Ana Totals	**2,371**	**2,649**	**2,620**	**2,176**
	Percentage by age	**24.15**	**26.99**	**26.69**	**22.17**

3.3 Extraction difficulties and distance to roads of registered bamboo stands

It is worth noting that one of the factors considered when planning surveys and defining survey sites is the acknowledgement of proximity to main roads. The results below were obtained from the analysis of 688 records:

Regarding the difficulty of extraction, 39.5% of the registered farms offered easy extraction, 41.4% offered moderate ease of extraction and only 13.7% were difficult to extract. The analysis made at the parish level shows that San Placido has the largest

presence of bamboo in this sample and is the parish that presents the highest percentage of records with a difficult extraction degree, at 79% (Table 4). These data reflect that a high percentage of bamboo in this parish is found in areas with steep slopes that are difficult to access—possibly due to the bamboo's ability to protect soils against landslides and erosion (Annex 3, Image g). Further, it should be considered that this information does not include that surveyed by drones, precisely because of the difficulty of accessing these sites (Annex 2, Image j and Annex 3, Image b).

Table 4. These figures indicate the degree of difficulty when extracting bamboo registered during the pilot operation using the INBAR Global Survey app, in the Portoviejo and Santa Ana cantons, between March and April 2019, Manabí province, Ecuador.

Canton	Parish	Difficulty degree for the exploitation of registered bamboo					
		Very easy	Easy	Moderate	Difficult	Very difficult	Grand Total
Portoviejo	Abdon Calderon (San Francisco)		39	11	5		55
	Alhajuela (Bajo Grande)		2	1			3
	Chirijos	1	9	9	20		39
	Crucita		2				2
	Portoviejo	1	14	6	3		24
	Pueblo Nuevo		20	10	12		42
	Riochico (Rio Chico)		5	5	1		11
	San Placido	6	95	77	38	2	218
	Totals A	**8**	**186**	**119**	**79**	**2**	**394**
	Percentage A	**2.03**	**47.21**	**30.20**	**20.05**	**0.51**	
Santa Ana	Ayacucho	2	15	57	11	1	86
	Honorato Vasquez	5	7	23			35
	La Union	4	32	42	1		79
	Santa Ana De Vuelta Larga	15	32	44	3		94
	Totals B	**26**	**86**	**166**	**15**	**1**	**294**
	Porcentage B	**8.8**	**29.3**	**56.5**	**5.1**	**0.3**	
	Totals A+B	**34**	**272**	**285**	**94**	**3**	**688**
	Percentages A +B	**4.94**	**39.53**	**41.42**	**13.66**	**0.44**	

3.4 Distribution of farms according to their size

It is vital to observe the distribution of farms according to their size, as this reflects the conditions of bamboo in a great part of Ecuador, where there are no large plantations, but

rather, small natural patches or stands. Most registered bamboo stands are less than half a hectare. The data collected show that, out of 688 records, 78.8% are less than 0.25 ha and 8.9% have 0.25–0.5 ha. These portions account for, 603 out of 688 records, illustrating that 87.7% of the records represent up to 0.5 ha. In addition, only 4.2% of the records have 1–5 ha, and only 0.3% correspond to stands greater than 5 ha (Table 5). It is also important to note that all records correspond to natural stands and not bamboo plantations.

Table 5. Size ranges of bamboo stands registered during the pilot operation using the INBAR Global Survey app, carried out between March and April 2019, in the Portoviejo and Santa Ana cantons, Manabí, Ecuador.

SITE	Bamboo stand area				
	0-0,25 Ha	0,25 - 0,5 ha	0,5 - 1,0 ha	1,0 - 5,0 ha	more than 5,0 ha
Portoviejo	**308**	**36**	**34**	**16**	**0**
Abdon Calderon	46	2	6	1	0
Alhajuela (Bajo Grande)	2	0	1	0	0
Chirijos	36	1	0	2	0
Crucita	2	0	0	0	0
Portoviejo	17	2	5	0	0
Pueblo Nuevo	34	2	4	2	0
Riochico (Rio Chico)	9	1	1	0	0
San Placido	162	28	17	11	0
Santa Ana	**234**	**25**	**19**	**13**	**2**
Ayacucho	75	6	2	2	0
Honorato Vasquez	34	1	0	0	0
La Union	57	13	5	3	1
Santa Ana De Vuelta Larga	68	5	12	8	1
TOTAL	**542**	**61**	**53**	**29**	**2**

3.5 Land tenure of natural bamboo farms

The analysis of this parameter indicates that, in Portoviejo, 29.7% of the 270 registered properties do not have legalised land tenures, whilst in Santa Ana, of the 148 registered

properties, 13.6% do not have legalised land tenures (Table 6). It is important to highlight that this data were not validated by the presentation of supporting documents of the producers' information regarding their properties. Furthermore, this issue generally causes a sense of distrust amongst the producers. In this way, there is a growing concern that this type of information may result in tax increases for farmers. Consequently, it is possible that there will be more data from non-legalised lands.

