THE IMPACT OF THE EL NIÑO PHENOMENON ON FISHING, AGRICULTURE, AND LIVESTOCK ACTIVITY IN THE SECHURA DESERT

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1. INTRODUCTION

For many years, Peru has been significantly affected by events such as the El Niño Phenomena of 1982/1983; 1997/1998; 2016/2017, bringing to light how susceptible society can be to these climactic changes and their negative consequences on infrastructure, health, economy, and more. We are currently living in a context of climate change and COVID-19 which could be increasing the intensity of these impacts on society, even more so in rural farming societies that heavily depend on environmental factors for their economic and food development. This is supported by Wang et al.'s 2019 study, which indicates that El Niño phenomena and subsequent changes in the environment will increase in frequency, aggravating this situation even more.

In the face of this uncertainty arises the need to search for and identify opportunities and alternatives to economic development which allow societies to adapt and take advantage of the positive aspects which may have been generated throughout the El Niño phenomena in Peruvian communities.

Within this context, the Sechura desert - in the northern Peruvian region of Piura - has not been exempt from the El Niño phenomena which has brought with it large floods and economic losses among the population and its economic activities (including commerce, fishing, agriculture, livestock, aquaculture, etc.). However, very little attention has been paid to the opportunities which El Niño has been generating in some farming communities located in the most arid areas of the desert. The high frequency of rains and overflowing rivers has increased the availability of freshwater and, therefore, the formation of major bodies of water in the middle of the desert.

One of the largest bodies of water which has been forming during El Niño is locally known as the "La Niña Lagoon" which, along with the El Niño event of 2017, extended to a maximum area of 2172 km^2 and a volume of $5.18x10^9$ m^3 (Escudero and Xu, 2019). This large temporary body of water has been taken advantage of by local and foreign communities, generating temporary fishing activity given the abundance of biomass and hydrobiological resources, composed mainly of mullet (*Mugil cephalus*) and tilapia (*Oreochromis sp.*) (Panta, 2015). On the other hand, the humidification of arid land in the desert has given way to agricultural development of species with short vegetative periods, as well as the abundance of pastures and natural forage contributing to livestock production, composed of sheep and goats. The events thus improve the acquisitive power of the citizens, who in previous non-Niño years have been suffering from a lack of available freshwater, subsisting on emerging and temporary agriculture and, in some cases, illegal activities such as carob tree felling.

In this sense, the project "Fishing and Farming in the Desert: a platform for understanding how to respond to El Niño in the context of climate change in Sechura, Peru", conducted through the Agrarian Development Fund (Fundación para el Desarrollo Agrario, FDA), the National Agrarian University La Molina (Universidad Nacional Agraria La Molina, UNALM), and the University of St Andrews (Scotland), has sought to quantitatively and qualitatively

understand how the last El Niño Phenomenon (2017, called “Coastal El Niño”) has generated impacts on the economic activities of desert communities.

For this, surveys were carried out among desert residents that partake in fishing, agriculture, and livestock activities, and whose activity has been carried out between 2016 and 2021, with the goal of evaluating the impact of the coastal El Niño on species catching, agricultural and livestock production, and the economic aspects of these activities.

Likewise, the search for and subsequent analysis of grey literature in databases such as those of the National Institute of Statistics (Instituto Nacional de Estadísticas, INEI), other publications, and field interviews facilitated a better understanding of how these productive activities are developed. The survey focused on villages in the districts of Sechura, near the desert and the "La Niña" lagoon. Two groups of communities were identified as possibly being impacted differently during an "El Niño" phenomenon. The first group of farmer communities is located to the northeast of Sechura, whose agricultural system is based on canal irrigation, and is close to large cities such as the capital of Sechura, Bernal, La Unión, and Catacaos. On the other hand, the second group is located between the Pan-American Highway north of Piura and Chiclayo, whose agricultural activity does not have a canal irrigation system.

Finally, this report seeks to characterise the impact of the El Niño phenomenon on the fishing, agricultural, and livestock activities of these communities in the Sechura desert as a starting point for recommendations that will lead to better resilience in the productive and commercial aspects of their activities.

2. BACKGROUND

2.1. Demographic characteristics

According to the 2017 National Census conducted by the INEI, the province of Sechura has a population of 81612 inhabitants, representing 4.23% of the population of the Piura department (1929970 inhabitants). Of these, the most populated areas are Sechura (district) and Vice with 45778 and 16290 inhabitants respectively (Table 1) (INEI, 2018).

Table 1. Rural and urban population according to district in the province of Sechura.

DISTRICT	N° Inhabitants	URBAN	RURAL
Sechura (District)	45778	44313	1465
Vice	16290	15878	412
Bernal	7176	6715	461
Bellavista de la Unión	4841	4660	181
Cristo Nos Valga	4497	2734	1763
Rinconada de Llicuar	3030	3024	6

Source: 2017 National Census (INEI, 2018).

It should also be noted that 39% of the inhabitants of the Cristo Nos Valga district come from rural areas, making it the district with the largest rural population. On average, 9.2% of the population in the province of Sechura comes from rural areas.

Table 2. Villages and settlements according to each district in the province of Sechura.

DISTRICT	VILLAGES AND SETTLEMENTS
Cristo Nos Valga	Santa Clara, Chuper, Chutupe, Mala Vida, Cerritos, Nuevo Chuper, San Ramon, Los Jardínes, Laguna de Ñapique Grande, Valverde, A.H. Alberto Älvarez Purizaca.
Bellavista	Venecia, Miraflores, San Clemente, Alto de los Santiagos, Soledad, Quinta San Joaquin, Quinta San Juan.
Bernal	Onza de Oro, Chepito, Chancay, Coronado, Santo Domingo, La Cordillera, Nuevo Pozo Oscuro, Nuevo Vega del Chilco, Nuevo Chancay, Vega del Chilco, Antiguo Pozo Oscuro, A.H. San Francisco.
Rinconada de Llicuar	Dos Pueblos, A.H. Cirilo Antón, A.H. Bernardo Ayala, Rinconada, Llicuar
Sechura	Parachique, Playa Blanca, Constante, Las Delicias, Chusis, Yapato, Belisario, Tres Cruces, La Angostura, Pampa Loro, Tajamar, Miramar, Puerto Rico, Illescas, Alto de Roque, El Sauce, Chulliyache, Bayovar, Matacaballo, El Barco, Nuevo Parachique, Las Pozas, La Capilla, La Coscola, Cabo Verde, Minchalles, Sombrero Verde, Bazan, Nueva Esperanza, Pueblo Nuevo, La Huaca, Punta Arena, La Maceta, Los Pocitos, Noria Honda, Cirilo, Pan de Azufre, Santa Rosa, Virgen de la Luz.

Vice	Chalaco, Sánchez, Becará, Letirá, La Tortuga, Santa Rosa de Satuo, A.H. San José, A.H. Las Mercedes, A.H. Virgen del Carmen, A.H. Luis Barahona, A.H. La Primavera, A.H. Nuevo San Martin, A.H. San Pedro de Becará, A.H- Señor Cautivo.

Source: Sechura Municipality, 2018.

2.2. La Niña Lagoon

2.2.1. Location

La Niña is located between the coordinates 05'49'05.7 South and 80°38'48.2 West, also known as the Bayóvar depression by the National Geographic Institute (Instituto Geográfico Nacional, IGN) because it has a depth of 37 metres below sea level (Fig 1). This water surface is exceptionally formed in the years when El Niño occurs (Deza et al., 2010; Panta, 2015). Additionally, the Ñapique and Ramon lagoons are located to the north between the coordinates 05°25'30"-05°35'35" South and 80°35'00" - 80'345'00" West, 30 km southwest of the city of Piura.

Figure 1. Location of the La Niña lagoon, Ñapique y Ramon.
(Source: Google Earth)

La Niña lagoon is bordered to the north by the districts of Bernal and Cristo Nos Valga, to the east by Pampa Monte Triste, Duna Julián Chico, Barranco, Las Salinas and Pampa Chocol, to the west by Altos Negros, Médanos Tres Brazos, Médano Blanco, and Pampa Las Salinas, and to the south by the mouth of the Virrilá estuary (GORE-Piura, 2010).

Given their proximity, the districts of Bernal and Cristo Nos Valga are the population centres with the greatest interaction with the La Niña, Ramon and Ñapique lagoons.

2.2.2. Expansion and dimensions

Due to the cyclical formation of this body of water during El Niño, many efforts have been made to calculate its dimensions and to have a precise idea of the volume of water it holds. After flying over the area in 1925, the pilot Faucett - almost disoriented by the large size of the lagoon - was able to estimate its dimensions of 60 by 40 kilometres (2400 km^2). After 73 years, the La Niña lagoon was formed again, reaching a size of 300 km long and 40 km wide (12000 km^2), with a depth of between 1 and 2 metres, and separated from the sea by a strip 5 km wide (Lillo, 1999).

Escudero (1999), quoted by Escudero and Xu (1999), estimated the maximum extent of the lake through satellite imagery, which amounted to 2325 km^2 in March 1998 and decreased over the following months (Fig 2).

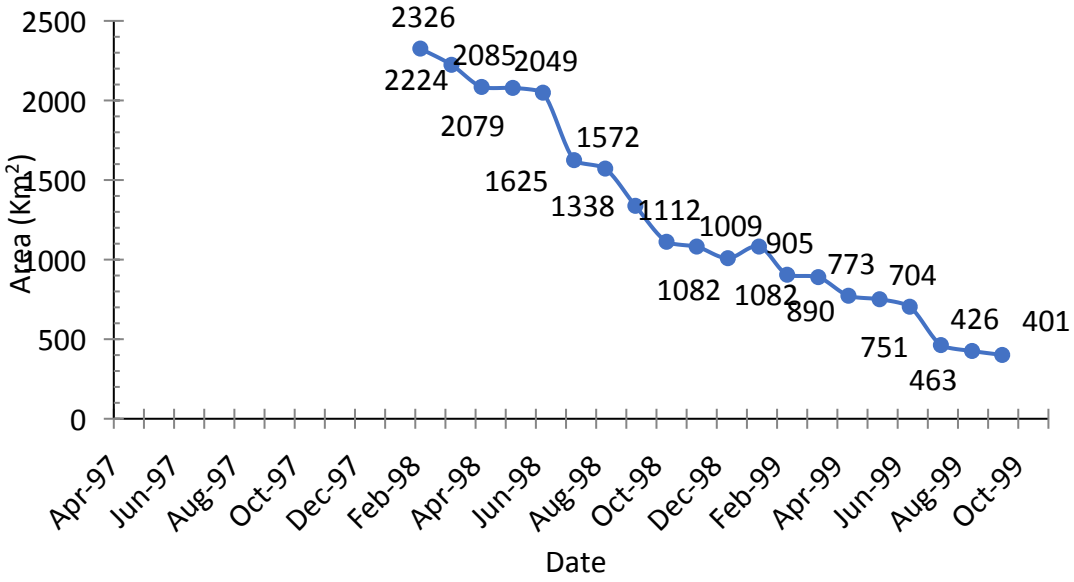

Figure 2. Area of the La Niña lagoon from March 1998 to November 1999 (Taken from Escudero and Xu, 2019).

Likewise, reports by Deza et al. (2015), who evaluated the La Niña lagoon between November (2009) and March (2010), show its greatest expansion in March, calculating an average area of 20 km by 10 km (200 km^2). Then, in November, it decreased to as size of 10 km long by 6 km wide (60 km^2).

Recently, during the 2017 Coastal El Niño event, MODIS-AQUA satellite images were analysed to monitor the formation and evolution of the La Niña lagoon between January and November of that year. The lagoon began to form in late January and reached a maximum extent of 2,172km^2 in early April (Escudero and Xu, 2019).

2.2.3. Changes in water volume

Almost at the centre of the desert (5° 40' South, 80° 41' West), inthe area occupied by the La Niña lagoon, there is a remarkable depression that occupies an area of approximately 185 km^2 and reaches a maximum depth of 37m below sea level (IGN, 1995 cited by Deza et al., 2010). Therefore, this lagoon has 200 million cubic metres of freshwater suitable for

irrigation at the end of summer. In November, its volume reaches 60 million cubic metres. Naturally dammed, this lagoon is equivalent to the Poechos dam, twice as much as the San Lorenzo dam (Piura), part of Tinajones (Lambayeque), and a third of the Gallito Ciego dam in the Jequetepeque valley (Deza et al., 2010).

Thanks to satellite data analysis by Escudero and Xu (2019) throughout the months of January to November during the 2017 Coastal El Niño event, it was estimated that the maximum volume of water reached in the La Niña lagoon was in April, with an estimated $5.18*10^9$ m^3 (far higher than that calculated by Desa et al., 2010), which decreased over the months (Fig. 3).

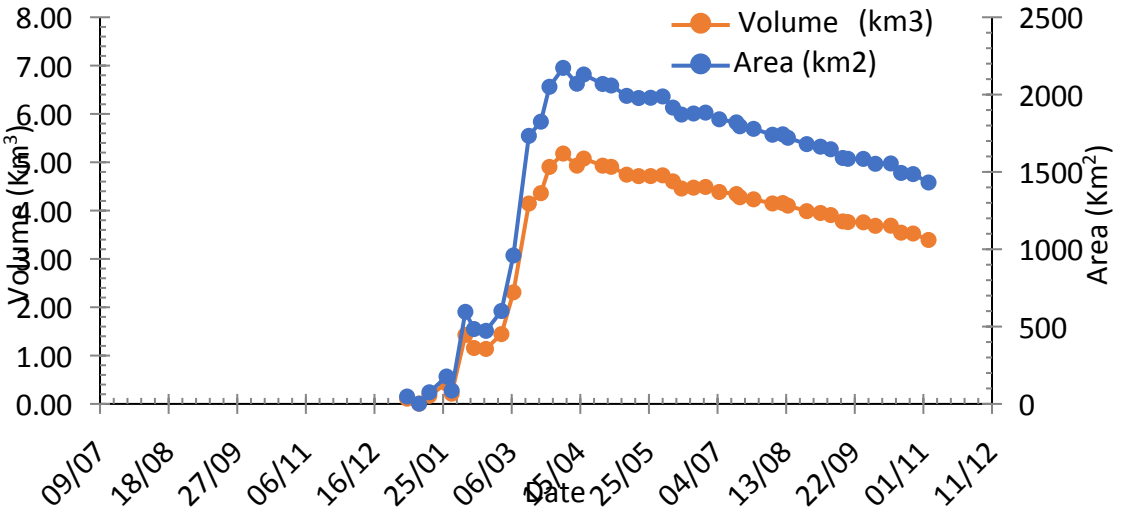

Figure 3. Area and volume of the La Niña lagoon, January to November 2017 (Escudero and Xu, 2019).

The increased flow of the Piura River between February and April was the main cause for the formation of the lagoon in the lower Piura areas. However, the data does not surpass the records of the 1982-83 and 1997-98 El Niño events. The maximum flooded area of the La Niña lagoon was 2,326 km^2 in 1998, 6.6% higher than that of 2017 given that the flows were higher for the 1997-1998 El Niño event (Escudero and Xu, 2019).

2.3. Continental fishing activity

2.3.1. Socioeconomic characteristics

The province of Sechura has 641 fishermen whose activity is carried out in continental environments: 112 of them live in the district of Bernal and 104 in the district of Cristo Nos Valga. Both districts represent 33.7% of the fishermen registered at the provincial level (Fig. 4). However, the largest number of fishermen are located in Sechura (district) and Vice.

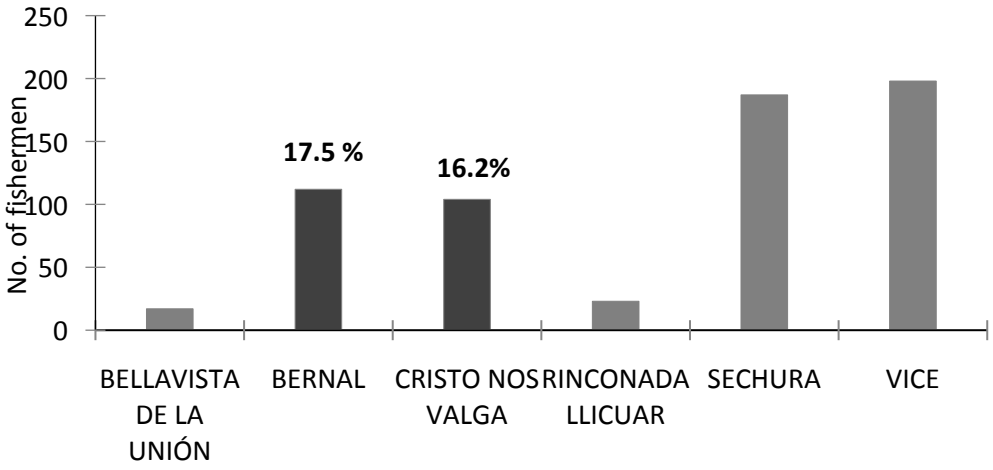

Figure 4. Number of registered fishermen in the districts of the Sechura province. (Source: INEI, 2020)

On the other hand, 62.5% of fishermen in Bernal and 39.42% in Cristo Nos Valga listed fishing as their main economic activity (Fig. 5). These results coincide with Paico (2016) who indicates that 39% of the 500 families in Cristo Nos Valga carry out artisanal fishing activities in nearby lagoons such as Ñapique or Ramon. The majority of fishermen who have fishing as a secondary activity are mostly engaged in agriculture (78% and 76% in Bernal and Cristo Nos Valga, respectively) (Fig. 6). In smaller amounts, they are also shown to be engaged in livestock, construction, and sea fishing in both districts.

Likewise, 66.1% of fishermen in Bernal and 52.9% in Cristo Nos Valga stated that the reason they chose to be artisanal fishermen was because of economic necessity; and 31.3% in Bernal and 47.1% in Cristo Nos Valga said it was due to family tradition. Only 2.7% of the fishermen in Bernal stated that this activity offers them the possibility of development. Additionally, 63% of fishermen in Bernal and 44% in Cristo Nos Valga have more than 10 years of experience (INEI, 2020).

