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Climate Change Impacts and Adaptation in Peru: The Case of Puno and Piura

Erika Trigoso Rubio

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Introduction

Understanding adaptation has become one of the most important foci of research into climate change impacts and vulnerability (Blaikie et al. 1996; Adger 1999; Kasperson & Kasperson 2001; Leichenko & O'Brien 2002; Brooks & Adger 2003; Downing & Patwardhan 2003; Huq et al. 2003; O'Brien et al 2004). When looking at developing countries, vulnerability is the one factor that could potentially be managed to reduce negative impacts of environmental change. Despite this fact, there is little research at the regional and local level that examines detailed vulnerability in terms of exposure, sensitivity and adaptive capacity; which are three components of vulnerability identified by the Intergovernmental Panel on Climate Change (IPCC). I will explore these ideas through the assessment of vulnerability and adaptation in two study sites of Peru: the department of Puno located in the southern Andes and the department of Piura along the northern coast. The first study site has a long history dealing with droughts while the latter deals with frequent flood events. In order to assess adaptation constraints I will explore the concept of environmental orthodoxies. These are generally accepted scientific explanations for environmental problems that have influenced policies for a number of years, but that now are being challenged by new research especially at the local level (Gary & Moseley 2005; Forsyth 2003; Carswell 2003). I will use a political ecology approach to undertake a structural and ecological analysis of vulnerability by identifying environmental orthodoxies that negatively influence vulnerability levels in the study areas. This perspective will allow me to question the reasoning behind Western explanations of the environmental destruction/degradation that lead to higher vulnerability levels and more difficult adaptation.

Rationale and Background

Peru is a Latin American country experiencing challenges at both socio-economic and environmental levels. Despite experiencing steady economic growth it has 48% of its population living in poverty conditions (INEI 2007). Peru has been ranked third globally in terms of risk to climate related disasters, being ranked in the top thirty countries for the last three decades and second in the last ranking for the Latin American region (Brooks & Adger 2003). There are concerns about the current and future impacts of climate change in Latin America in terms of vulnerability (IPCC 2001) and this concerns aggravate the future panorama of Peru. Peru is also South America's most water stressed with 70% of its population living in the coastal desert were only 2% of water resources are found. Here, river runoff coming from the Andes is crucial and this is due to seasonal glaciar melt. The Andean region has lost 22% of its glacier area since 1970 (Becker 2007). The consequences of glacial melting for local populations are serious. Glaciers regulate stream flow diminishing seasonal variations during a critical three-month period (September through November) due to the rivers' reduced levels of flow during those months (UN 2006).

Within Peru, two of the most recurrently impacted regions are Puno and Piura that represent well the wide spectrum of climate related impacts that occur in this country. Global change research has been deficient in analyzing interrelated economic, environmental and political forces on vulnerability of societies like those in Puno and Piura. As the skill of climate change modeling improves, it will become increasing critical to understand how global economic processes, national policies and local actions interact with each other and with environmental variables at different scales to determine the vulnerability and adaptive response of a population. Without this understanding, it will be highly difficult to recognize the implications of global climatic change for particular populations in specific places.

This article is designed to address this deficiency in our understanding of these interactions through the analysis of two scenarios: vulnerability and adaptation of the predominantly mountainous society in Puno and the coastal society in Piura. Despite the constraints of high altitude (where most of the territory is over 3,500 m.o.s.l.), Puno lies in one of world's cradles of agriculture (high Andean plateau), where products such as potato, quinoa, and mashua, among others, were first domesticated. Despite the recurrence of droughts, frosts and El Niño Southern Oscillation (ENSO) events, especially in Piura, the study areas are ill prepared to confront the impacts of the increase in sea surface temperature (affecting fishing), and fluctuations in temperature and precipitation, (affecting farming).

Theoretical Framework

Vulnerability is a complex term that has to be adjusted to what it is that a certain population is susceptible to (WFP 2004); despite having its origins in geography and natural hazards research, vulnerability as a concept is now widely used by many different disciplines (Füssel 2005). In relation to climate change an integrated approach to vulnerability involves understanding the extent to which a social system is susceptible to damage from climate change threats. Furthermore the IPCC Third Report identifies vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (McCarthy et al. 2001).

The biophysical components of vulnerability have been widely addressed within hazards and risk literature while the social components are not well studied, mainly because of the difficulty of quantifying them (Cutter et al 2003). A variety of authors (Cannon 2000, O'Brien et al 2004, Füssel 2005) emphasize the importance of understanding the social component of vulnerability. Vulnerability theorists like Cannon (2002) analyze vulnerability via a political economy framework in which vulnerability is measured as a ranking within a continuum with total resilience at one end and total susceptibility at the other. Under this framework both physical and social components should be addressed to permit mitigation and preparation measures as well as economic restructuring.

It is important to point out that a great amount of research on vulnerability focuses on climate change, especially in developing countries. It mostly concentrates on those components that are more sensitive to environmental stressors, like agriculture or food security (Fischer, Shah and van Velthizen 2002; Huddleston, Ataman and Fè d'Ostiani 2003; WFP 2004; Javed 2005).