Table 6. Quantity and percentage of farms with bamboo stands that have obtained legalised land tenures, registered during the pilot operation using the INBAR Global Survey app, in the Portoviejo and Santa Ana cantons, carried out between March and April 2019, Manabí province, Ecuador.

Land tenure percentage per canton					
Canton	yes	%	no	%	Total per Canton
Portoviejo	277	70.3	117	29.7	394
Santa Ana	254	86.4	40	13.6	294
Grand Total	531	77.2	157	22.8	688

By contrast, in locations like Las Tabladas de Mancha Grande, La Curva and Guarumo in the San Placido parish, there are important bamboo areas that are part of the protected forest. For these areas, the land legalisation process is the MAE's responsibility, whilst land legalisation processes in the rest of the parishes are registered under the jurisdiction of the MAG—an organisation that has recently taken a special interest in streamlining this process and worked together with the municipal GADs of Portoviejo and Santa Ana.

3.6 Species found and dendrometry

The operation confirmed that the predominant species in Manabí (and the Ecuadorian coastal region) is *Guadua angustifolia*—present at rates of 90.41% as natural stands and 9.44% as plantations. Altogether, *Guadua angustifolia* represented 99.85% of the total records (Table 7). The rest was distributed amongst small plantations with minimal areas of *Dendrocalamus asper*, *Bambusa vulgaris* and *Bambusa tulda*.

Table 7. Presence of *Guadua angustifolia* according to crop type found as part of the pilot operation using the INBAR Global Survey app, in the Portoviejo and Santa Ana cantons, between March and April 2019, Manabí province, Ecuador.

Location	Hectares of *Guadua angustifolia*		Total hectares of bamboo
	Natural Stands	Plantation	
Portoviejo	**77.43**	**1.23**	**78.67**
Abdon Calderon	8.61	0.21	8.82
Alhajuela	0.53	0.00	0.53
Chirijos	5.50	0.05	5.54
Crucita	0.00	0.00	0.00
Portoviejo	4.78	0.03	4.81
Pueblo Nuevo	9.29	0.00	9.29
Riochico (Rio Chico)	1.31	0.13	1.44
San Placido	47.41	0.81	48.23
Santa Ana	**65.66**	**13.71**	**79.59**
Ayacucho	12.79	0.39	13.20
Honorato Vasquez	1.96	0.06	2.15
La Union	23.50	0.01	23.51
Santa Ana De Vuelta Larga	27.41	13.26	40.74
Total	**143.10**	**14.94**	**158.27**
Percentage of *G. angustifolia* over total bamboo hectares	**90.41%**	**9.44%**	**99.85%**

Guadua angustifolia dendometry registered an average diameter at breast height (DBH), of 11.57 cm, which is significantly higher than the minimum recommended by the Ecuadorian Standard for Construction with this species (Annex 2, Image i). The average height was 19.57 m, which allows harvesters to obtain at least two 6-m-long canes for preservation that meet the construction requirements. The average inter-node measure was 24.79 cm, which offers a lot of resistance—an important factor for construction. In addition, the wall thickness at the base averaged 1.72 cm (as shown in Table 8), adding resistance to the material and generating different manufacturing uses for laths.

Table 8. Bamboo species dendometry registered during the pilot use of the INBAR Global Survey app, in the cantons of Portoviejo and Santa Ana, between March and April 2019, Manabí province, Ecuador.

Species	Average culm diameter (cm)	Average culm height (m)	Average inter-node length (cm)	Average wall thickness (cm)
Bambusa tulda	2.87	12.00	35.00	0.10
Bambusa vulgaris	8.95	15.40	29.40	1.23
Dendrocalamus asper	12.81	21.29	33.22	1.84
Guadua angustifolia	11.57	19.57	24.79	1.72

3.7 Bamboo commercialisation

Harvesting bamboo in the two cantons is conducted using machetes and mules for carrying the bamboo. Most of the bamboo harvested is either used for self-consumption or for the producers to sell the product beside the main roads. The average value per “balsa” (raft—the local term for 24 culms of 9 m each, used in the early days to arrange a raft for transportation along rivers) is USD 50. Producers also sell bamboo individually for an average price of USD 1 per culm. However, no producers were found selling directly to warehouses, collection centres or builders. It is important to clarify that no producers that were interviewed requested harvesting permits or mobilisation guides. Such work is done by traders, who buy bamboo from their farmstands.