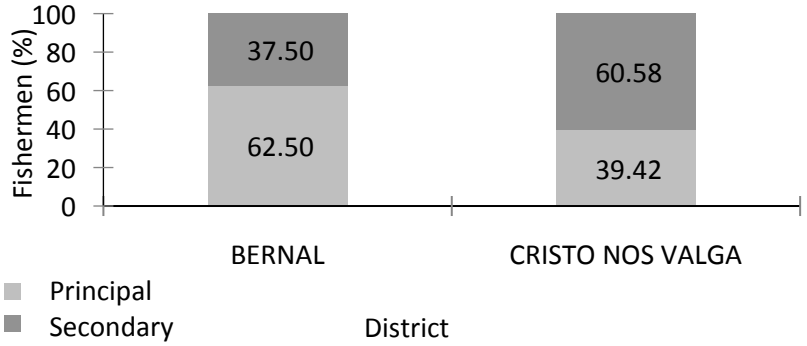

Figure 5. Proportion of registered fishermen in the districts of Bernal and Cristo Nos Valga who fish as their main or secondary activity. (Source: INEI, 2020)

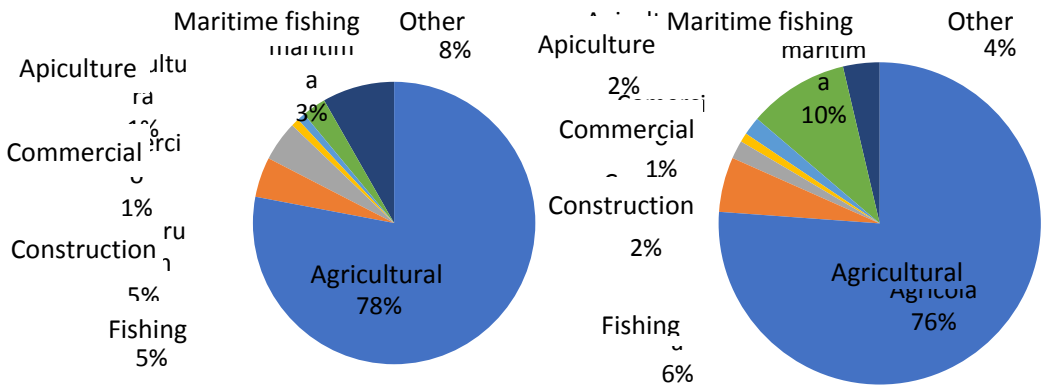

Figure 6. Other economic activities developed by the registered fishermen from the Bernal (left) and Cristo Nos Valga (right) districts. (Source: INEI, 2020).
Note: The information provided allows multiple answers.

3 associations of artisanal fishermen (OSPAs) belonging to the districts of Bernal and Cristo Nos Valga have been identified from the Ministry of Production database (PRODUCE, 2020a). In Bernal, there is the "Asociación de Pescadores Artesanales Señor Cautivo" (Señor Cautivo Association of Artisanal Fishermen) and the "Gremio de Pescadores de Santo Domingo para pescar en La Laguna La Niña en Balsilla" (Santo Domingo Fishermen Guild to fish in the La Niña lagoon on rafts), with 5 and 57 members respectively. In Cristo Nos Valga, the "Asociación De Pescadores Artesanales Acuicultores Marcer" (Marcer Association of Artisanal Fishermen and Aquaculturists) has been registered with 04 members. Due to the proximity of these districts to the "Ñapique" and "Ramón" lagoons, it is possible that they are related to the continental fishery that takes place in the area.

2.3.2. Fishing areas

Lagoons are the main bodies of water where inland fisheries are carried out in Bernal and Cristo Nos Valga. In the district of Bernal, fishermen from the villages of "Bernal", "Nuevo Pozo Oscuro", and "Nuevo Vega del Chico" fish only in lagoons; likewise, other villages such as "Cordillera", "Onza de Oro", and "Pozo Oscuro Antiguo" among others, fish in rivers, marshes, canals, streams, and lakes. Additionally, fishermen in the villages of Cristo Nos Valga fish almost entirely in lagoons, while a small group fish in rivers (INEI, 2020).

For both districts, the Ñapique lagoon is one of the main fishing areas, followed by the La Niña lagoon, the formation of the latter depending on the occurrence of a strong El Niño phenomenon such as those of 1983 or 2017. Likewise, the Ramon lagoon is rarely mentioned as a fishing area, probably because it is currently used as farmland (Fig. 7).

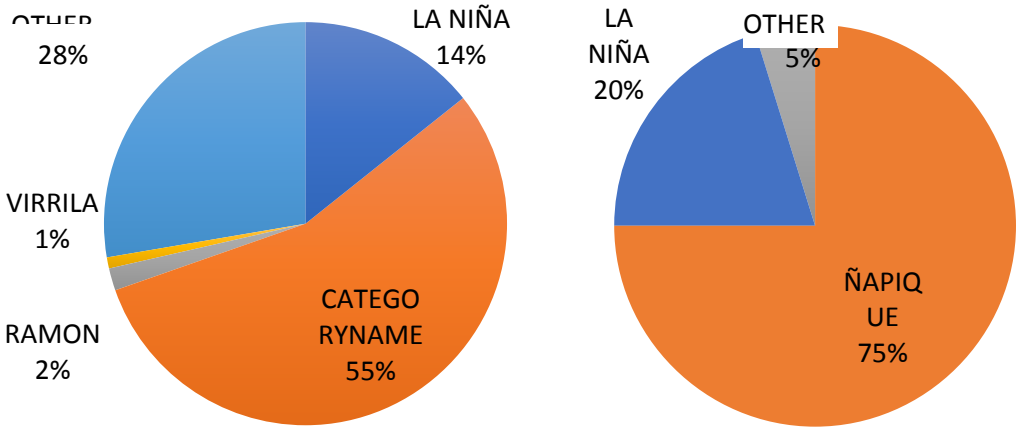

Figure 7. Lagoons where fishing activities are carried our for fishermen of the Bernal and Cristo Nos Valga districts. (Source: INEI, 2020).

Panta (2015) was able to identify 7 fishing areas in the La Niña lagoon (Pan de Azufre, Palo Parado, La Niña-Sector Sur, Lechuzal, Huaquillas, Vega Lejía, El Peñal) and 9 in the Ñapique lagoon (Ñapique Chico, Zona turística, Zona Vilela, Zona Pazos, Cabecera Ñapique, Zona Martínez, Colorado Tizal, Colorado, Balneario) (Fig. 8 and Fig. 9).

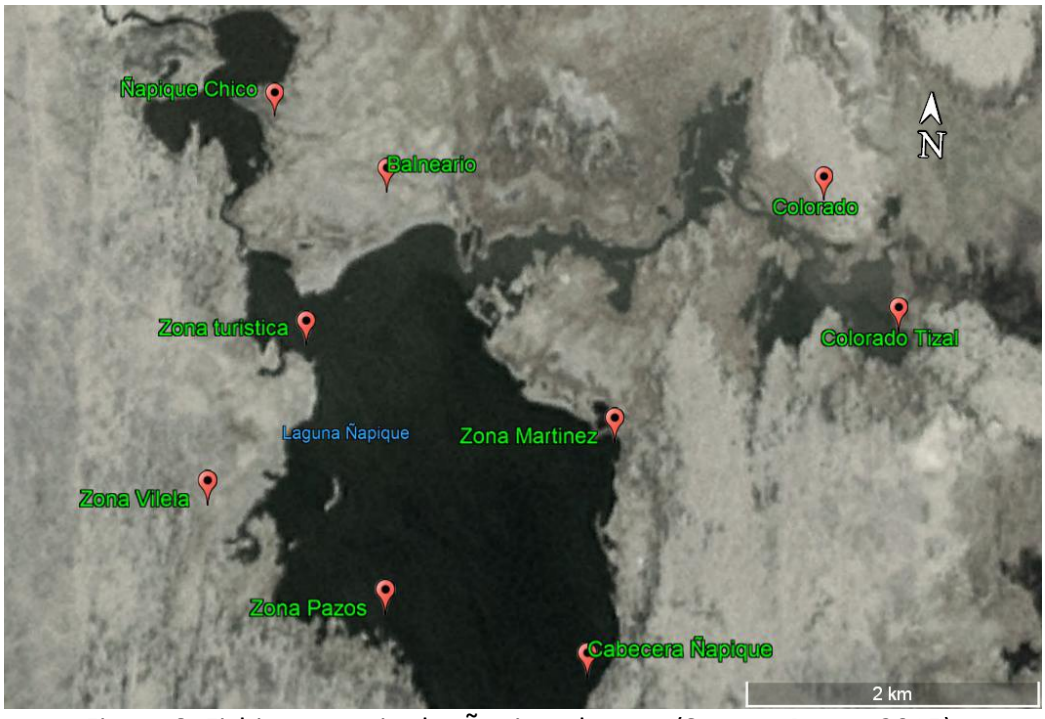

Figure 8. Fishing areas in the Ñapique lagoon (Source: Panta, 2015).

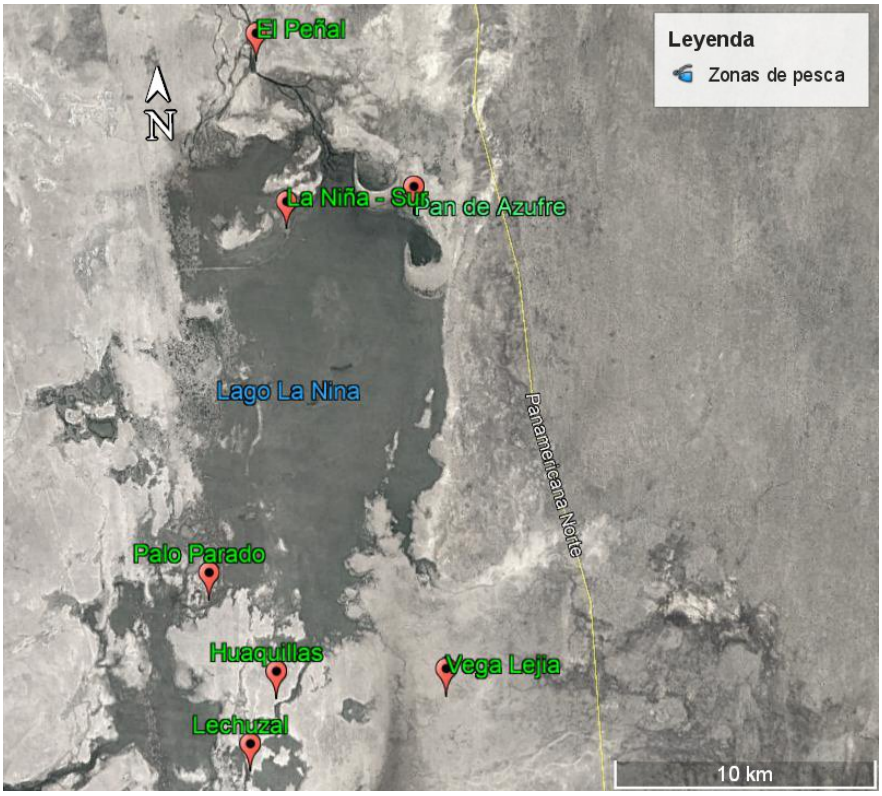

Figure 9. Fishing areas in the La Niña lagoon (Source: Panta, 2015).

2.3.3. Fishing trips and species composition

According to I CENPESCO, the fishing activity in Bernal and Cristo Nos Valga between August 2012 and July 2013 was most intense (number of active fishermen) in the months of January to March (summer) and less intense from July to September (winter), as shown in Fig. 10. Likewise, the duration of a fishing trip is no more than 1 day for 98% of fishermen in Bernal and 83% in Cristo Nos Valga. In the latter district, 15% of fishermen fish for between 1 to 3 days and 2% could fish for between 4 to 6 days (INEI, 2020).

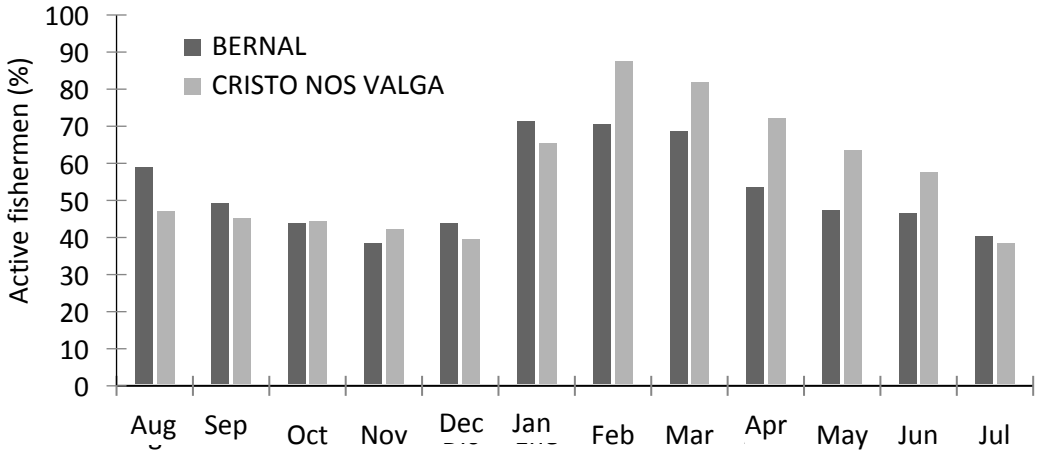

Figure 10. Percentage of active fishermen in the districts of Bernal and Cristo Nos Valga per month, between August 2012 and July 2013 (Source: INEI, 2020).

It should be noted that there is no record of the total Se termina de hacer una agenda para la reunion con Nina e Iona, asimismo se tiene una reunion con Nina donde se tratan diversos temas de los proyectos. Por otro lado se tiene que posponer la reunion con Cristina hasta masomenos el viernes de la siguiente semana asi mismo coordinar otra vez la entrega de el documento de correccion hecho por sus tesistas. catch volumes in the lagoons in the local statistics, probably due to the limited access to the area and the lack of presence of any government entity to monitor or collect information. Legal provisions, such as the ministerial resolution (RESOLUCIÓN MINISTERIAL) N° 263-2019-PRODUCE, authorised IMARPE to study fish biomass in the La Niña lagoon, however, this was not carried out due to budgetary issues, according to IMARPE in Decree N°455-2021-IMARPE/OGA.

Despite this, studies by Panta (2015) could shed light on how fishing develops in non-Niño years. In this regard, an average total catch of 6387 kg/month was reported for the winter and spring seasons between June 2013 and June 2014 in the Ñapique lagoon - decreasing from 5850 to 1362 kg/month in the following seasons (autumn 2014). On the other hand, the catch varied considerably in the La Niña lagoon, with 3030 kg/month recorded in autumn 2013 (taking into account that only June 2013 was assessed). After that period, there was a drop in extraction ranging from 1059 kg/month to 3 kg/month and, finally, in autumn 2014, some species of mullet, tilapia, and catfish were only found in one of the fishing areas, but in sizes too small for marketing. Some of the La Niña areas were completely dry, or, in some cases, there were stagnant waters that did not allow for the survival of the resource.

Likewise, results from the I CENPESCO show that daily individual catches present a progressive increase in the mean and variation of catches between the months of January and July for both districts, probably as a result of the bodies of water formed by the rains in the summer season (Dec-Feb) which then decrease between August and November (Fig. 11).

Figure 11. Total individual catch per month (August 2012 and July 2012) per fishermen from Bernal and Cristo Nos Valga (Source: INEI, 2020).

On the other hand, the individual catch shown between August and December (months without rain) is higher in Bernal than in Cristo Nos Valga. This could be due to the availability of other bodies of water such as rivers and marshes that, unlike Cristo Nos Valga, the inhabitants of Be AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL fishing areas.

According to the AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL *Mugil cephalus*) and tilapia (*Oreochromis niloticus*); other species such as peled, catfish, carp, and river shrimp, among others, are mentioned in smaller proportions (Fig. 10) (INEI, 2020). Panta (2015) was able to identify the commercial species caught in one year, between June 2013 and June 2014, which are shown in Table 3.

It is important to note that it is very common for species such as tilapia (*Oreochromis niloticus*) or mojarra (*Andinoacara sp.*) to be commonly referred to by fishermen as "trout", which could be confused with the species *Oncorhynchus mykiss* that are unable to develop in the area given the type of water and temperatures.

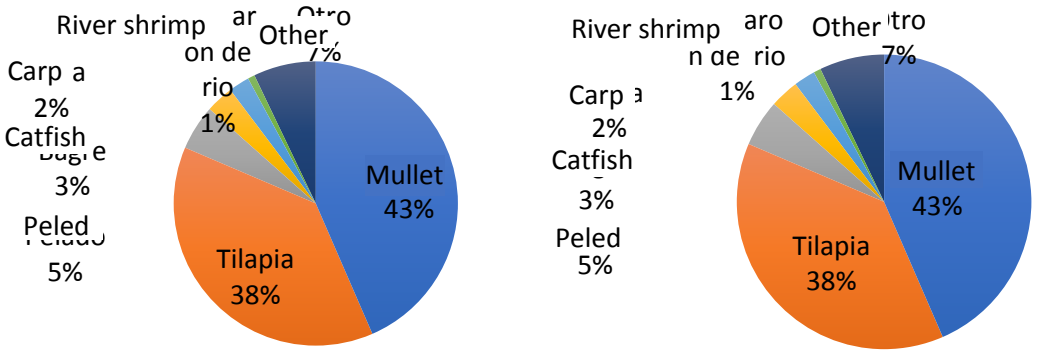

Figure 12. Species caught mentioned by fishermen of Bernal and Cristo Nos Valga (Source: INEI, 2020)

Table 3. Commercial species caught in the Ñapique and La Niña lagoons throughout June 2013 and June 2014. (Source: Panta, 2015).

No.	SPECIES	Common name	Common name (in Spanish)	Ñapique lagoon	La Niña lagoon
1	*Brycon atrocaudatus*	[South American trout]	Cascafé	x	x
2	*Bryconamericus brevirostris*	[South American trout]	Cachuelo	x	x
3	*Bryconamericus peruanus*	Shad	Sábalo	x	x
4	*Landonia Latidens*	(Little) White	Blanquito	x	
5	*Lebiasina bimaculata*	Two spotted lebiasina	Guavina, charcoca	x	x
6	*Cyprinus carpio carpio*	Common carp	Carpa común	x	x
7	*Cyprinus carpio specularis*	Mirror carp	Carpa espejo	x	x
8	*Gambusia affinis*	[Mosquitofish]	Gambusia	x	
9	*Mugil cephalus*	Big-headed mullet	Lisa cabezona	x	x
10	*Mugil curema*	White mullet	Lisa blanca	x	x
11	*Andinoacara rivulatus*	Blue bream	Mojarra azul	x	x
12	*Andinoacara stalsbergi*	Green bream	Mojarra verde	x	x
13	*Oreochromis niloticus*	Nile tilapia	Tilapia del Nilo	x	x
14	*Tilapia rendalli*	White tilapia	Tilapia blanca	x	x
15	*Trichomycterus sp.*	Catfish	Bagre	x	x
16	*Chaestostoma breve*	Catfish	Carachama	x	

2.3.4. Catch and commercialisation volumes

78.77% of catch in Bernal is destined to be sold, while in Cristo Nos Valga it is 75.71%. Own consumption is represented by a percentage of 35.45% in Bernal and 42.55% in Cristo Nos Valga. In smaller proportions, 14.55% and 10.83% are destined to be traded in both districts respectively (Fig 14).

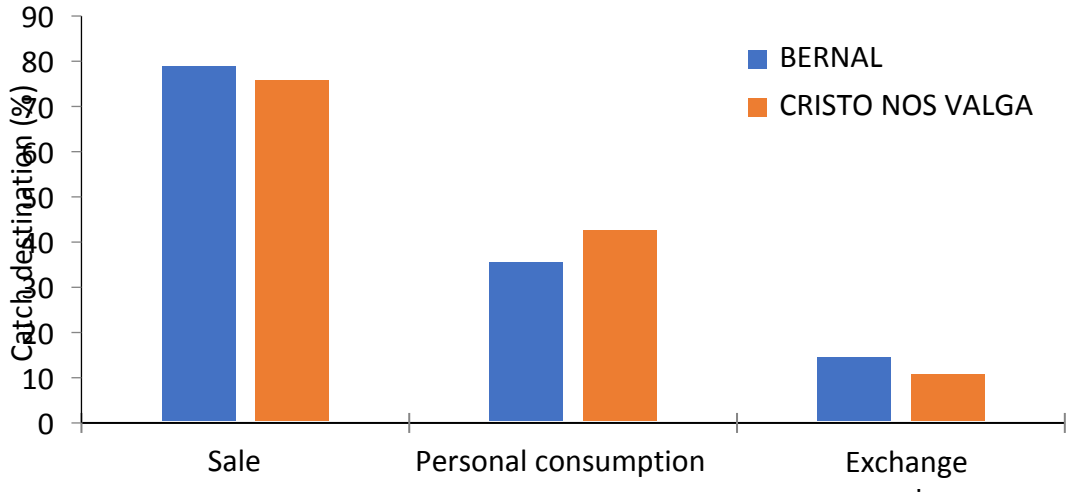

Figure 13. Proportion of catch according to destination for the fishermen of Bernal and Cristo Nos Valga (Source: INEI, 2020).

Paico (2016) states that, from the total catch of the species from the Ñapique and Ramon lagoons in April 2009 (non-Niño year), 50% of mullet caught (*Mugil cephalus*) is destined for sale and the rest is for own consumption. In the case of tilapia (*Oreochromis niloticus*), 65% of the catch is destined for own consumption and 35% for distribution in nearby markets such as Sechura, La Unión and, in special cases, Chiclayo. Likewise, 100% of catfish catch (*Trichomycterus sp.*) is destined for sale, specifically to the Chiclayo market, since there is no reported demand in the local market. On the other hand, 90% of the carp catch and 100% of the bream catch is destined for own consumption.

2.4. Aquaculture Activity

The aquaculture activity in these districts is low given the limited availability of water during normal or "non-Niño" seasons. The results of the I CENPESCO show that Bernal only has 1 aquaculture producer of tilapia, mullet, and ornamental species, whose centre of production develops the activity both extensively and informally (INEI, 2020). On the other hand, the results of the National Aquaculture Cadastre (Catastro Acuícola Nacional) indicate the registration of 01 aquaculture producer in Bernal in the Coronado village and under the AREL (Aquaculture of Limited Resources) modality, whose activity is based on the breeding of the Nile Tilapia (*Oreochromis niloticus*) with an extension of 0.01 ha (PRODUCE, 2020b).

It is possible that the only study with technical information is the one developed by Juarez (2012) with the culture of white shrimp (*Litopenaeus vannamei*) in the Ñapique lagoon, carried out through floating cages of 3m long by 2m wide and 1.2 m deep in a 5-metre-deep area of the Ñapique lagoon. It started with the acclimatisation of larvae and the growth of

pre-offspring in 60 days, finally achieving a gestation period of 120 days, with an average individual weight of 7.21 grams at a concentration of 550 ind/m^2. In that sense, a white shrimp culture campaign could be carried out in 180 days (6 months). This research shows that shrimp farming could be carried out in 3 to 4 seasons once the lagoon is full, taking into account the time it takes for La Niña to dry out.

Finally, Paico (2016) reported that the inhabitants of the Ñapique and Ramon lagoons have developed a form of artisanal farm for catfish species (*Trichomycterus sp.*) in which, instead of being caught, it is held in captivity until it reaches a commercial weight and size.

2.5. Agriculture and livestock activity in the research area

2.5.1. Agriculture

2.5.1.1. Socioeconomic characteristics

According to the INEI, the "agricultural unit" (unidad agropecuaria, UA) is defined as the land or set of land used fully or partially for agricultural production, including livestock, conducted as an economic unity by an agricultural producer regardless of size, tenure regime, or legal status. Similarly, a "plot" is defined as all the land within the agricultural unit which has no territorial continuity with the rest of the land within the original agricultural unit and is located within the same census district or area. An agricultural unit is considered to be divided into plots when its land is separated by roads, rivers, streams, etc. or by productive or uncultivated land that are not part of the unit (INEI, 2012).

The province of Sechura has a total of 8730 agricultural units (UA) which are divided into 16974 plots. The districts of Bernal and Cristo Nos Valga have 2492 and 963 UAs which represent 39.34% of the UAs in the province. Additionally, Bernal and Cristo Nos Valga have a total of 4805 and 1746 plots respectively, both representing 38.6% of total plots in the province (Fig. 16).

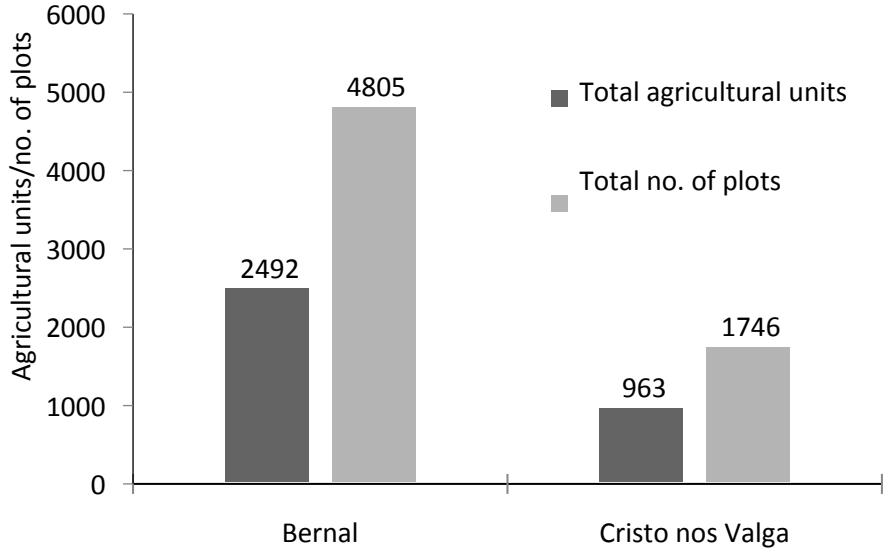

Figure 14. Total number of agricultural units and plots (Source: INEI, 2012).

On the other hand, Bernal has a total agricultural surface area of 3967 ha and Cristo Nos Valga has 2781 ha, representing 20.45% and 14.34% of the total agricultural surface area in Sechura respectively. Similarly, the data obtained by CENAGRO (INEI, 2012) facilitated the calculation of the average plot surface area for each district, that being of 1.61 ha (sd=2.68) for Bernal and 2.89 ha (sd=3.18) for Cristo Nos Valga.

It is worth noting that agricultural surface area is made up of fallow land, land with transitory crops, land with permanent crops, unworked land, and others. In 2012, 48% and 52% of the agricultural surface area in Bernal and Cristo Nos Valga respectively was fallow land, indicating the significant use of this technique which consists of not sowing for one or more seasons in order to recover its natural fertility, during which time some amendments may be added to the soil. However, it could also be attributed to the limited availability of water or economic resources which prevent farmers from sowing the total surface area of their land. In addition to this, land under transitory crops accounted for 38% of the total agricultural area in Bernal and 27.6% in Cristo Nos Valga (Fig. 17).

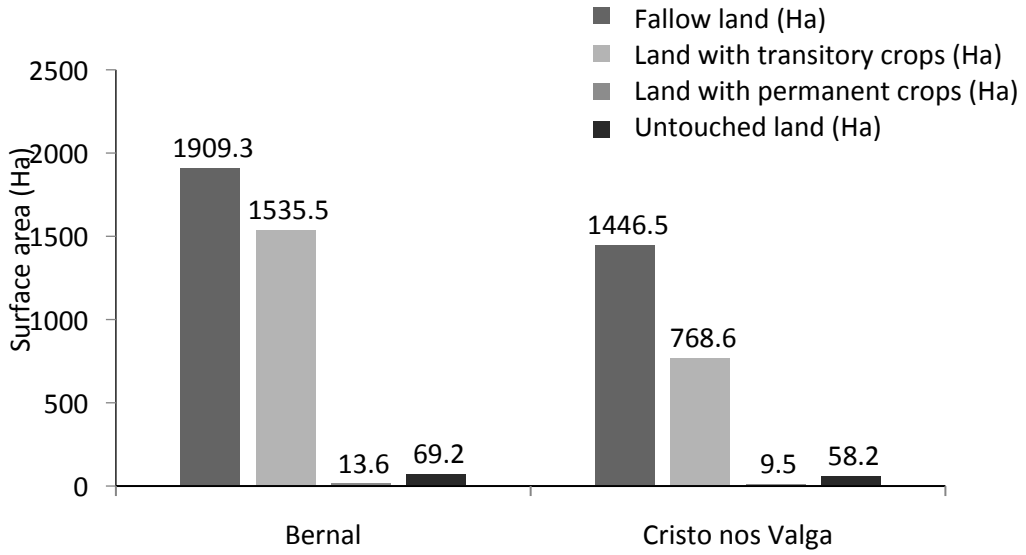

Figure 15. Agricultural surface area in hectares in the districts of Bernal and Cristo Nos Valga (Source: INEI, 2012).

Regarding the tenure status or regime, 68.9% of farmers in Bernal indicated that they are owners of their plots, followed by 13.5% who indicated that they are tenants of the land they cultivate. In Cristo Nos Valga, 51.7% of the farmers indicated that they are owners of their plots, 41.3% are possessors, and 5.1% are tenants. With regards to the area managed under these different tenure regimes, Bernal has 2692.7 ha and Cristo Nos Valga has 984.8 ha. With regard to the possession regime, Cristo nos Valga has 1670.3 ha and Bernal has 460 ha (INEI, 2012).

Likewise, the main reason they decided to plant the current crops, and the most frequent response for both districts, was because they are crops that generate little expense both in sowing and in their management. 34.4% of producers in Bernal and 52.2% in Cristo Nos Valga agreed on the low-cost incentive of these crops. They were also asked if the agricultural activity produced enough income to cover their expenses, and both districts

mostly responded that it did not generate the necessary income. In the case of Bernal, 76.3% responded that it was not enough, and 78.5% in Cristo Nos Valga expressed the same. This shows that this economic activity is purely for subsistence and does not provide them with enough income to be able to have a better standard of living (INEI, 2012).

Because of this, agricultural producers diversify their activities at different times of the year, partaking in other activities that can generate more income. In the district of Bernal, 62.39% of the producers mentioned that during the year they stop working in their agricultural unit to obtain another type of income in different activities, whereas this percentage is higher for the district of Cristo Valga, with 74.87% of the producers change their activity. Thus, a large majority diversify to other activities in the agriculture, livestock, and fishing sectors, followed by commerce, transport, and construction (Fig. 16).

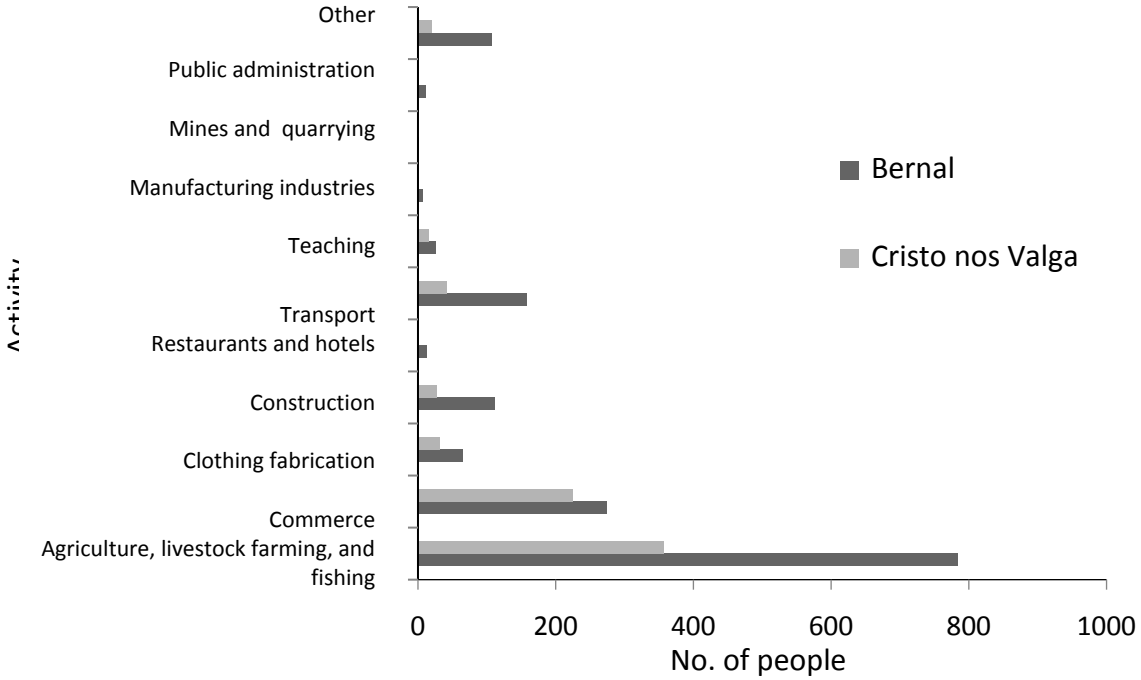

Figure 16. Main activity carried out when leaving work in the agricultural unit (Source: INEI, 2012).

2.5.1.2. Main crops

a) Transitory crops

Table 4 outlines the main transitory crops produced in the district of Cristo Nos Valga and the total surface area they occupy, the most significant ones being corn and maize with approximately 40% coverage, as well as legumes such as beans and Egyptian bean (zarandaja*)* with 30% coverage.

Table 4. Surface area of the main transitory crops in Cristo Nos Valga (Source: INEI, 2012).

Crops	**Surface area harvested**

	Ha	%
Hard yellow corn	184.9	22.11
Maize	153.3	18.33
Egyptian bean (zarandaja)	141.9	16.98
Beans	111	13.27
Pumpkin	63.6	7.60
Sweet potato	62.95	7.53
Watermelon	19.2	2.30
Lima beans	16.25	1.94
Maize-beans	13	1.55
Broad beans	8.97	1.07
Beans-sweet potato	8.41	1.01
Corn-sweet potato	6.9	0.83
Pumpkin-sweet potato	6.6	0.79
Beans-pumpkin	5.25	0.63
Other	33.99	4.06
Total	836.3025	

Similarly, in Bernal, beans occupy 38.5% of the sown area, followed by rice with 26.37%, yellow maize and corn with 20%, and others (Table 5). According to the scheduled development plan of the Sechura province, the province was one of the main producers of cotton in Peru until 1992, with a participation of over 10% at the national level. However, a crop reconversion began at the beginning of the 2000s, mainly towards rice, maize, and other products, discarding cotton production. In addition to this, the district of Bernal is one of the largest producers of cotton with the best quality in the Peruvian market, but, given its low price, many of farmers have converted their crops to other more profitable crops.

Table 5. Surface area of the main transitory crops in the district of Bernal (Source: INEI, 2012)

Crops	Surface area harvested	
	Ha	%
Beans	624.21	38.58
Rice	426.64	26.37
Hard yellow corn	232.41	14.37
Maize	109.98	6.8
Watermelon	43.34	2.68
Lima beans	35.98	2.22
Corn-beans	30.05	1.86
Sweet potato	20.4806	1.27
Egyptian beans	16.28	1.01

(zarandaja)		
Pumpkin-sweet potato	8	0.49
Fruit orchard	7.62	0.47
Beans-sweet potato	7.27	0.45
Pumpkin	6.42	0.4
Alfalfa	5.39	0.33
Other	43.725	2.7
Total	**1617.7956**	

b) Permanent crops

Permanent crops are those produced from plants that last for many seasons instead of being replanted after each harvest. In the district of Bernal, 27.7% of all plots have fruit trees, and in the district of Cristo Nos Valga, 22.5% of the plots have fruit trees (INEI, 2012).