4. Conclusion

- The use of INBAR's Global Survey application is simple, allowing people with minimal academic training to use it. Even more, processing downloaded data from the system does not present any difficulty, allowing the app to facilitate its subsequent statistical and geographic analysis in the geographic information system. For example, the fieldwork was completed within 15 working days, with some of the staff being unfamiliar with bamboo; moreover, although the rainy season produced challenging environmental conditions, it was possible to collect 688 records, representing a significant number of cartographic entities, which constitute valuable input for future analysis.
- The presence of bamboo in both cantons is evident, considering that, of the 418 properties visited, all had a 100% representation of bamboo, distributed amongst 158.27 ha in total. Therefore, it can be concluded that there is an average of 0.38 ha of bamboo per farm. Furthermore, the Santa Ana canton has the largest presence of bamboo, with an average of 0.54 ha of bamboo per property; in Portoviejo, there is an average of 0.29 ha of bamboo per farm.
- The use of bamboo is greater in Santa Ana than it is in Portoviejo, which is noticeable through the conditions of the existing bamboo stands. The study showed that the stands were cleaner and had an abundant supply of bamboo shoots per stand. In contrast, in Portoviejo, there was a greater presence of culms older than three years old—a symptom of poor maintenance and a lack of use.
- The distribution of bamboo in registered properties reflects that 78.8% correspond to bamboo stands smaller than 2500 m^2, that is, less than a quarter of a hectare; together with reaching up to half a hectare, they represent 87.7% of the total registered area of bamboo.
- The canton of Santa Ana has a greater record of land legalisation, at 80.4%, whilst in Portoviejo, this is the case with only 70.3% of farms.
- It is vital to facilitate the legalisation of properties, particularly if bamboo producers are interested in developing, being linked with social housing programmes or

possibly accessing alternative types of policy/specific programmes for the sectors. Otherwise, non-legalised properties may generate difficulty for the owners to access these kinds of incentives.

- The presence of nearby rivers and evidence of registered bamboo stands demonstrates that the population is aware, perhaps by tradition, of the benefits that bamboo creates for riverbank preservation. The 688 records illustrate that the amount of bamboo directly corresponds to water sources. In both cantons, 72.9% of the registries were located near rivers, with the bamboo protecting against floods and simultaneously maintaining the water flow.
- For the level of difficulty when extracting bamboo, in spite of the analysis—which indicated that 41.4% of the total records reflect moderately easy extraction—there is a great quantity of bamboo located in mountainous terrains with slopes (as in the parish of San Placido, which was registered by aerial drone images). Data registered with the aerial drones were not included in the analysis because the BSMS does not allow the uploading of external data.
- In the study area, bamboo commercialisation is poor. The main use is for self-consumption and to generate income through sales to intermediaries at the farm level. There were no cases identified where the bamboo was sold directly to collection centres or end users.
- Data concerning culm age reflects that bamboo is potentially being wasted, even when the conditions for accessing roads are relatively easy. This could partly be due to several factors, such as the lack of adequate marketing conditions, lack of knowledge about sustainable management of resources, the difficulty to extract the resource in certain areas onsite, the developing demand to organise, lack of association of producers regarding bamboo, lack of incentives regarding sustainable use of resources and difficulty in carrying out the procedures for exploitation and transportation.
- The potential bamboo offers for generating income in the surveyed areas is great, especially considering that a large swath of the population is living in poverty. Since bamboo is readily available in the area, it can be a crucial aspect for local and

familial economics. Bamboo also generates environmental services by combatting the effects of climate change; furthermore, the resource strengthens produces' resilience by offering incentives and opportunity for lower socio-economic sectors by increasing access to global markets for rural populations.

- Inter-institutional work at the territorial level is not only possible but also incredibly fruitful because the work requires expertise from the diverse participants involved and enables interdisciplinary teams to be formed. The incorporation of young students in this type of industry is extremely valuable for participating teams as a whole and for the students themselves, allowing them to experience different realities that may be foreign to them, which will contribute to their future careers.

5. Annexes

Annex 1

List of participants and participating institutions during the pilot use of the INBAR Global Survey mobile application developed in the cantons of Portoviejo and Santa Ana, Manabí province, Ecuador, 2019.

Interinstitucional team	
Andrés Montenegro	Génessis Graciela Zamora Zambrano
Byron Alfredo Lajones Ruano	Jack Hamlet Limongi Vera
César Andrés Cabrera Andrade	Jahaira Elizabeth Cevallos Delgado
Deyton Javier Mera	Juan Carlos Salazar
Edison Alfredo Pincay Mera	Luis Alberto Rodríguez Bello
Fabián Eduardo Moreno Ortiz	Marcelo Andrade Mesía
Fabricio Jamil Ponce Ponce	Miguel Alejandro Giler Soledispa
Fausto Geovanny Sornoza Macías	Pablo Roberto Izquierdo Salvador
Freddy Germán Merchán Álvarez	Paúl Daniel Pincay Mejía
Gary Gabriel Galarza Rodríguez	Ronald Javier Reyes Reyes