Bernal and Cristo Nos Valga have 15500 and 4417 total fruit trees respectively, and the average number of fruit trees per plot is approximately 11 trees in Bernal and 12 trees in Cristo Nos Valga. Figures 17 and 18 show the total number of fruit trees per species planted in Bernal and Cristo Nos Valga: banana, coconut, mango, and tamarind have the highest number of plants in both districts.

Figure 17. Number of fruit trees by type in the Bernal district (Source: INEI, 2012).

Figure 18. Number of fruit trees by type in the Cristo Nos Valga district (Source: INEI, 2012).

2.5.1.3 Water use, organisational level, and funding sources

42.1% of the producers in Bernal indicate that a lack of water is the main obstacle to expanding their cultivation areas, and the same is true for 41.9% of the agricultural producers in Cristo Nos Valga. Regarding the source of irrigation water, the largest percentage of the cultivated area is irrigated with water from reservoirs or small reservoirs. In the case of Bernal, 95.7% of the agricultural units state that they are irrigated with water from these sources and only 4% irrigate with water from rivers. In Cristo Nos Valga, 91.4% of UAs are irrigated with water from reservoirs and small reservoirs whereas 8% irrigate lands with water from rivers (INEI, 2012).

The predominant modality of water use rights in both districts is through licensing. 94.41% of farmers in Bernal are licensed, with 55.87% in Cristo Nos Valga. However, 43.82% of producers in Cristo Nos Valga stated that they do not have the right to use water, and, in the case of Bernal, the percentage is significantly lower at 3.26% (INEI, 2012).

With regards as to whether or not they belonged to an irrigation commission in the district of Bernal, 95.82% of the farmers did belong to a commission while the remaining 4.17% did not belong or did not know. However, in the district of Cristo Nos Valga, 55.56% said that they did belong to an irrigation commission, compared to 43.82% who said they did not belong to any commission, and 0.62% said they did not know about it (INEI, 2012).

Regarding memberships for producer committees or cooperatives, 92.9% of producers in Bernal said they belong to one, while 7.1% said they did not. Cristo Nos Valga district was different as 55.97% said they belonged to a cooperative and 44.03% said they did not. Producers were also asked if there was any benefit to belonging to these associations, committees, or cooperatives. In Bernal, 31.4% said that belonging to one of these committees or cooperatives did not provide any benefit, and 39.1% in Cristo Nos Valga said the same (INEI, 2012).

The level of relations between peasant organisations in the lower Piura valley is non-existent and very precarious, as is the case with user commissions that are limited to the

acquisition of water supplies. On the other hand, the links with the different actors in the production chain are unequal, in which the providers of technical assistance services, inputs, and financing, as well as intermediaries and final buyers, have the power to establish prices and transaction conditions. The low level of organisation in these groups of small-scale producers is an indicator of the limited development of social capital in small-scale agriculture in the lower Piura valley (Juarez and Córdova, 2012).

Additionally, the access to financing for agricultural campaigns is one of the main limitations of small-scale agriculture in the lower Piura basin. In Bernal, 46.4% of the producers who sought financing obtained loans mainly from the municipal savings banks, followed by 18.5% from EDYPIME, and 9.8% from AGROBANCO. The case of Cristo Nos Valga is similar, where 46.4% of the producers obtained loans from the municipal savings bank, followed by 20.7% from AGROBANCO, and 16.8% from EDYPIME. In both cases, the remaining percentages are distributed between multiple banks, cooperatives, moneylenders, rural banks, and NGOs, etc.

2.5.1.4. Commercialisation and supply chain

The main destination of agricultural production in Bernal and Cristo Nos Valga is for sale and own consumption. 80.7% of the production in Bernal and 56.8% in Cristo Nos Valga is destined for sale. Likewise, 14.4% of the production in Bernal and 42.7% of that in Cristo Nos Valga is destined for own consumption (Fig. 19).

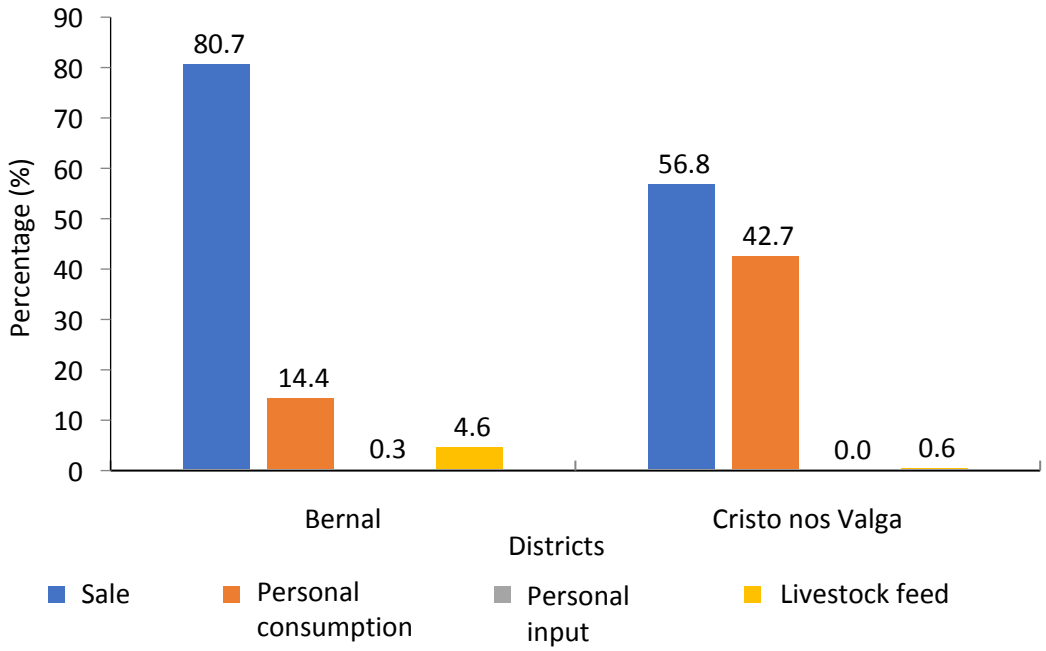

Figure 19. Destination of agricultural production in Bernal and Cristo Nos Valga.

2.5.2. Livestock

2.5.2.1. Livestock activity and headcount

Between 10 and 20% of agricultural units in Bernal and Cristo Nos Valga have cattle, sheep, or pigs. It is worth noting that the IV CENAGRO results do not indicate the percentage of agricultural units with goats, but they do count the number of sheep, pigs, and cattle. In Bernal there are a total of 4614 animals, of which 2373 are sheep, 1345 pigs, and 896 cattle. Similarly, the total number of animals in Cristo Nos Valga is 3414, of which 2562 are sheep, 466 pigs, and 386 cattle (Fig. 20).

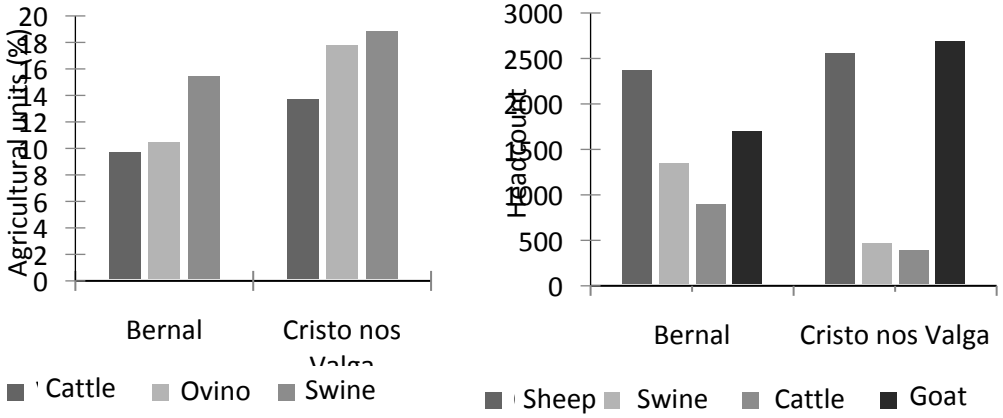

Figure 20. Percentage of agricultural units with cattle, sheep, and pigs (left) and animal headcount in the districts of Bernal and Cristo Nos Valga (right) (Source: INEI, 2012).

The average number of cattle, pigs, and goats as livestock per agricultural unit is 33, with sheep and goats being most numerous. Additionally, each farmer has an average of 10 to 15 sheep or goats (Fig. 21).

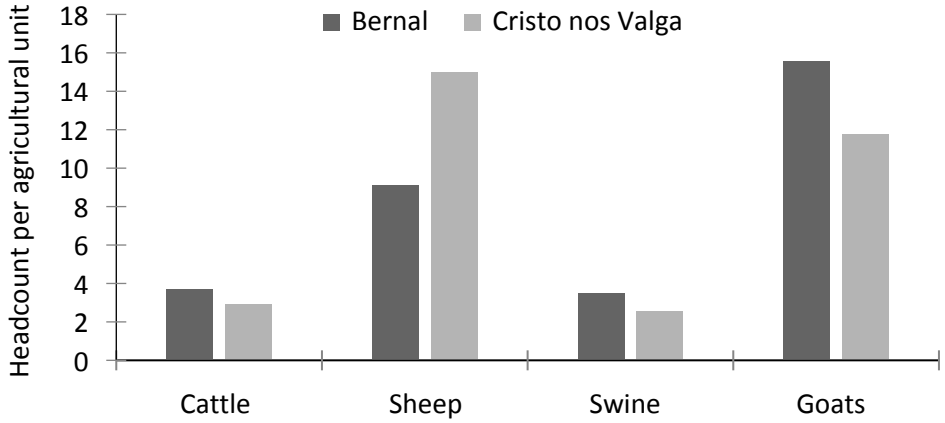

Figure 21. Average headcount per agricultural unit according to the type of livestock in the districts of Bernal and Cristo Nos Valga (Source: INEI, 2012)

2.5.2.2. Livestock production and by-products

With regards to the destination of the production of milk and by-products from cattle, 95.74% of the production from Cristo Nos Valga is destined for own consumption and 91.04% from Bernal, while the production destined for sale is 4.26% in Cristo Nos Valga and 2.99% in Bernal. It is worth mentioning that the percentage of production destined for sale is only representative for Bernal with 5.97%. On the other hand, a large percentage of the overall total for both districts do not produce milk - 72.31% for Cristo Nos Valga and 64.39%

for Bernal, indicating that cattle farming is not developed in these districts (Fig. 22). It is also worth noting that the IV CENAGRO (INEI, 2012) does not have information on the destination of the by-products of sheep, goat, and pig production.

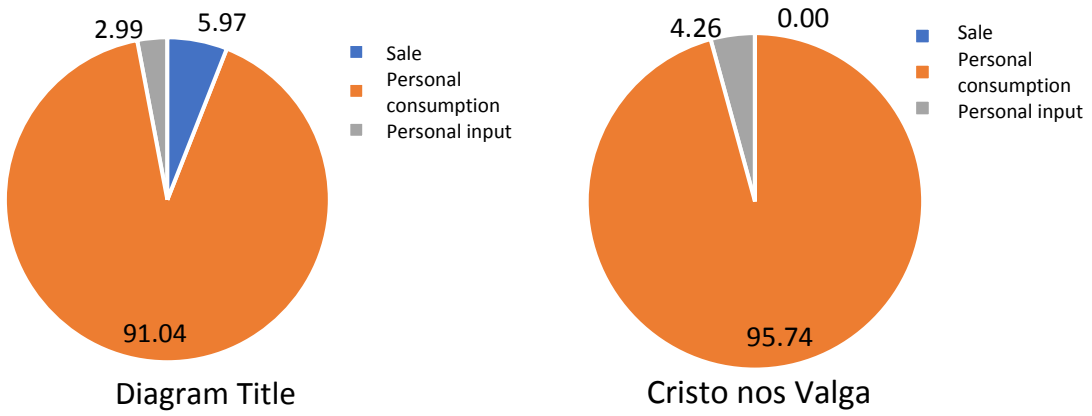

Figure 22. Destination of livestock by-products in the district of Bernal and Cristo Nos Valga (Source: INEI, 2012).

3. AIMS

- Analyse the effects of the El Niño Phenomenon on the productive fishing, agriculture, and livestock activities in farmer communities surrounding the La Niña, Ñapique, and Ramon lagoons.

- Identify opportunities for adaptation based on positive productive aspects that the El Niño Phenomenon brings to desert communities.

4. METHODOLOGY

4.1. Location

Villagers from the districts of Bernal and Cristo Nos Valga who live in the villages closest to the Ramon, Ñapique, and La Niña lagoons were surveyed. These villages were categorised into two groups of communities. The first group was called the "irrigated area" and is composed of villages located to the northeast of Sechura whose agricultural system is based on canal irrigation. The second group is located between the Pan-American Highway north of Piura and Chiclayo, whose agricultural activity does not have a canal irrigation system and is developed in an arid environment along with rising river levels in the summer seasons (Fig. 23).

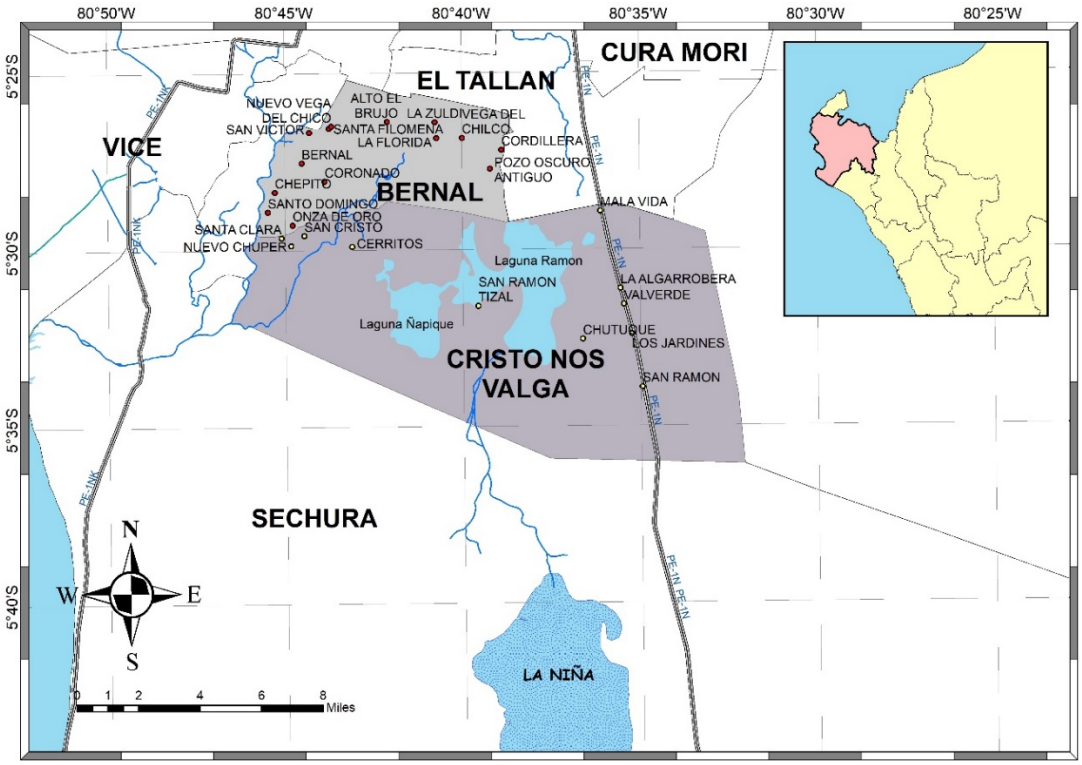

Figure 23. Village locations in the Sechura desert.

4.2. Information sources

The information obtained from the IV National Agricultural Census "V CENAGRO, 2012", the I National Inland Fisheries Census "I CENPESCO, 2013" (INEI, 2012, 2020), and other bibliographic sources - such as technical reports, scheduled development plans (MUNI SECHURA, 2018), National Housing Census, etc., informed the elaboration of surveys addressed to inhabitants involved in agriculture, fisheries, and livestock (Annex 1).

It was also complemented by interviews with 33 different actors in the agricultural and fisheries supply chain in the districts of Bernal and Cristo Nos Valga carried out in 2017, 2018, and 2019, which were delivered by Dr Nina Laurie (University of St Andrews).

The NGO PRISMA provided a database through which the inhabitants were identified. Additionally, with the support of the Sechura, Bernal, and Cristo Nos Valga municipalities, face-to-face meetings were held with the leaders of the rural communities in these districts (Annex 2). It is important to note that in the context of COVID-19, the national and local authorities implemented social restrictions that made it impossible to frequently collect information in the rural communities. Nevertheless, the telephone numbers of some villagers were provided through community leaders, and in the case of areas with poor telephone signals, some visits were made under a strict biosecurity protocol.

A total of 111 residents were surveyed, 37 of them belonging to the irrigated area and 74 to the dry area, or area without irrigation, as shown in Table 6.

Tabla 6. Number of surveyed according to type of area and village.

Type of area	Village	People surveyed	TOTAL
Irrigated area	Cerritos	11	37
	San Cristo	11	
	Onza de Oro	3	
	Santa Clara	3	
	Santo Domingo	3	
	Bernal	2	
	Chancay	1	
	Chepito	1	
	Coronado	1	
	Nuevo Chancay	1	
Dry area	Mala Vida	32	74
	Chutuque	21	
	Nuevo Pozo Oscuro	17	
	Los Jardines	4	

The number of farmers, fishermen, and livestock farmers surveyed is shown in Table 7. A total of 194 surveys were conducted, a number greater than that of villagers surveyed given that villagers often perform more than two activities at the same time. 44% percent of the respondents carried out more than two activities, 38% one activity, and 17.6% three activities.

Table 7. Number of respondents according to type of area and economic activity carried out.

Activity	Irrigated area	Dry area	Total surveys
Farmers	34	65	99
Livestock farmers	10	36	46
Fishermen	13	36	49
TOTAL	57	137	194

4.3. Information processing

The analysis of the IV CENAGRO database was obtained through the portal of the National Institute of Statistics and Informatics (Instituto Nacional de Estadísticas e Informática, INEI) (http://iinei.inei.gob.pe/microdatos/), in ".dbf" format, which was then transformed into ".xls" format and sorted into tables using Excel. This information was manually decoded with the help of INEI's Standardised Code Query System (http://webinei.inei.gob.pe:8080/sisconcode/publico.htm) and then processed using dynamic table functions. In addition to this, information from the IV CENAGRO meta data was used, such as: census card, technical sheet, and data dictionary. Information relating to the characteristics of the producer and the agricultural unit, land use, crops in the agricultural unit, additional data on the plot, fruit trees, sowings, irrigation, existence of

livestock, poultry, other animals and beehives, associativity, and producer's appreciations was processed.

Similarly, connecting to the server through MySQL and XAMPP programmes was necessary for the analysis of the "I CENPESCO", which was requested from the INEI through the transparency portal via e-mail and whose initial format was in SQL. The RStudio computer program was used to extract the tables of sections I, II, V and VII referring to location, characteristics of the population, fishing operations, financing, production, and commercialisation respectively, to then be processed in Excel using dynamic table functions. The metadata available in the data dictionary and the census form were used for the understanding and coding of the database.

Finally, the data from the surveys were digitalised in Excel tables for a subsequent analysis through dynamic table functions.

5. RESULTS

5.1. The impact of the El Niño Phenomenon on fishing

5.1.1. Fishing trips and catch composition

The Ñapique lagoon is a permanent body of water and has allowed the communities in both areas to carry out fishing activities based on tilapia (*Oreochromis sp.*) in non-Niño years. However, given its location and roads to access it, this lagoon is frequented more by the populations of the irrigated area, allowing it to be used more frequently. This is perhaps the reason why 83.3% of the respondents in the dry area indicated that they do not fish in non-Niño years. Similarly, some fishermen from the irrigated area migrate to the Virrilá estuary, where fishing activity is mainly based on mullet (*Mugil cephalus*).

The situation changes with the arrival of El Niño and the formation of the "La Niña lagoon", during which more than 90% of the fishermen from both areas migrate to this lagoon (Fig. 24). Likewise, the fishery is mainly based on mullet and tilapia due to their abundance; however, there are other species commonly named by the fishermen, including catfish; shrimp; carp; catfish; bream; and snook.

It is worth noting that the Ramon lagoon, which is fed by a stream from the Piura River, has now been converted into farmland and, even so, the fishermen take advantage of areas with water remaining to carry out fishing trips.

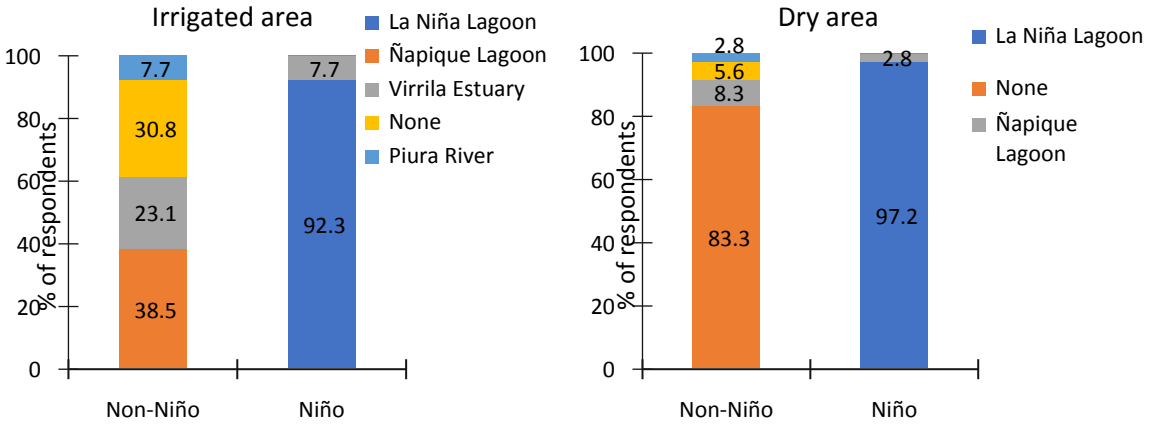

Figure 24. Main fishing areas of the surveyed inhabitants in a Niño and non-Niño year, according to the area.

The results also demonstrate that, during non-Niño years, fishing is almost non-existent in the dry area as opposed to the irrigated area, where some fishermen continue the activity less frequently. However, there is an increased frequency of fishing trips by villagers in both zones during El Niño (Fig. 25).

Figure 25. Fishing days per year between a Niño and non-Niño year, according to area type

5.1.2. Catch and commercialisation volumes

Catch volumes per fishing trip increase during Niño events in both areas. In the case of mullet from fishermen in the irrigated area, there is an increase in average catch size ranging from 15 kg per trip in non-Niño periods to 250 kg per trip after an El Niño event. Similarly, for fishermen coming from the dry area, the increase is from 0 kg per catch to 100 kg per catch.

Non-Niño

Non-Niño

Tilapia is the second most caught resource reported. Fig. 27 shows catch increase per trip during an El Niño event, according to the type of area the fishermen are from.

Figure 26. Mullet catch (*Mugil cephalus*) during the absence and presence of El Niño according to area type

Figure 27. Tilapia catch (*Oreochromis sp.*) during the absence and presence of El Niño according to area type

Both fisheries are managed in an artisanal way using gillnets. However, unlike the mullet fishery which operates passively, tilapia is caught using a method called "trawling" or "dragging", which consists of positioning the net in the fishing area and then moving it to increase the probability of gillnetting the resource.

Non-Niño

Non-Niño

Non-Niño

Non-Niño

On the other hand, the commercialisation of mullet stock in normal times (non-Niño) in both areas is based on own consumption and direct sales to local markets or to the nearest cities such as La Unión, Piura, Catacaos, and Sechura. The percentage of mullet catches for own consumption in the irrigated areas reaches 16.2% while 80% of their catches are destined for sale locally or in city markets (Fig. 28).

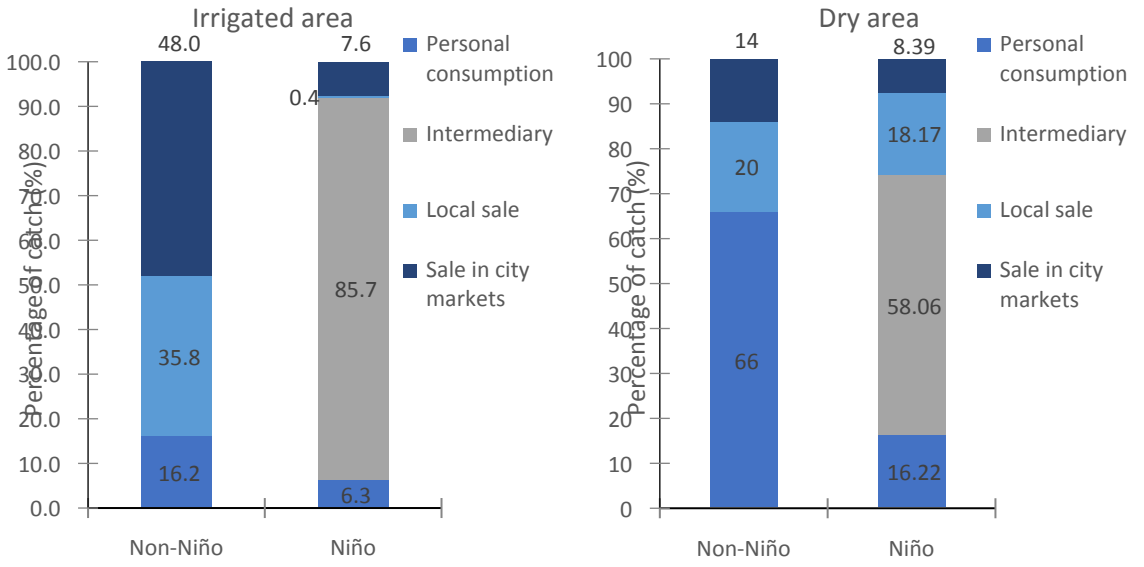

Figure 28. Main destination of mullet catches (*Mugil cephalus*) in absence or presence of El Niño, according to area type

Contrasting the irrigated area, the percentage of mullet caught in the dry area destined for own consumption is higher, reaching a value of 66%, thus prioritising it as a vital protein source for the communities' food. Additionally, 20% of this catch is destined for local sale, meaning it is sold to village neighbours, and only 8.39% is destined for sale in large markets.

However, during the El Niño phenomenon, the abundance of this resource generates a change in the composition of catch destinations, allowing the entry of intermediaries who collect the fishermen's catches in trucks with cold chambers and sell them to fishing terminals in Piura, Chiclayo, Lima, etc.

Furthermore, the main destinations of tilapia catches are similar to those of mullet. In non-Niño seasons, the main destination for both areas is own consumption, but demand from intermediaries is also high, even more so in the irrigated area because it has higher tilapia catches (Fig. 29).

During El Niño, the abundance of tilapia allows fishermen to market much of their catch directly to city markets, due to high demand. It can be seen that the percentage of the tilapia catch going to intermediaries is lower during El Niño in both areas.

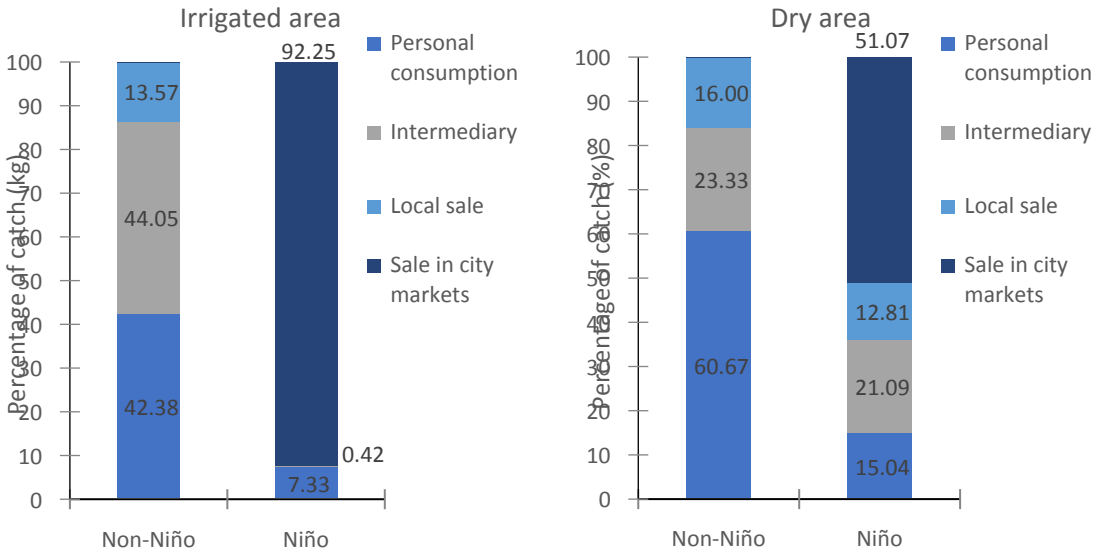

Figure 29. Main destinations for tilapia (*Oreochromis sp.*) catch in absence or presence of El Niño, according to area type

5.2. The impact of El Niño on agriculture

5.2.1. Water source

The water source is one of the characteristics that has allowed us to understand why there are differences between the two areas. In the irrigated area, more than 90% of the agricultural fields have a water supply system through a canal, which is administered by the User Commission of the San Andrés Hydraulic Sub-Sector (Comisión de usuarios del Sub Sector Hidráulico San Andrés). Likewise, the water supply in this area is based on two seasons per year, the first one is called "large season" which starts in the summer and allows the producers to sow crops that require an abundance of water, and the second season is called "small season", which takes place between August and September and allows the farmers to sow short term crops due to the limited water flow provided by the canals.

On the other hand, the communities in the dry area are supplied by the main water riverbed coming from a spring in the southeast of the Piura River basin (Fig. 20), whose use is temporary (summer) and allows some farmers with nearby plots of land to irrigate their fields through flooding to then sow.

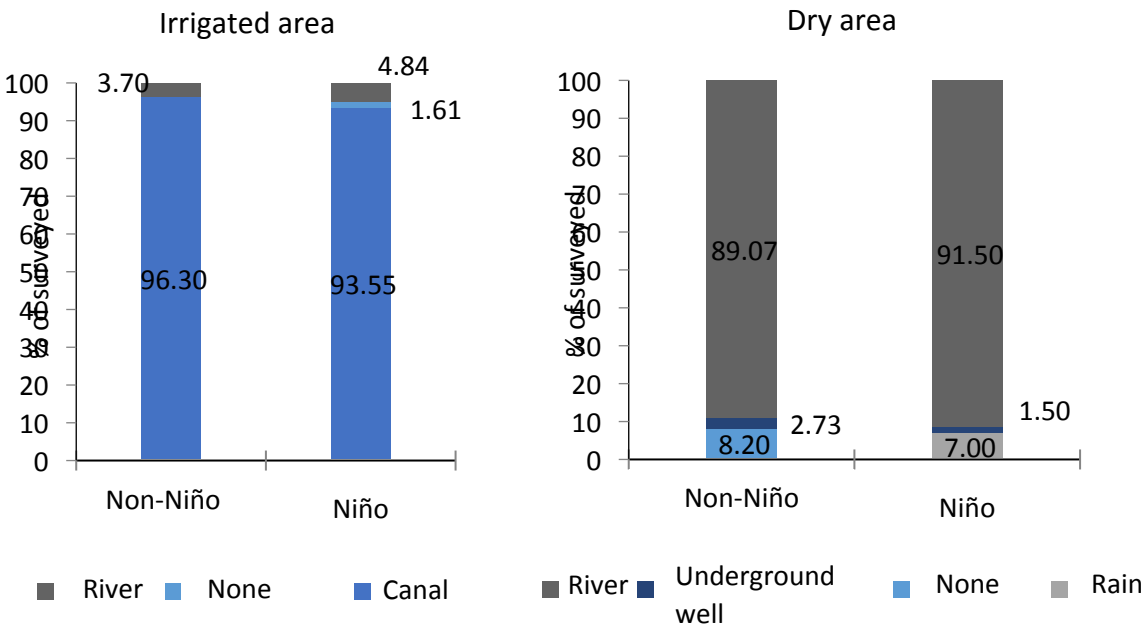

Figure 30. Type of water source destined for agriculture during the presence and absence of El Niño, according to the area.

During an El Niño event, villagers in the irrigated area mention that increased rainfall and water levels have been damaging water infrastructure. The overflow of water in the canals has been flooding crop fields and generating economic losses for farmers.

On the other hand, in the dry area, El Niño is increasing the flow of the Piura River and surrounding bodies of water, flooding agricultural fields that had been dry for a long time.

5.2.2. Area sown and main crops

During non-Niño years, farmers in the irrigated area have a larger area for planting than farmers in the dry area, where in many cases there is no planting at all due to a lack of water. Fig. 31 shows that the average harvested area in the irrigated area is higher than in the dry area.

Generally, in a non-Niño year, each farmer in the dry area sows on average 40% of the total areas or plots. However, after El Niño, farmers sow 100% of the total area they own. This is not the case in the irrigated area, where the area sown by each farmer does not vary.

Figure 31. Area harvested by farmers in the absence or presence of El Niño, according to area type.

During the 1983 El Niño, ecologists F. Duhme and Franz Wielgolaski mentioned in an interview that the rainfall caused by the El Niño phenomenon could be increasing soil fertility in the agricultural zone, as well as the growth of herbaceous vegetation and the proliferation of insects, animals, and birds. This is due to the formation of layers of silt which fertilises the soil and forms a large phreatic zone, allowing for the accumulation of groundwater (Diario Correo, 1983; Diario Correo, 1997).

Figures 32 and 33 show that the main crops harvested are corn, beans, pumpkin, Egyptian beans (zarandaja), and cotton in both areas. However, after corn, rice is the most frequently harvested in the irrigated area given that it requires an abundance of water for growth.

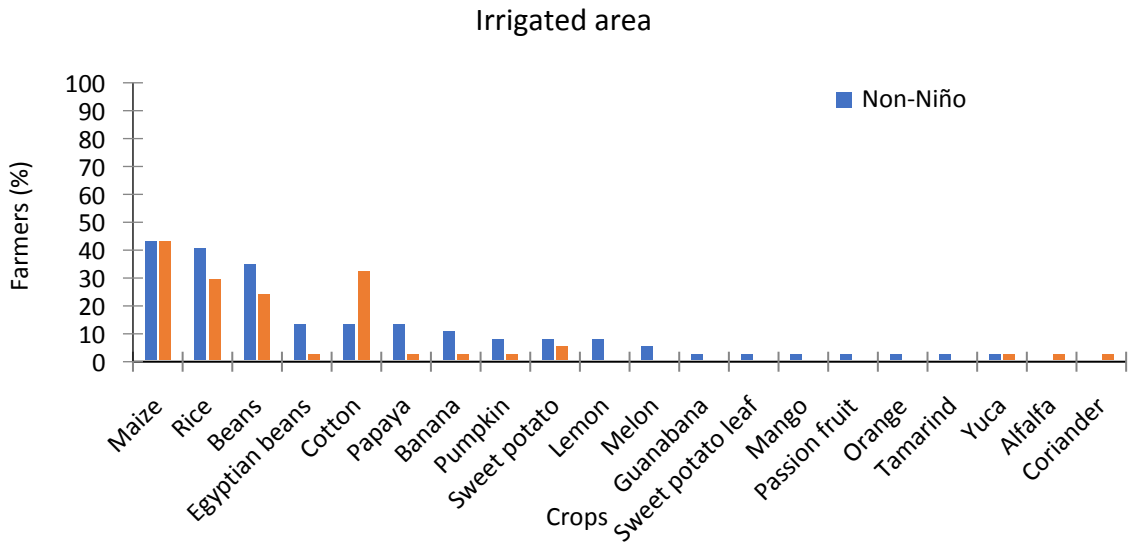

Figure 32. Main crops according to the frequency of harvest during the absence or presence of El Niño in the irrigated area.