Participant Institutions

Annex 2

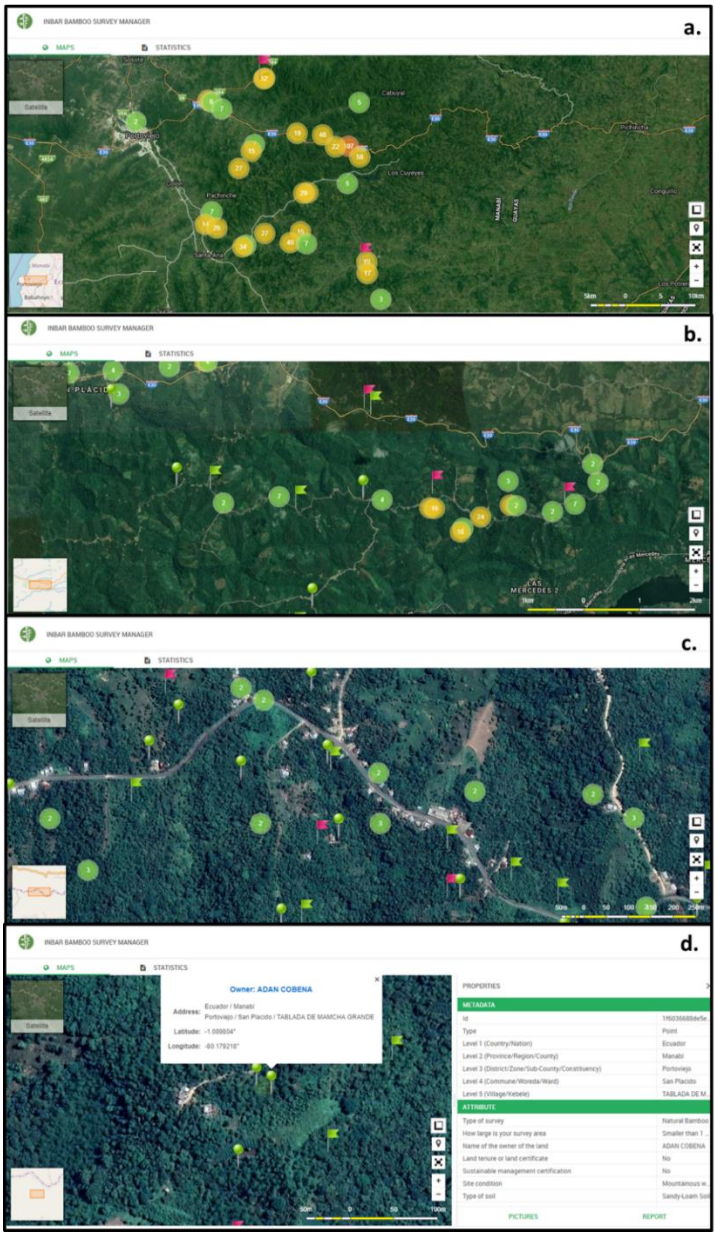
Image 1: a–h. Theoretical and practical workshops on the use of the INBAR Global Survey application carried out in the Portoviejo and Santa Ana cantons. **i.** Measuring the diameter of a Guadua culm. **j.** Aerial photograph taken by a drone of a natural stand of *Guadua angustifolia.*

Annex 3

Image 2: a and **e.** Evidence of *Guadua angustifolia* on riverbanks. **b** and **f.** Aerial photographs of extensive or inaccessible stands of *Guadua angustifolia.* **c.** Bamboo registration fieldwork. **d.** Constant rain during fieldwork. **g.** Presence of bamboo on a slope of a registered property.