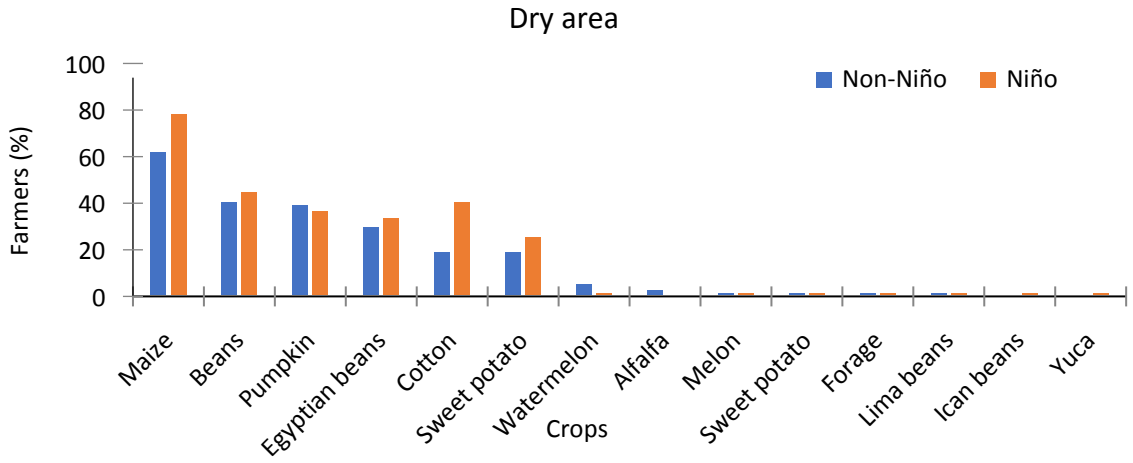

Figure 33. Main crops according to the frequency of harvest during the absence or presence of El Niño in the dry area.

Cotton is also one of the most frequently planted crops after an El Niño event. Many producers indicate that, with the 2017 El Niño, cotton companies financed farmers and promoted its cultivation in the desert.

5.2.3. Harvest volumes

The irrigated area is mainly characterised by rice production during the large season, due to the high demand for this crop. During the small season, maize, cotton, beans, and other

short-term crops are grown (Fig. 34). During El Niño, production volumes decrease in this area as a result of the flooding of agricultural fields and the collapse of water infrastructure.

Figure 34. Agricultural production per farmer according to the type of crop in the absence and presence of El Niño in the irrigated area.

On the other hand, the temporary humidity of the land in the dry area during the rainy season or river flooding throughout non-Niño years allows some farmers to plant crops such as cotton, maize, and beans with average production values of no more than 2 tonnes. However, agricultural production increases during the El Niño. In 2017, local producers took advantage of El Niño to plant cotton due to the high demand and good price of the product, and they also mentioned that they received advice from ginning companies.

Figure 35. Agricultural production per farmer according to the type of crop in the absence or presence of El Niño in the dry area.

5.2.4. Commercialisation

In relation to selling prices, as shown in Fig. 36, products such as cotton and beans have a higher price than other products during non-Niño years. However, during an El Niño event, it can be seen that there is a tendency for prices to decrease. This price decrease occurs in both areas except for cotton, whose value can increase up to 3.60 soles per kilogramme, according to farmers in the dry area.

Figure 36. Market price variations according to the type of crop and area in the absence and presence of El Niño.

Regarding the destination of the main crops in the irrigated area in both Niño and non-Niño years, 100% of the cotton harvests are destined for stockpilers and, similarly, more than 80% of the rice is destined for the same purpose. Likewise, maize is one of the crops with the largest harvest destined for own consumption, as it is also used for animal feed (Fig. 37).

Similarly, 100% of the cotton harvest in the dry area is destined to stockpilers in the absence or presence of El Niño. However, more than 50% of maize, bean, and pumpkin production is destined for own consumption (Fig. 38).

Figure 37. Destination of the main crops in the irrigated area in absence or presence of El Niño.

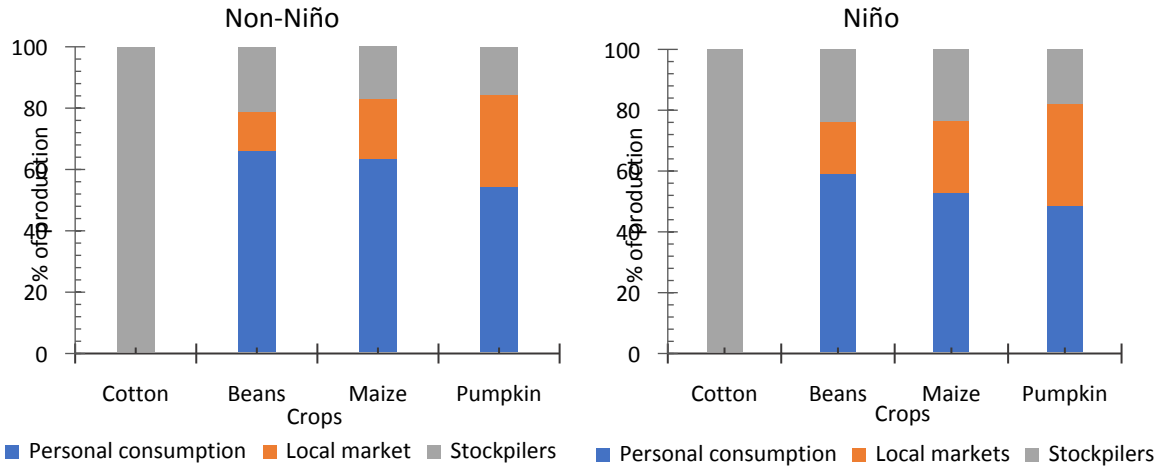

Figure 38. Destination of the main crops in the dry area in the absence or presence of El Niño.

5.3. Impact of El Niño on livestock

5.3.1. Headcount and production (goats and sheep)

The number of goats and sheep in the irrigated area tends to almost double in El Niño years because of the greater availability of pasture for feed which allows farmers to breed their animals. It can also be seen that the number of livestock (goats and sheep) owned by each farmer is higher in the presence or absence of El Niño in the dry area (Fig. 39).

Figure 39. Livestock headcount (goats and sheep) per producer in the absence or presence of El Niño according to area type.

Additionally, meat production in kilograms per farmer tends to increase in both areas during El Niño (dry area and irrigated area), but the increase is higher in the dry area, with annual meat production per farmer increasing from 300 kg to 700 kg per year (Fig. 40).

According to the residents, the increase of livestock production during an El Niño event is a result of the increasing pasture area and the availability of water in the desert which allows the livestock to reproduce and gain biomass in a short period of time.

Figure 40. Meat production (kg) of goats and sheep in the absence or presence of El Niño according to area type.

5.3.2. Commercial characteristics

The price of goat and cattle are the same given the slight tendency to decrease in price during El Niño year in both areas, as Fig. 14 shows. It is likely that the oversupply of this resource is causing prices to decrease. Additionally, it shows the greater variability in cattle price in the irrigated areas, as opposed to the dry one.

Figure 41. Price in soles per kilogram of meat (sheep or goat) in the absence or presence of El Niño, according to area type.

Additionally, in relation to the final destination of the product from both areas and before El Niño, the results indicate that more than 50% of the goat and sheep meat production is destined for own consumption, and another large proportion (20 to 40%) is destined for sale in the local market or villages.

However, with increasing livestock populations during an El Niño event, the demand for traders or intermediaries also increases. They visit the localities in the desert to buy livestock and supply them to the main markets, such as those of La Unión, Piura, Chiclayo, etc. (Fig. 42).

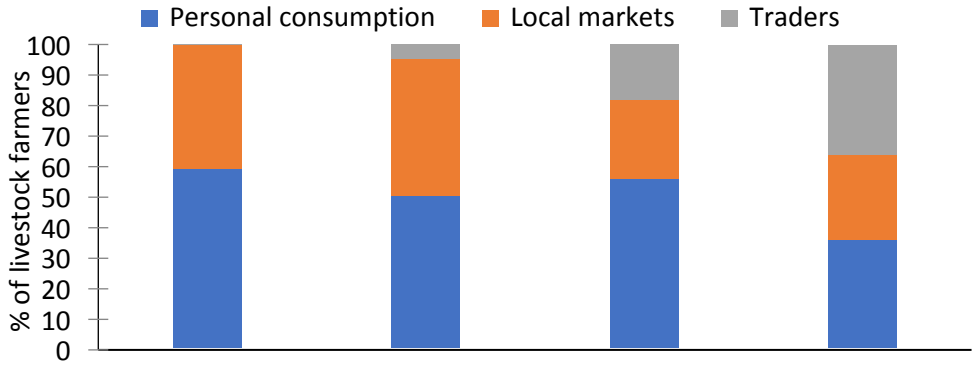

Figure 42. Livestock (goat and sheep) product destinations during the presence or absence of El Niño, according to the area type.

6. CONCLUSIONS AND RECCOMENDATIONS

The impact of the El Niño phenomenon on the economic activities of inhabitants of the Sechura desert has made it possible to understand which aspects are positively and negatively affected. It has also been possible to identify that the inhabitants who have access to canal irrigation have been negatively affected in various aspects, unlike the inhabitants of the dry area, whose impact has been mostly positive due to their limited agricultural and livestock activity in non-El Niño periods.

6.1. Fishing activity

The abundance of fishing resources such as mullet and tilapia during the El Niño phenomenon allowed for an increase in catches of these species, contributing directly to the economy and food security of families in both areas. It is likely that fishermen from other

localities, including coastal fishermen, also migrated to the La Niña lagoon to compensate for the economic losses that El Niño may have generated.

The farming communities do not have a union system or associative organisations for fishing activity, which makes it difficult for them to have access to the state through its different programmes. Additionally, the fishing activity that is carried out is not controlled by the government; there is no statistical data on landings or evaluations of the biomass of the fishing resources provided by the lagoons. This informality could be generating socio-economic conflicts among the inhabitants due to control of the fishing zones, as well as the use of fishing gear that is not very selective.

Given that fishing activity in the lagoon is temporary, many villagers mention that they do not have a specific regulation for the minimum legal size of mullet, thus using the norm referenced for coastal marine zones which prohibits the capture of mullet smaller than 35 cm. Once the lagoon dries out, hundreds of mullets have been found which could not be caught due to these regulations.

Given this, the following actions are recommended:

1. Elaborate a management plan for the fishing of mullet and tilapia for the La Niña lagoon and temporary bodies of water, sustaining the minimum legal size.
2. Identify potential aquatic species of short-term growth with the aim of promoting aquaculture and to take advantage of the bodies of water that are generated.
3. Strengthen the associative capacities of the artisanal fishermen for access to state programmes.
4. Strengthen commercial and preservation capacities of fishing resources for direct sale of fish to the final consumer.
5. Discuss the feasibility of repopulating species like mullet, tilapia, shrimp, catfish, etc which allow for the maximum exploitation of the available bodies of water.
6. Identify potential eco-friendly and sustainable tourist activities in the bodies of water, such as adventure fishing, which allows for the inhabitants to provide different services to visitors.

6.2. Agricultural activity

Agricultural activity among the most important economic pillars for the inhabitants of the Sechura desert. Communities in the dry area have been taking advantage of the El Niño phenomena to develop agriculture on land with less access to water. However, communities like the irrigated areas have been suffering from the rains associated to El Niño as they flood their agricultural fields. The research has shown that many crops remain unchanged over the years (little rotation), as is the case of rice in the irrigated area. The lack of crop diversification leads to an oversupply of agricultural products which has an impact on soil erosion and prices. There is little to no historical statistical information about agricultural production in Sechura, making it impossible to evaluate and propose agronomic policies to benefit farmers.

Currently, the use of and access to water is a problem for the inhabitants of the desert who, in some cases and only in the summer season, plant crops with the rising waters of the Piura River. However, most of the population does not have access to irrigation canals or permanent water sources. In addition to this, the level of associations in these communities is precarious, making it impossible for them to access government credits or programmes, and limiting the power to negotiate with trade intermediaries who offer purchase prices well below market prices.

Given this, the following actions are recommended:

1. Identify crops with short growing periods and maximum profitability (for example: cotton, vegetables, grains, etc) in order to take advantage of temporary wetlands in the desert.
2. Identify alternative crops with short growing periods and minimum investments in the areas that are negatively impacted by El Niño for the recovery and mitigation of losses generated.
3. Strengthen the capacities of associations that allow communities from the irrigated area to access funding sources for re-investment in agricultural production in irrigated areas.
4. Strengthen the capacities of associations that allow communities from the dry area to obtain access to government programmes and funding to maximise investments for harvesting.
5. Elaborate contingency plans in hydraulic infrastructure, such as the reinforcement and maintenance of canals, for better water management in the irrigated area.
6. Strengthen the capacities of direct commercialisation from the farmer to the final consumer, allowing the farmer to obtain better earnings.
7. Promote technical irrigated agriculture for an efficient use of water in water-deficient areas.
8. Strengthen the technical agricultural capacities of inhabitants through agreements with universities or technological centres.

6.3. Livestock activity

Livestock activity is also one of the most important family activities for the people of Sechura given its contribution as a source of protein and to the local economy. The main types of livestock are goats and sheep, which, due to their adaptability, can thrive in hostile environments such as the desert. They are raised for local consumption and sale. El Niño has a positive impact on this activity, as the abundance of vegetation allows livestock populations to increase, thus enabling the villagers to commercialise their meat. The low presence of associations does not allow them to access trainings for the adequate management of livestock and facilities, which leads to frequent animal theft (UBIGEO).

With regards to the commercial aspect, producers are not satisfied with market prices and often opt to consume the livestock and only sell it when they are in need of money.

Given this, the following action are recommended:

1. Encourage goat raising through adequate management with access to better animals that provide higher yields of meat, milk, and by-products.
2. Strengthen the capacities of associations for livestock farmers to access government programmes such as vaccinations, genetic improvement, etc.
3. Establish assisted fertilisation plans through the artificial insemination of goats and cattle in order to increase livestock production and maximise the use of pasture areas.
4. Strengthen commercial capacities through the direct sale to restaurants, hotels, local markets, etc.
5. Encourage the use of adequate infrastructure to shelter animals, especially during El Niño rainy seasons, to avoid diseases caused by excess humidity.

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8. ANNEXES

ANNEX 1. Survey used for the productive fishing, agricultural, and livestock activities in the communities of the Sechura desert

SURVEYS OF AGRICULTURAL, LIVESTOCK, AND FISHING ACTIVITIES IN FARMING COMMUNITIES IN THE SECHURA DESERT

AIM

To quantify the effects (positive or negative) of El Niño on the productive activities of the villages in Sechura surrounding the La Niña, Ramon, and Ñapique lagoons.

I. METHODOLOGY

With the help of the Sechura Municipality and of the NGO PRISMA's database, a group of farmers will be identified in the villages of the districts of Bernal and Cristo Nos Valga; additionally, snowball sampling will be used to identify other potential respondents.

The survey will be conducted in person and through telephone communication (the latter for vulnerable or unwilling villagers). The following biosecurity protocol will be used for in-person surveys:

- Use of KN95 face masks for the interviewer and interviewee
- Minimum distancing of 2 m
- The survey will be carried out in open areas
- Only one person will be interviewed at a time per household or economic group
- People older than 65 will be interviewed over the phone

Before the survey, the interviewee will receive a brief explanation of the objectives of the project and the aims of the survey. Where possible, all the interviews will be recorded – with the consent of the interviewee – for the sole purpose of transcription. On the other hand, the personal information of the interviewee will be kept strictly confidential.

The coding system (ID) to identify each interview will be carried out as shown in the following table:

Coding system for each interview

ID	001BE
Order number	001
District	BE (Bernal) / CV (Cristo Nos Valga) / OT (Other)

II. GENERAL DATA

Interviewee personal data

ID	

Name and Surname	
Age	
District of residence	
Village of residence	
Phone / email address	

About the economic activities

Main economic activities in order of importance *number as indicated by the interviewee	Agriculture ( )
	Livestock farming ( )
	Fishing ( )
	Apiculture ( )
	Carob tree syrup - *Algarrobina* ( )
	Other: …..... ....

III. SURVEY FOR FARMERS

ID: _____

a. Where are your plots located? _____

b. Which El Niño events did you experience (years)? Which one do you remember most?

_____

c. What is the total size of your plot? What is the harvest area? _____

	Non-Niño	**Niño**
Total plot size (ha)		
Harvest area (ha)		

d. Where do you obtain water to irrigate your crops?

Type		
	Non-Niño	**Niño**
Rivers		

Rain		
Canal		
Reservoir		
Lagoon		
Others:		

e. What are your main crops?

Non-Niño: _____
Niño: _____

f. Of the three main crops, mention what the table requests.

- *During normal times (non-Niño)*

Crops (1, 2, 3.) in order of importance	**Percentage of harvested area per crop**	**Area (ha)**	**Production per season**	**Unit of measurement**	**Price**	**Number of seasons**	**Comments**

- *During El Niño years*

Crops (1, 2, 3.) in order of importance	**Percentage of harvested area per crop**	**Area (ha)**	**Production per season**	**Unit of measurement**	**Price**	**Number of seasons**	**Comments**

g. Where do you/have commercialise(d) your main crops?

Main crops	**Non-Niño**				**Niño**			
	Sale price	**Own consumption (%)**	**Local market (%)**	**Stockpilers (%)**	**Sale price**	**Own consumption (%)**	**Local market (%)**	**Stockpilers (%)**

h. As a farmer, do you belong to any type of organisation?