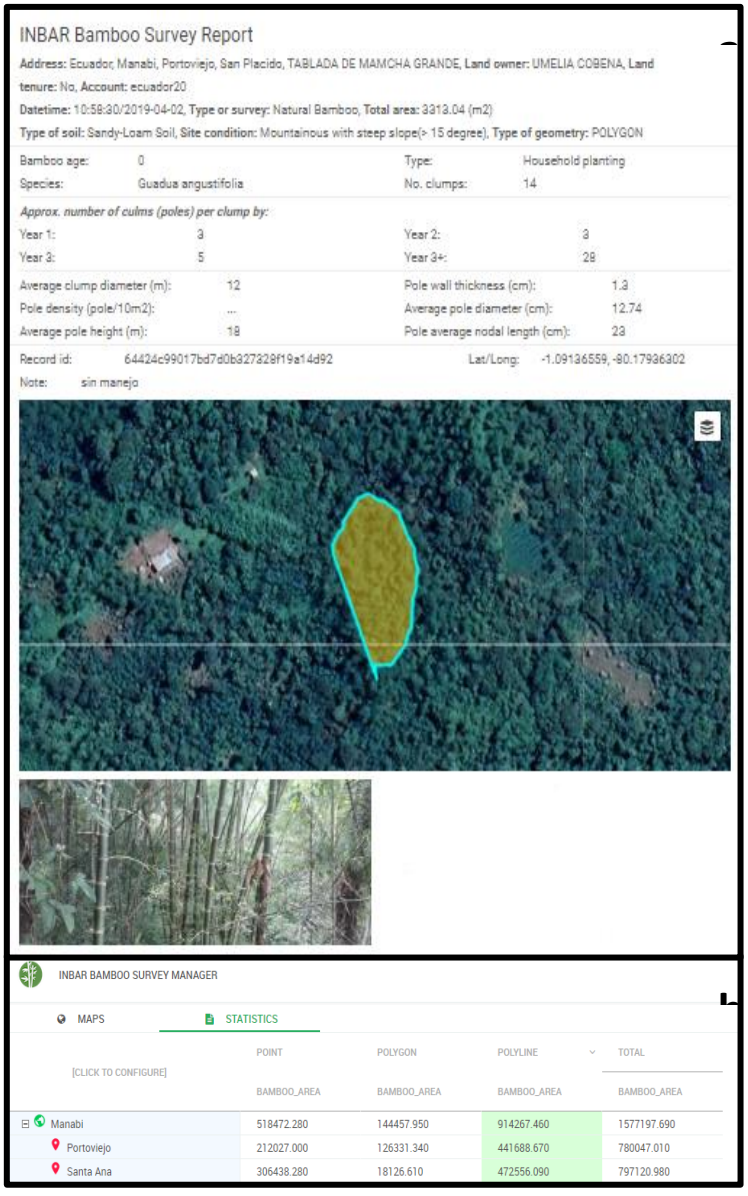
Annex 4

Image 3: a–d. Visualisation of the information collected in the online INBAR Bamboo Survey Manager system, obtained during the pilot operation of the INBAR Global Survey application in the cantons of Portoviejo and Santa Ana, March and April 2019, Manabí province, Ecuador.



Annex 5

Image 4: a. Example of a bamboo record obtained using the INBAR Global Survey application, generated from the online INBAR Bamboo Survey Manager system. **b.** Example of statistical calculations generated directly in the INBAR Bamboo Survey system based on data collected during the pilot use of the INBAR Global Survey application in the cantons of Portoviejo and Santa Ana, March and April 2019, Manabí province, Ecuador.



INBAR Bamboo Survey Report

Address: Ecuador, Manabi, Portoviejo, San Placido, TABLADA DE MAMCHA GRANDE, **Land owner:** UMELIA COBENA, **Land tenure:** No, **Account:** ecuador20

Datetime: 10:58:30/2019-04-02, **Type or survey:** Natural Bamboo, **Total area:** 3313.04 (m2)

Type of soil: Sandy-Loam Soil, **Site condition:** Mountainous with steep slope(> 15 degree), **Type of geometry:** POLYGON

Bamboo age:	0	Type:	Household planting
Species:	Guadua angustifolia	No. clumps:	14

Approx. number of culms (poles) per clump by:

Year 1:	3	Year 2:	3
Year 3:	5	Year 3+:	28
Average clump diameter (m):	12	Pole wall thickness (cm):	1.3
Pole density (pole/10m2):	...	Average pole diameter (cm):	12.74
Average pole height (m):	18	Pole average nodal length (cm):	23

Record id: 64424c99017bd7d0b327328f19a14d92 Lat/Long: -1.09136559, -80.17936302

Note: sin manejo

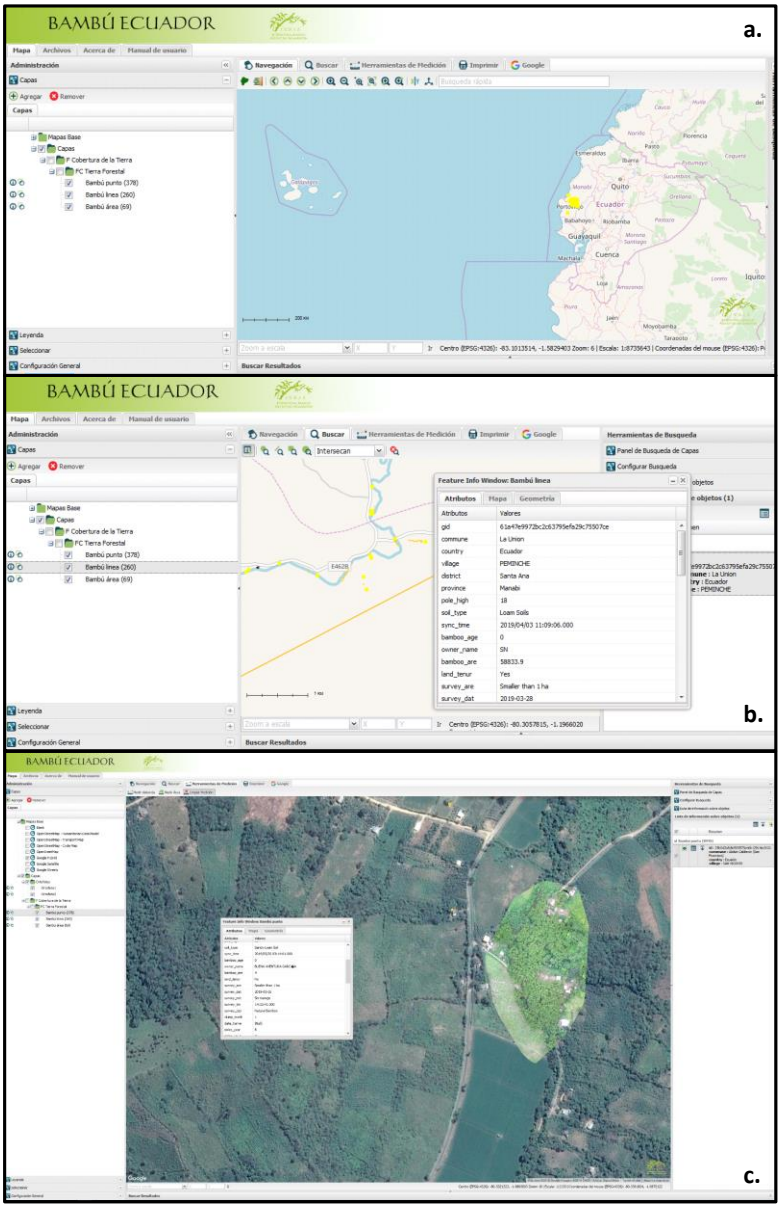
INBAR BAMBOO SURVEY MANAGER

MAPS STATISTICS

[CLICK TO CONFIGURE]	POINT	POLYGON	POLYLINE	TOTAL
	BAMBOO_AREA	BAMBOO_AREA	BAMBOO_AREA	BAMBOO_AREA
Manabi	518472.280	144457.950	914267.460	1577197.690
Portoviejo	212027.000	126331.340	441688.670	780047.010
Santa Ana	306438.280	18126.610	472556.090	797120.980

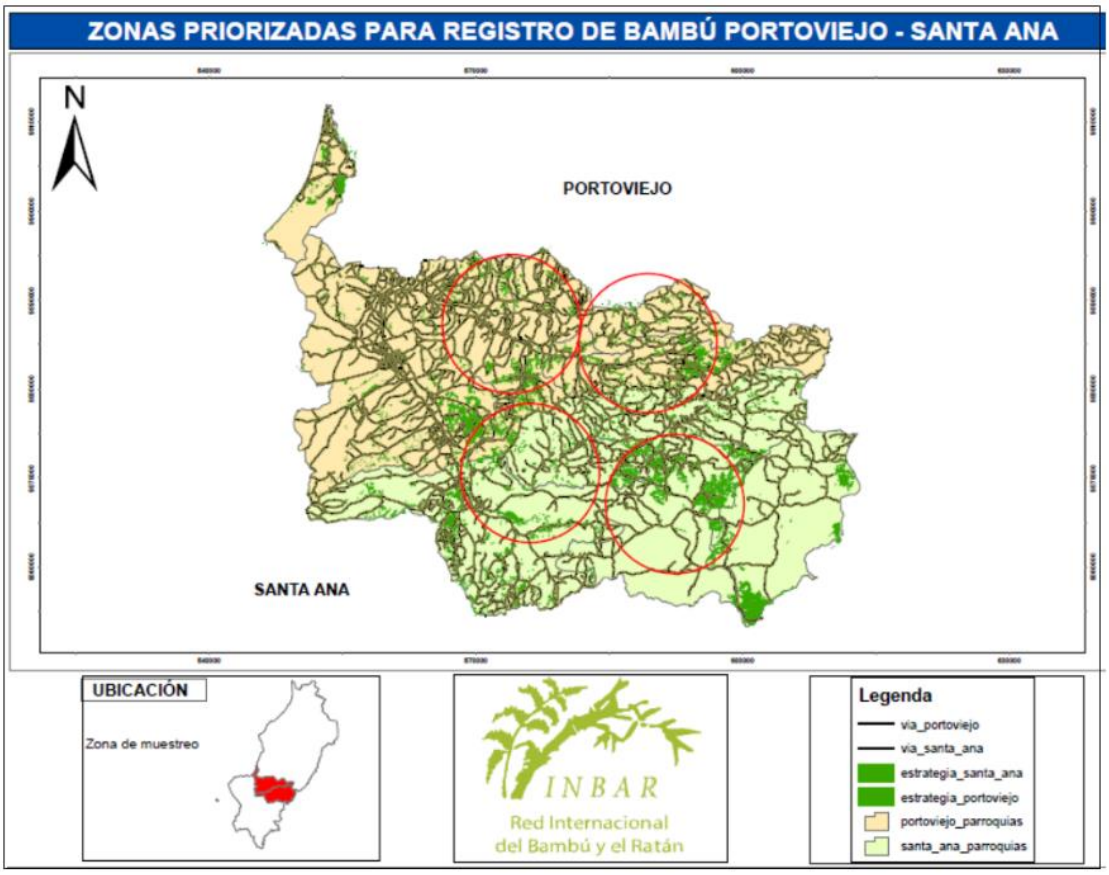
Annex 6

Image 5: a. and **b.** Geographical information visualiser, showing the bamboo data registered during the use of the INBAR Global Survey application in the cantons of Portoviejo and Santa Ana, Ecuador, 2019. **c.** Ortho-photography uploaded to the data viewer, collected with drones during the operative using the INBAR Global Survey application in the canton of Santa Ana and Portoviejo, Manabí province, Ecuador, 2019.