Organisation type	**Select (X)**	**Name of association**
Association		
Guild		
Board		
Other:		

None		

i. How do you/did you finance your harvest?

Finance source	Non-Niño year	Niño year
Bank		
Municipal cash office		
Lenders		
Savings		
Other: …....		

IV. SURVEY FOR LIVESTOCK FARMERS

ID: _____

a. Where is your farm located? _____

b. Which El Niño events did you experience (years)? Which do you remember most?

_____

c. What type of animals do you have, how many, and what products do you obtain from them?

Animals	Quantity	
	Non-Niño	Niño
Goats		
Sheep		
Swine		
Cattle		
Birds		

d. What is the production, frequency, price, and where are they destined to go? – Non-Niño

Animals	Meat production			Meat sales			
	Production or animals benefiting	Frequency	Average weight (kg)	Price (soles/kg)	Own consumption (%)	Local market (%)	Commercial (%)

Animals	Milk production		Milk sales			
	Production (lt)	Frequency	Price (soles/lt)	Own consumption (%)	Local market (%)	Commercial (%)
Goat						
Sheep						
Cattle						

Animals	Cheese production		Cheese sales			
	Production (Kg)	Frequency	Price (soles/kg)	Own consumption (%)	Local market (%)	Commercial (%)
Goat						
Sheep						
Cattle						

e. What was the production, frequency, price, and where are they destined to go? – Niño

Animals	Meat production			Meat sales			
	Production or animals benefiting	Frequency	Average weight (kg)	Price (soles/kg)	Own consumption (%)	Local market (%)	Commercial (%)

Animals	Milk production		Milk sales			
	Production (lt)	Frequency	Price (soles/lt)	Own consumption (%)	Local market (%)	Commercial (%)
Goat						
Sheep						
Cattle						

Animals	Cheese production		Cheese sales			
	Production (Kg)	Frequency	Price (soles/kg)	Own consumption (%)	Local market (%)	Commercial (%)
Goat						
Sheep						
Cattle						

f. As a livestock farmer, do you belong to any type of organisation?

Organisation type	Select (X)	Name of association
Association		
Guild		
Board		
Other:		
None		

g. How do you/did you finance your production?

Finance source	Non-Niño year	Niño year
Bank		
Municipal cash office		
Lenders		
Savings		
Other: ….....		

V. SURVEY FOR FISHERMEN

ID: _____

a. Which El Niño events did you experience (years)? Which do you remember most? _____

b. Where do you fish? _____

Non-Niño: _____

Niño: _____

c. During which months do you fish and how long do your fishing trips last?

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Non-Niño												
Niño												

d. How many days a month do you go out to fish? Non-Niño: _____ / Niño: _____

e. What are the species you catch the most?

Non-Niño: _____

Niño: _____

f. What is your daily catch? What is your fishing method or gear? Describe as indicated in the table.

		Daily catch (kg)		Fishing effort		
	Species	Normal trip	Good trip	Fishing method or gear	Unit of fishing effort	Number of fishing effort units
Non-Niño						
Niño						
Non-Niño						
Niño						
Non-Niño						
Niño						
Non-Niño						
Niño						
Non-Niño						
Niño						

g. How much are you paid per species per kilo? Where do you commercialise and what proportion of your catch is commercialised?

		Commercialisation					
	Species	Price	Own consumption	Local sale	City markets sale	Merchants	Observations
Non-Niño							
Niño							
Non-Niño							
Niño							
Non-Niño							
Niño							
Non-Niño							
Niño							
Non-Niño							
Niño							

h. As a fisherman, do you belong to any type of organisation? If so, which one?

Organisation type	Select (X)	Name of association
Association		
Guild		
Board		
Other:		

.....		
None		

i. How do you finance your fishing trips?

Finance source	Non-Niño year	Niño year
Bank		
Municipal cash office		
Lenders		
Savings		
Other:		

ANNEX II. MEETINGS

ACTIVITIES CARRIED OUT UNDER THE PESCAGRI PROJECT

I. Table summarising the activities carried out

Meeting #	Type of meeting	Date	Aims	Participants	No. of participants
1	Community outreach meeting	07/10/2020	(1) Meet community leader, (2) Present the FDA objectives in the project, (3) Organise a coordination meeting.	Alex Eche, Bernardo, Ivan Gomez, Evelyn Inguil, Oliver Calle	5
2	Meeting Cristo Nos Valga's Mayor	23/11/2020	(1) Present FDA objectives in the project to the mayor, (2) Request a local space and convene community leaders	Evelyn Inguil, Ivan Gomez, Angel	3
3	Meeting Bernal's Mayor	23/11/2020	(1) Present FDA objectives in the project to the mayor, (2) Request a local space and convene community leaders	Evelyn Inguil, Ivan Gomez, Boris	3
4	Field trip – Ñapique lagoon	24/11/2020	(1) Visit Ñapique lagoon, (2) Meet local fishermen	Ivan Gomez, Evelyn Inguil, (2) fishermen Onza de Oro	4
5	I Coordination Meeting - Cristo Nos Valga	02/12/2020	(1) Present FDA objectives in the project to community leaders, (2) Request backing and support during surveys.	Evelyn Inguil, Ivan Gomez, Angel (Mayor), Community leaders.	16
6	I Coordination Meeting - Bernal	07/12/2020	(1) Present FDA objectives in the project to community leaders, (2) Request backing and support during surveys.	Evelyn Inguil, Ivan Gomez, Municipal representatives, Community leaders.	23
7	Meeting for capacity building activities	07/01/2021	(1) Restate survey strategies, (2) Identify productive opportunities, (3) Engage community leaders	Dr. Jaime Mendo, Evelyn Inguil, Ivan Gomez, Bernardo Tume, Diego Chunga	5

8	Meeting Alex Eche – Economic Development Manager	07/01/2021	(1) Report on progress, (2) Recommend the city council to support the formalisation of villagers according to their productive activities (fishing, agriculture, etc).	Dr. Jaime Mendo, Alex Eche, Evelyn Inguil, Ivan Gomez	4

II. Details of activities carried out

2.1. Community outreach meeting

On the 8th of October 2020, an initial meeting was held to meet Mr Bernardo Tume Ruiz (president of the COMMITTEE OF TEMPORARY WATER USERS FOR AGRICULTURAL IRRIGATION, LIVESTOCK, FISHING, TOURISM, AND OTHERS ON THE LEFT AND RIGHT BANKS ON THE PIURA RIVER, SECHURA PROVINCE – R.A. N°040-2019-MDCNV/A) with the aim of presenting the FDA objectives in the project "Fishing and Farming in the Desert: a platform for understanding how to respond to El Niño in the context of climate change in Sechura, Peru".

The meeting aims were the following:

1. Meet the community leader Bernando Ruiz.
2. Present the FDA objectives in the project.
3. Organise a coordination meeting.

Results:

- Acceptance of community leader and support for data collection was achieved.
- Bernardo recommends convening leaders from each community in his organisation.
- It is agreed that the coordination meeting will be held in the San Cristo Municipality.

Fig 1. First coordination meeting with FDA, Muni Sechura, and residents of Chutuque (Cristo Nos Valga)

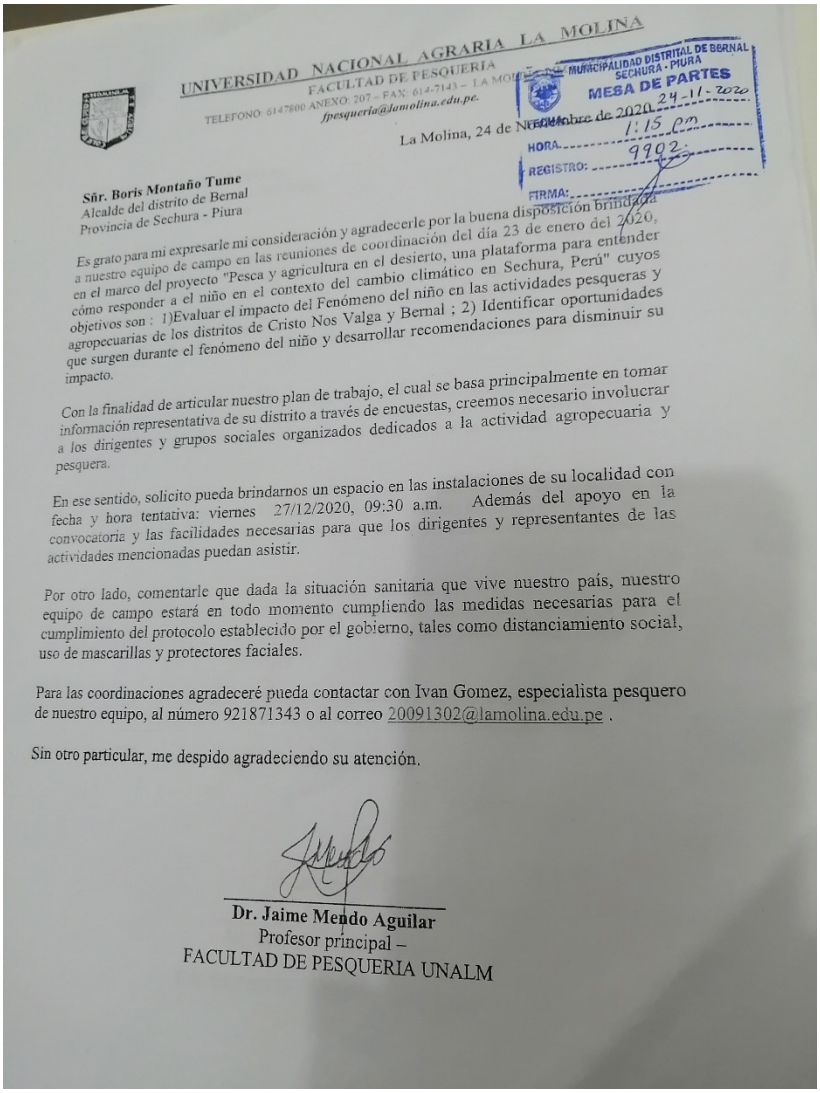
2.2. Meting the mayor of Cristo Nos Valga

With the aim of seeking backing from the Cristo Nos Valga municipality, the FDA field team met with the mayor of said district, Mr Angel Agurto Pingo. The agenda was the following:

1. Present the FDA objectives in the project to the mayor
2. Request a local space and convene community leaders

Results:

- The mayor committed to providing a space to carry out the coordination meeting.
- The mayor committed to convening community leaders for said meeting.
- The mayor delegated the relevant coordination to Mr Alejandro Tume Ruiz (Deputy Mayor).
- The FDA is requested to formalise the order through a document.



UNIVERSIDAD NACIONAL AGRARIA LA MOLINA
FACULTAD DE PESQUERIA
TELEFONO: 6147800 ANEXO: 207 – FAX: 614-7143 – LA MOLINA
fpesqueria@lamolina.edu.pe

MUNICIPALIDAD DISTRITAL DE BERNAL SECHURA - PIURA
MESA DE PARTES
FECHA: 24-11-2020
HORA: 1:15 pm
REGISTRO: 9902
FIRMA:

La Molina, 24 de Noviembre de 2020

Sñr. Boris Montaño Tume
Alcalde del distrito de Bernal
Provincia de Sechura - Piura

Es grato para mi expresarle mi consideración y agradecerle por la buena disposición brindada a nuestro equipo de campo en las reuniones de coordinación del día 23 de enero del 2020, en el marco del proyecto "Pesca y agricultura en el desierto, una plataforma para entender cómo responder a el niño en el contexto del cambio climático en Sechura, Perú" cuyos objetivos son : 1)Evaluar el impacto del Fenómeno del niño en las actividades pesqueras y agropecuarias de los distritos de Cristo Nos Valga y Bernal ; 2) Identificar oportunidades que surgen durante el fenómeno del niño y desarrollar recomendaciones para disminuir su impacto.

Con la finalidad de articular nuestro plan de trabajo, el cual se basa principalmente en tomar información representativa de su distrito a través de encuestas, creemos necesario involucrar a los dirigentes y grupos sociales organizados dedicados a la actividad agropecuaria y pesquera.

En ese sentido, solicito pueda brindarnos un espacio en las instalaciones de su localidad con fecha y hora tentativa: viernes 27/12/2020, 09:30 a.m. Además del apoyo en la convocatoria y las facilidades necesarias para que los dirigentes y representantes de las actividades mencionadas puedan asistir.

Por otro lado, comentarle que dada la situación sanitaria que vive nuestro país, nuestro equipo de campo estará en todo momento cumpliendo las medidas necesarias para el cumplimiento del protocolo establecido por el gobierno, tales como distanciamiento social, uso de mascarillas y protectores faciales.

Para las coordinaciones agradeceré pueda contactar con Ivan Gomez, especialista pesquero de nuestro equipo, al número 921871343 o al correo 20091302@lamolina.edu.pe .

Sin otro particular, me despido agradeciendo su atención.

Dr. Jaime Mendo Aguilar
Profesor principal –
FACULTAD DE PESQUERIA UNALM

Fig. 2. Letter of request for the mayor of Bernal.

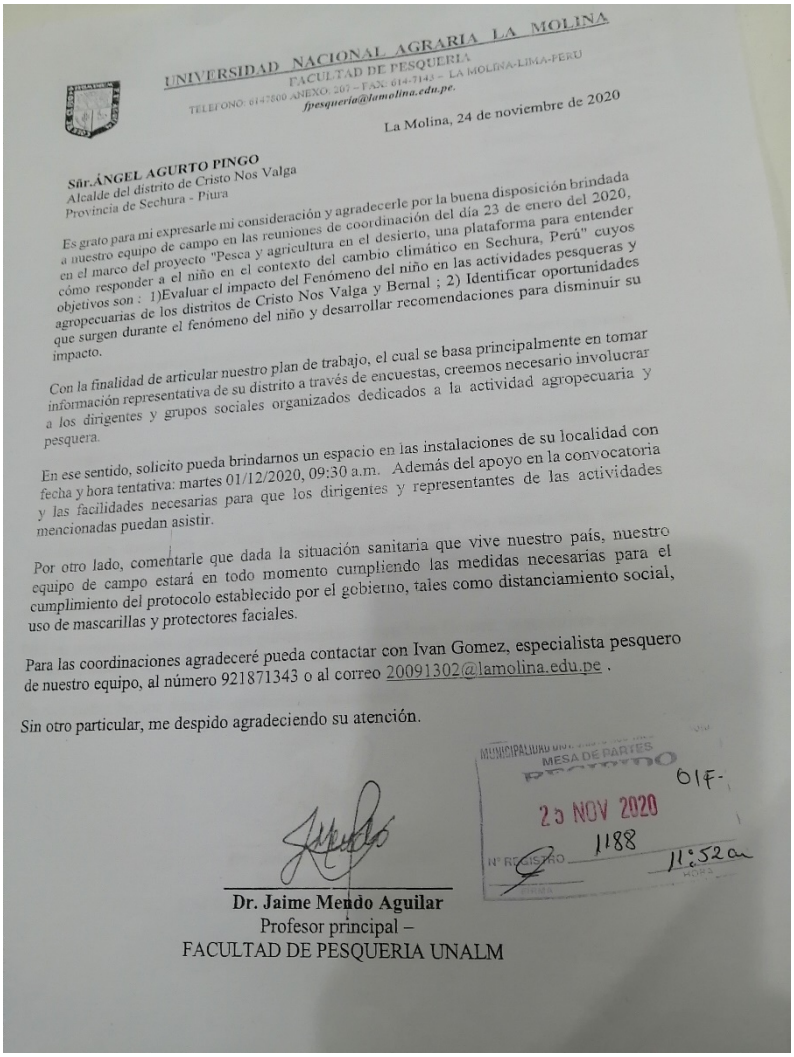
2.3. Meeting with the mayor of Bernal

With the aim of seeking backing from the municipality of Bernal, the FDA field team met with the representative mayor of said district, Mr. Boris Montaño Tume. The agenda was the following:

1. Present FDA objectives in the project to the mayor.
2. Request a local space and convene local leaders.

Results:

- The mayor assigned Jose Fiestas (Councillor) for the meeting, who committed to providing a space within which to carry out the coordination meeting.
- Mr Jose Fiestas committed to convening community leaders for said reunion.
- Mr Jose Fiestas assigned Mr Richard Chapilliquen (Manager of Economic Development) for relevant coordination.
- The FDA is requested to formalise the order through a document.



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fpesqueria@lamolina.edu.pe.

La Molina, 24 de noviembre de 2020

Sñr. ÁNGEL AGURTO PINGO
Alcalde del distrito de Cristo Nos Valga
Provincia de Sechura - Piura

Es grato para mi expresarle mi consideración y agradecerle por la buena disposición brindada a nuestro equipo de campo en las reuniones de coordinación del día 23 de enero del 2020, en el marco del proyecto "Pesca y agricultura en el desierto, una plataforma para entender cómo responder a el niño en el contexto del cambio climático en Sechura, Perú" cuyos objetivos son : 1)Evaluar el impacto del Fenómeno del niño en las actividades pesqueras y agropecuarias de los distritos de Cristo Nos Valga y Bernal ; 2) Identificar oportunidades que surgen durante el fenómeno del niño y desarrollar recomendaciones para disminuir su impacto.

Con la finalidad de articular nuestro plan de trabajo, el cual se basa principalmente en tomar información representativa de su distrito a través de encuestas, creemos necesario involucrar a los dirigentes y grupos sociales organizados dedicados a la actividad agropecuaria y pesquera.

En ese sentido, solicito pueda brindarnos un espacio en las instalaciones de su localidad con fecha y hora tentativa: martes 01/12/2020, 09:30 a.m. Además del apoyo en la convocatoria y las facilidades necesarias para que los dirigentes y representantes de las actividades mencionadas puedan asistir.

Por otro lado, comentarle que dada la situación sanitaria que vive nuestro país, nuestro equipo de campo estará en todo momento cumpliendo las medidas necesarias para el cumplimiento del protocolo establecido por el gobierno, tales como distanciamiento social, uso de mascarillas y protectores faciales.