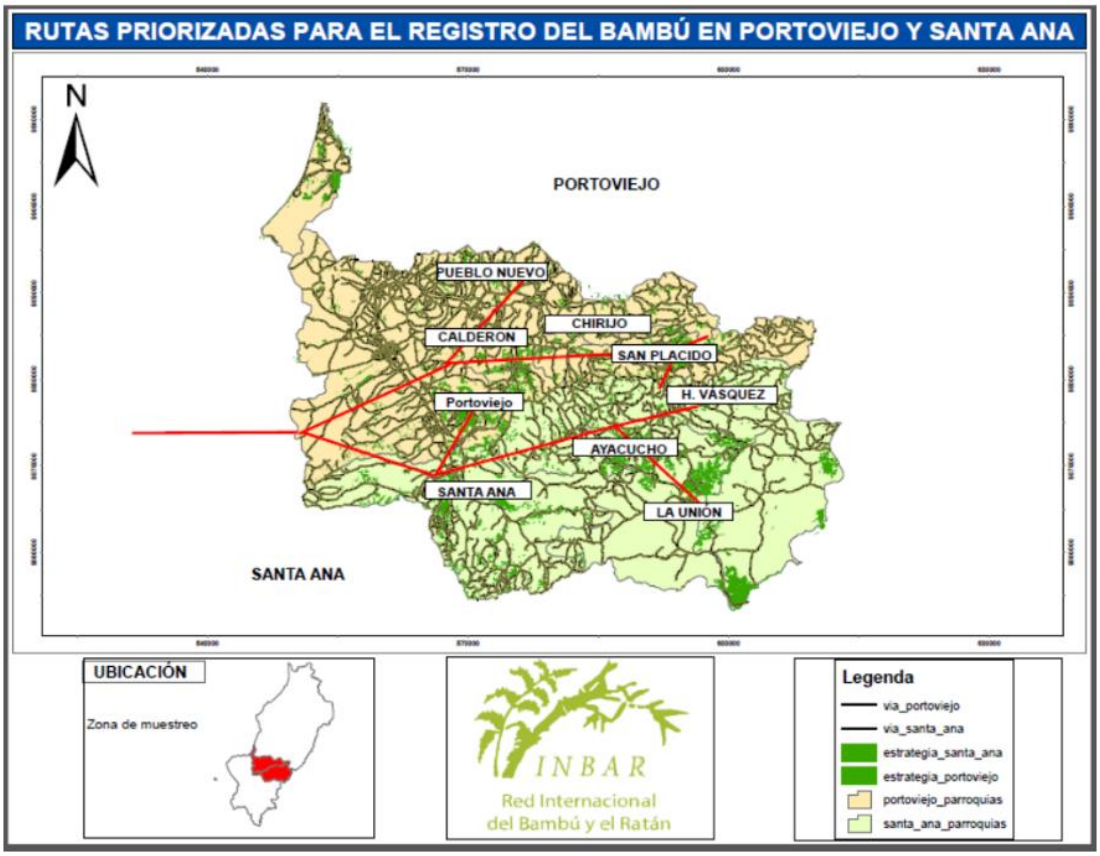


Annex 7

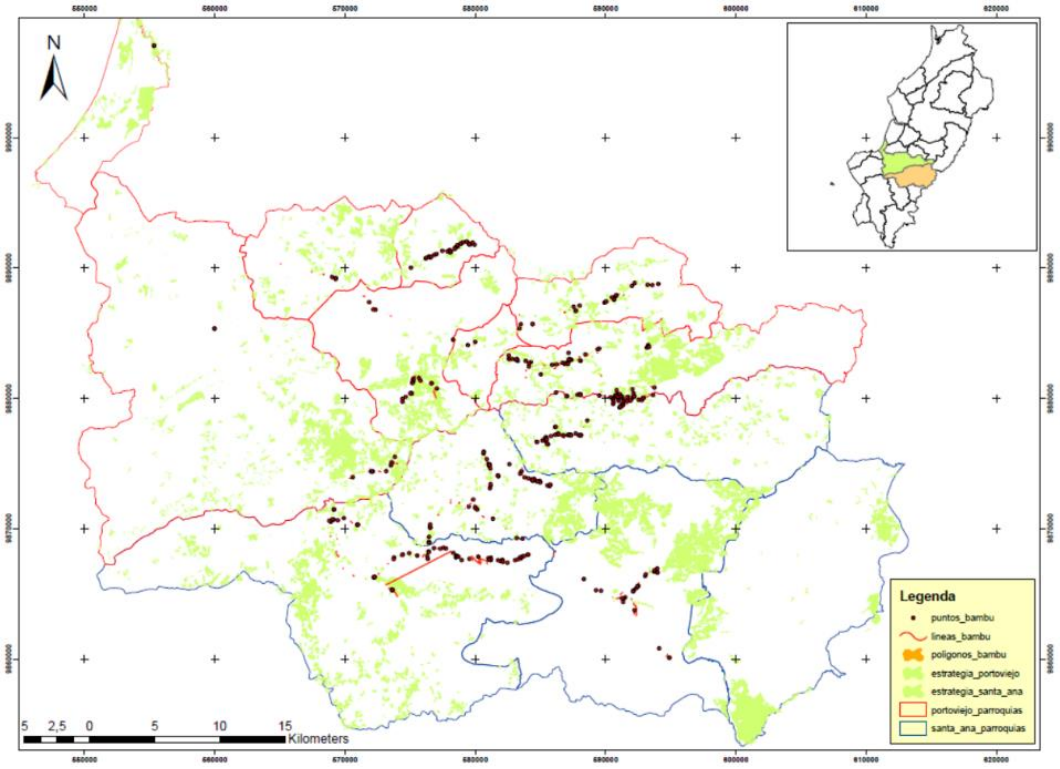
Map 1. Visual of sampling areas.



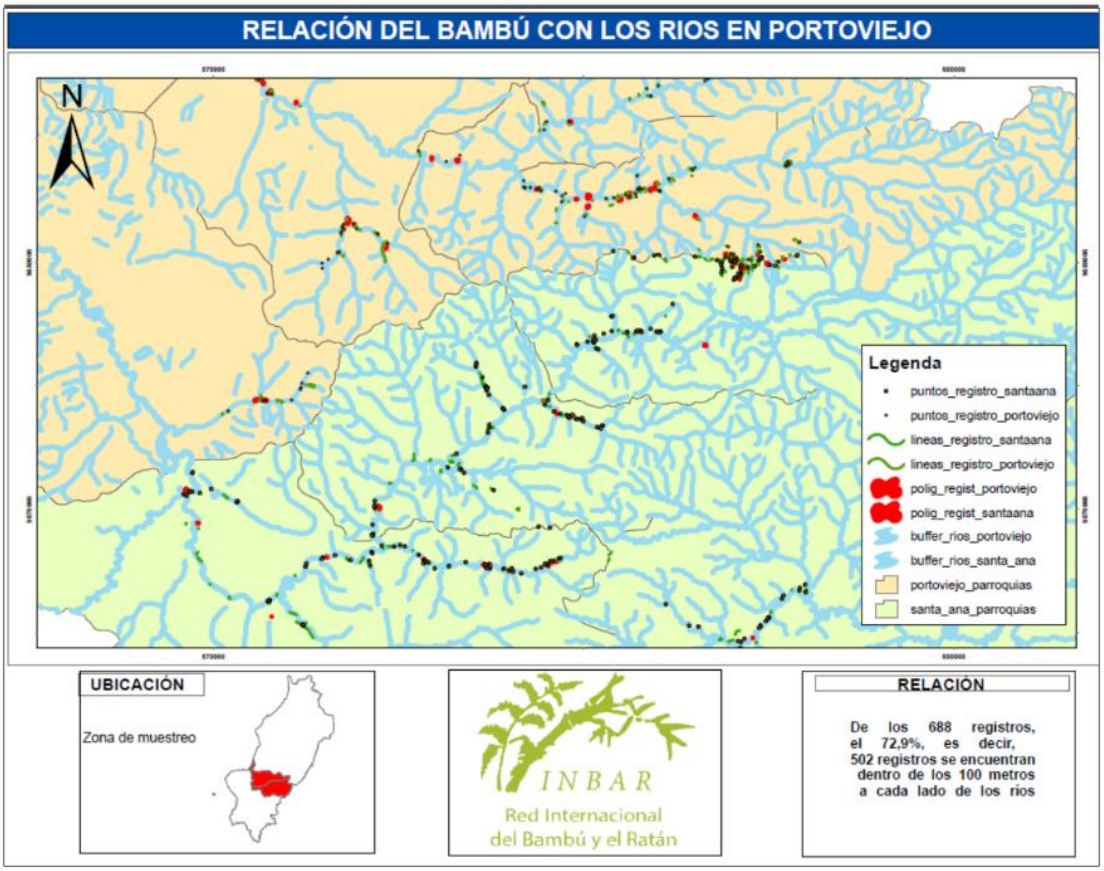
Map 2. Visual of routes used for bamboo registration.



Map 3. Visual of bamboo registered during the pilot operation and estimation of bamboo presence in the studied cantons according to the National Bamboo Strategy 2018–2022.



Map 4. Visual of the relationship between the existing bamboo recorded during the operation and the presence of rivers in the cantons of Portoviejo and Santa Ana, Manabí province, Ecuador, 2019.



Established in 1997, the International Bamboo and Rattan Organisation (INBAR) is an intergovernmental development organisation that promotes environmentally sustainable development using bamboo and rattan. In addition to its Secretariat Headquarters in China, INBAR has five Regional Offices in Cameroon, Ecuador, Ethiopia, Ghana and India.

www.inbar.int