Para las coordinaciones agradeceré pueda contactar con Ivan Gomez, especialista pesquero de nuestro equipo, al número 921871343 o al correo 20091302@lamolina.edu.pe .

Sin otro particular, me despido agradeciendo su atención.

MESA DE PARTES
25 NOV 2020
N° REGISTRO 1188
11:52 a

Dr. Jaime Mendo Aguilar
Profesor principal –
FACULTAD DE PESQUERIA UNALM

Fig. 3. Invitation letter for the mayor of Cristo Nos Valga.

2.4. Field trip – Ñapique lagoon

The FDA field team visited the Ñapique lagoon on the 24th of November 2020 with the aim of familiarising themselves with the lagoon and to interact with local fishermen. They were able to contact Mr Roger Paiva and his son, Regulo Paiva, fishermen of the Onza de Oro community, who mentioned that the villages of Onza de Oro, Santo Domingo, and Cerritos have fishermen dedicated to continental fishing in the Ñapique lagoon and nearby sources of water. A pending follow-up visit was organised to survey the area and accompany them on fishing trips.

Fig. 4 left to right: (1) First visit to the Ñapique lagoon; (2) PVC raft for fishing mullet.

2.5. I Coordination Meeting – Cristo Nos Valga

The 2nd of December 2020, the first coordination meeting took place in the facilities in the Cristo Nos Valga municipality. This meeting was attended by Mr Angel Agurto Pingo (mayor of Cristo Nos Valga) and the communal leaders of the district villages.

Through the Cristo Nos Valga municipality, community leaders were convened from the villages dedicated to agricultural, livestock, and fishing activities with the aim of informing and articulating the working plan, which is based mainly on obtaining representative information about the district through surveys.

The aims of the meeting were the following:

- Disseminate the scope of the project to community leaders.
- Collect information on the location and number of members per village through the community leaders.
- Draw up a timetable agreed with the community leaders for carrying out surveys in the communities.

Fig 5. Project presentation in the Cristo Nos Valga municipality.

Proyecto: "Pesca y agricultura en el desierto, una plataforma para entender cómo responder a el niño en el contexto del cambio climático en Sechura, Perú "

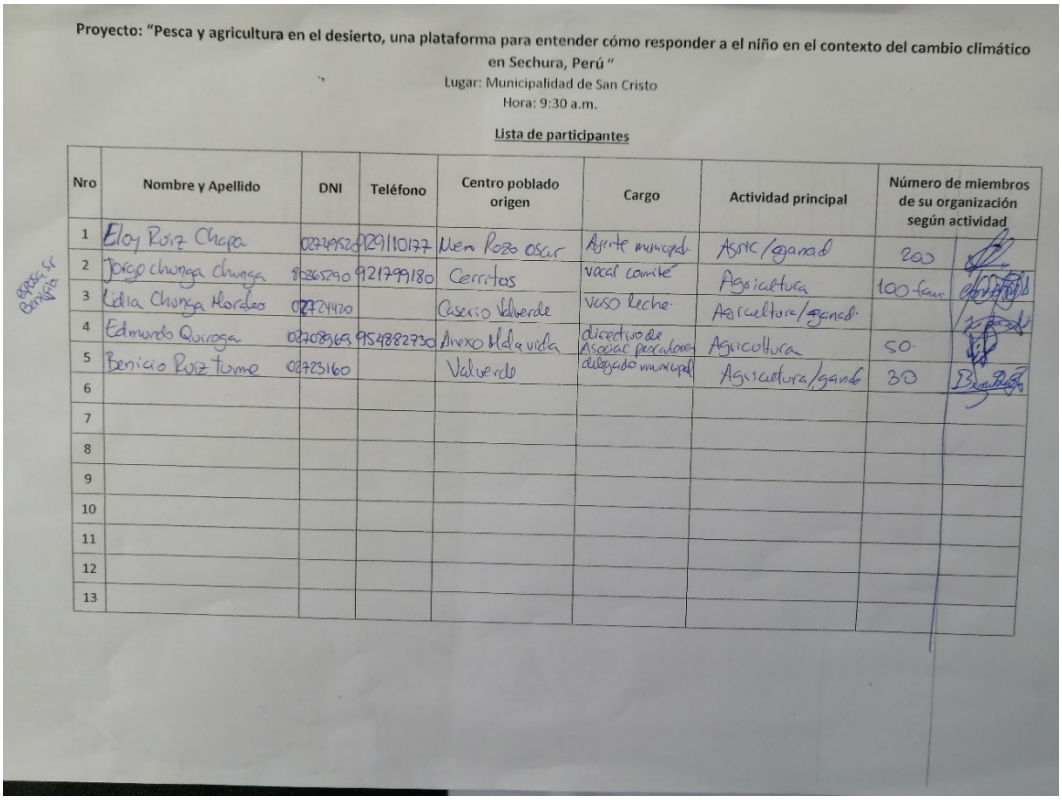
Lugar: Municipalidad de San Cristo

Hora: 9:30 a.m.

Lista de participantes

Nro	Nombre y Apellido y	DNI	Teléfono	Centro poblado origen	Cargo	Actividad principal	Número de miembros de su organización según actividad
1	Bernardo Ruiz Tume	027090	969374212	CHUTUQUE	Pdte comité Riego Temporal	AGRICULTOR	100
2	Pablo Purizaca Chunga	02709374	954711787	CHUTUQUE	PDTE JUNTA ADM. LOCAL	AGRICULTOR	100
3	Santos MARTINEZ FIESTAS	02832370	912527568	SAN RAMON	TENIENTE GOBERNADOR	AGRICULTOR	10
4	Simon Purizaca Chavez	02708819	986712381	LA ALGARROBERA	DELEGADO MUNICIPAL	AGRICULTOR	15
5	DIEGO CHUNGA MORRES	42328497	976276744	CHUTUQUE	TENIENTE GOBERNADOR	AGRICULTOR	100
6	ANIBAL AYALA ESPINOZA	43161638	912319457	CERRITOS	DELEGADO	AGRICULTORA	60
7	JUAN HILARIO JACINTO TEMOCHE	02757706	969320936	VICE	PRESIDENTE GRUPO COMUNAL	AGRICULTORA	120
8	ANTONIO ESPINOZA CHAPILLIQUEN	02809850	925554519	CERRITOS	POBLADOR	AGRICULTORA	50
9	ISIDRO PURIZACA RAMOS	02708833	957107714	MALA VIDA	PRESIDENTE JAS	AGRICULTORA	200
10	Braulio Cesar Alvarez Anton	45835692	981498097	Cristo nos valga	Presidente Club deportivo	Agricultora.	100
11	Alejandro Morales Paco	40132275	942329878	caseríoMalavida	Secretario de JAS de la parcelación	Agricultura	300
12	Claudio Paiva Navarro	02872493	926938055	Mala vida	Teniente gobernador	Agricultura	280
13	Timoteo Chapa Morales	02862384	969888659	Nuevo Pozo oscuro	Vocal de comisión de terrenos	Ganadería	300

Fig. 6. List (1) of attendees at the meeting in the Cristo Nos Valga municipality.



Proyecto: "Pesca y agricultura en el desierto, una plataforma para entender cómo responder a el niño en el contexto del cambio climático en Sechura, Perú "

Lugar: Municipalidad de San Cristo
Hora: 9:30 a.m.

Lista de participantes

Nro	Nombre y Apellido	DNI	Teléfono	Centro poblado origen	Cargo	Actividad principal	Número de miembros de su organización según actividad	
1	Eloy Ruiz Chapa	02749520	929110177	Nuevo Rosa oscar	Agente municipal	Agric/ganad	200	
2	Jorge chunga chunga	80865290	921799180	Cerritos	vocal comité	Agricultura	100 fam	
3	Lidia Chunga Morales	02724920		Caserio Valverde	vaso leche	Agricultura/ganad		
4	Edmundo Quiroga	02708965	954882730	Anexo Vida vida	directivo de Asociac pescadores	Agricultura	50	
5	Benicio Ruiz toma	02723160		Valverde	delegado municipal	Agricultura/ganad	30	
6								
7								
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Fig. 7. List (2) of attendees at meeting in the Cristo Nos Valga municipality.

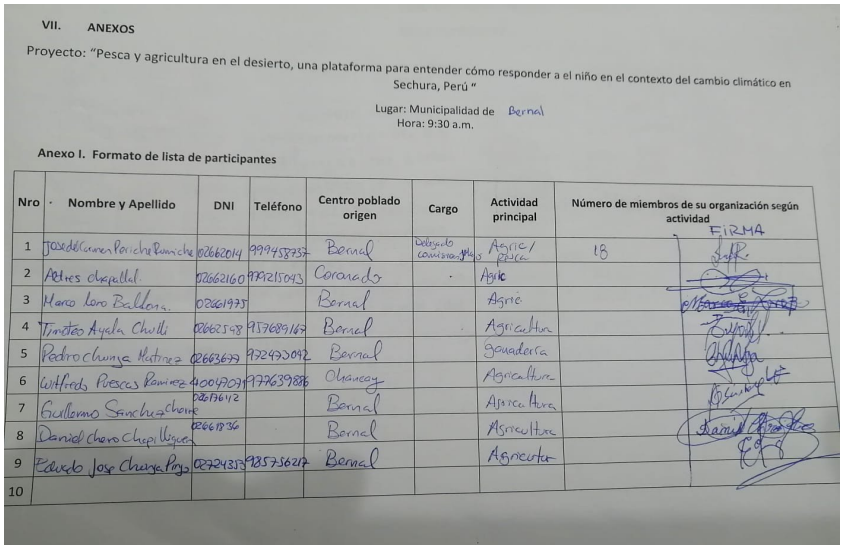
2.6. I Coordination Meeting – Bernal

The 7th of December 2020, the first coordination meeting was held in the facilities of the Irrigation Committee in Bernal. This meeting was attended by the representatives of the Bernal municipality, Mr Richard Chapilliquen (Economic Development Manager) and the community leaders of the district's villages.

Through the Bernal municipality and the district's Irrigation Committee, community leaders were convened from the villages dedicated to agricultural, livestock, and fishing activities with the aim of informing and articulating the working plan, which is based mainly on obtaining representative information about the district through surveys.

The aims of the meeting were the following:

- Disseminate the scope of the project to community leaders.
- Collect information on the location and number of members per village through the community leaders.
- Draw up a timetable agreed with the community leaders for carrying out surveys in the communities.



VII. ANEXOS

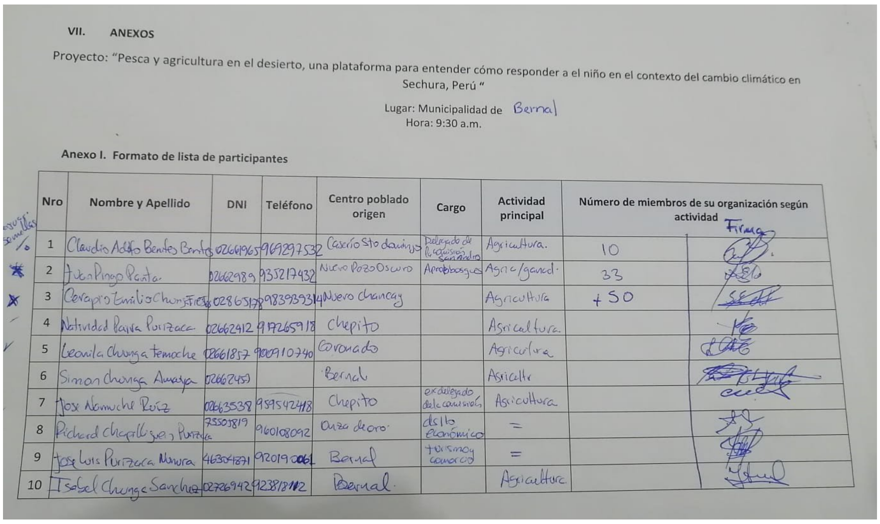
Proyecto: "Pesca y agricultura en el desierto, una plataforma para entender cómo responder a el niño en el contexto del cambio climático en Sechura, Perú "

Lugar: Municipalidad de Bernal
Hora: 9:30 a.m.

Anexo I. Formato de lista de participantes

Nro	Nombre y Apellido	DNI	Teléfono	Centro poblado origen	Cargo	Actividad principal	Número de miembros de su organización según actividad	FIRMA
1	Jose del Carmen Paricha Panicha	02662014	999458757	Bernal	Delegado comisaria	Agric/ Pesca	18	
2	Pedres chapallal	02662160	997215043	Corrado		Agric		
3	Marco Loro Ballona	02661973		Bernal		Agric		
4	Timoteo Ayala Chulli	02662548	957689167	Bernal		Agricultura		
5	Pedro Chunga Martinez	02663677	972495092	Bernal		ganadería		
6	Wilfredo Pescas Ramirez	40019707	977639886	Chanecay		Agricultura		
7	Guillermo Sanchez Chone	02673612		Bernal		Agricultura		
8	Daniel chero Chapilliquen	02661836		Bernal		Agricultura		
9	Eduardo Jose Chunga Puyo	02724337	985756217	Bernal		Agricultor		
10								

Fig. 8. List (1) of attendees to the meeting in the Irrigation Committee facilities in Bernal.



VII. ANEXOS

Proyecto: "Pesca y agricultura en el desierto, una plataforma para entender cómo responder a el niño en el contexto del cambio climático en Sechura, Perú "

Lugar: Municipalidad de Bernal
Hora: 9:30 a.m.

Anexo I. Formato de lista de participantes

Nro	Nombre y Apellido	DNI	Teléfono	Centro poblado origen	Cargo	Actividad principal	Número de miembros de su organización según actividad
1	Claudio Adolfo Benites Benites	02661965	969297532	Caserío Sto domingo	Delegado de la comisión San Andrés	Agricultura.	10
2	Juan Pingo Panta	02662989	935217432	Nuevo Pozo Oscuro	Aprobosques	Agric/ganad.	33
3	Cerapio Emilio Chunga Fiestas	02865178	983939314	Nuevo chancay		Agricultura	+50
4	Natividad Paiva Purizaca	02662412	917265918	Chepito		Agricultura.	
5	Leonila Chunga temoche	02661857	980910740	Coronado		Agricultura	
6	Simon Chunga Amaya	02662451		Bernal		Agricult.	
7	Jose Nomuche Ruiz	02663538	959542418	Chepito	ex delegado de la comisión	Agricultura	
8	Richard Chapilliquen Purizaca	75503819	960108092	Onza de oro	dsllo económico	=	
9	Jose Luis Purizaca Nomura	46304871	920190061	Bernal	turismo y comercio	=	
10	Isabel Chunga Sanchez	02726942	923818112	Bernal.		Agricultura	

Fig. 9. List (2) of attendees to the meeting in the Irrigation Committee facilities in Bernal.

2.7. Capacity building meeting

In the framework of the project " Fishing and Farming in the Desert: a platform for understanding how to respond to El Niño in the context of climate change in Sechura, Peru" and with the aim of strengthening coordination activities for the collection of information from the inhabitants of the communities surrounding the Ñapique and La Niña lagoons in the Sechura desert, the technical team of the Foundation for Agrarian Development (FDA) visited the village of "Chutuque" in the district of Cristo Nos Valga, Sechura. The FDA was attended by Dr Jaime Mendo and his technical team, who met with Mr Bernardo Ruiz Tume (president of the COMMITTEE OF TEMPORARY WATER USERS FOR AGRICULTURAL IRRIGATION, LIVESTOCK, FISHING, TOURISM, AND OTHERS ON THE LEFT AND RIGHT BANKS ON THE PIURA RIVER, SECHURA PROVINCE – R.A. N°040-2019-MDCNV/A) and Mr Diego Chunga Morales (Lieutenant Governor of the village of "Chutuque").

Dr Jaime Mendo started the meeting with a brief explanation of the project and its importance for decision making in the face of opportunities generated by El Niño for local economic activities, mainly those of fishing and agriculture. Mr Bernardo Tume and Diego Chunga communicated their interest in supporting the project for the deployment of the survey to more villagers and committed to providing support so that more communities in the organisation can provide facilities to gather information. Additionally, they mentioned that said committee was executing a project titled "LA TAPA DEL CUY" (The Guinea Pig's Lid), whose aim is to dam the water coming from the Piura river to be used for family agriculture, and they requested support, whether through the university or another institution, for the development of productive projects such as aquaculture, grape production, carob tree forest management, production of brine shrimp, and training for the use of technical irrigation as an alternative in the face of water scarcity.

The FDA team explained to the leaders the importance of the organisation to access competitive funds for the development of productive pilot projects of social impact and promised to contact professors from the UNALM to advise and virtually train the villagers in the use of technical irrigation in local agricultural production. It is worth noting that the leaders have been carrying out a census of the inhabitants of their organisation and offered to provide the information needed. This organisation includes the villages of "Mala Vida", "Cerritos", "Onza de Oro", "Nuevo Pozo Oscuro", "Los Jardines", among others.

Finally, the FDA team held a meeting in Sechura with Mr Alex Eche Chunga (Economic Development Manager of the Sechura Municipality) who expressed his interest in strengthening the level of organisation in these communities in order to access future competitive funds and logistical support to continue with the surveys during the following months.

ANNEX III. PHOTOGRAPHS

Annex 3.1. Rafts used for fishing mullet in the La Niña lagoon formed in 1998. (Source: El Comercio, 2020).

Annex 3.2. Fishermen and rafter camp in the La Niña lagoon formed in 1998. (El Comercio, 2020).

Annex 3.3. Road occupied by the body of water of the La Niña lagoon in the summer of 1998 (El Comercio, 2020).

Annex 3.4. Dry surface of the Ramon lagoon before being destined as land for temporary harvest (October, 2020).

Annex 3.5. Remnants of mullet (*Mugil cephalus)* that weren't taken advantage of in the La Niña lagoon. (Photo by Marlon Eche).