From political ecology[1] I want to explore the intersection between the physical risk (floods and droughts) and vulnerability caused by a altered environment where this change may be driven by terms of change by different actors (see Table 1), by specific laws or by a identifiable part of a political system. Within the political ecology idea, I will also explore the concept of environmental orthodoxies due to the identification of different western approaches to environment in Latin America that may influence negatively the way in which the environment is understood and exploited.

Table 1: Interest Groups in Peru and Role in Political Ecology

Actors	Position in Political Ecology	Source of Power	Interests and Aims	Means to Reach Change
Local residents	Marginalized, excluded. No agricultural support	Limited but through community organizations	Safety of housing and crops	Informal jobs, forecasts, improved crops
Mayors / Municipios	Control district apparatus, access to a small budget, local leader, control on community lands	Democratic elections but subject to regional government	Personal legitimacy, safety of inhabitants, land conservation	Municipal budget, access to power among population
Federal government	Control national apparatus, creates policies	Democratic elections , populism approach	Control of people, reelection, less impact	Centralistic development budget

Case Studies

The 2001 report of Working Group II for the IPCC has identified key concerns for Latin America in relation to climate change in which vulnerability levels are expected to increase while adaptive capacity will decline. Among these issues are predictions that flood and droughts will become more frequent and the loss and retreat of glaciers will affect

[1] Term used in geography to relate policies to interactions between society and its environment

negatively impact runoff and water supply due to the fluctuations that it will bring to water bodies volume. The cases of Puno and Piura illustrate a climate change impacts dichotomy in Peru. On one hand there are drought and frost impacts in Puno (predominantly mountainous) and floods in Piura (predominantly coastal). Both regions are administered primarily from Lima and face similar socioeconomic circumstances such as a high percentage of poverty: Puno 74.0% and Piura 60.5% (INEI 2007) and a high percentage of economic active population employed in agrarian activities: Puno 78.2% and Piura 89.2% (INEI 1996) these two regions will be contrasted (see Figure 1).

Figure 1: Peru - Location of Study Sites

The departments of Piura and Puno are both recurrently impacted by climate related events where they rank high among the other departments. For example, during the decade of 1995-2005 Piura and Puno ranked second and third respectively in loss of agricultural land (see Table 2).

Table 2: Indicators of Disaster Related Impacts 1995-2005

Departments	Population (2005)	Number of emergencies due to climatic events	Agricultural land lost (ha)	Affected Housing	Casualties
Piura	1660952	346	88150	54859	80
Puno	1245508	881	59994	24678	439

Source: INEI 2005, SINADECI 2006

The Case of Puno

Mountainous areas are important sources of water, energy, and agricultural products. They are also valuable biological reserves. Furthermore, mountain regions are unique areas for detection of climate change processes since climate, vegetation and hydrology change rapidly with altitude in small horizontal distances (Beniston 2003, 5-6). However mountainous areas of South America are poorly understood in terms of vulnerability to climate change processes. Although global warming is being portrayed via different scenarios, most results suggest a situation in which the hydrological cycle will become more active. This will enhance evaporation as well as greater precipitation events that will affect soil moisture, groundwater reserves, and the frequency and intensity of floods and droughts (IPCC 1996).

The Andean region is formed by a great diversity of fragile ecosystems that due to this variability are greatly vulnerable to climate change (CONAM 2004). Puno lies within the Altiplano area, a region shared among Peru, Bolivia, and Chile. This high and flat mountainous area is located between two Andean ranges and is home to Lake Titicaca. The presence of Lake Titicaca serves to moderate the climate over an extended area. Nevertheless, the Altiplano is greatly impacted by seasonal climate variations that range from frost events several times a year, to droughts that can be related to ENSO. Most of Puno’s territory lies over 3800 m.o.s.l. which is considered the limit for most viable agriculture (INEI 1998). Despite this, the agricultural sector remains the second most important economic activity with 16.3% of the regional GDP (INEI 2002).

The area of Puno presents three types of constraints that contribute to vulnerability (based on Huddleston, Ataman and Fè d’Ostiani 2003, 17): environmental constraints, isolation/lack of access infrastructure and malnutrition/poor health. Under present conditions the high altitude is the main environmental constraint due to the difficulty it presents for agrarian activities. Due to its continentality, 68% of Puno’s surface area lies within a zone with pronounced temperature oscillations within a 24-hour period. Furthermore, the high probability of frost events during critical fenology periods is considered the most important constraint for agricultural activities. Seasonal floods caused by summer precipitation affect the Lake Titicaca floodplain causing river flooding. Droughts are also present in a cyclical way causing important losses (INEI 2003). Additionally, the Comision Nacional del Medio Ambiente (CONAM 2004) has identified socioeconomic causes for the high vulnerability present in Puno: occupation of floodplain areas mostly around Lake Titicaca; the lack of drainage systems around Lake Umayo; an occupation pattern that does not take into account restrictions in dangerous areas; the inadequate management of resources that contribute to deforestation, lack of use of better pastures, the use of deficient construction materials; a socioeconomic infrastructure exposed to climate hazards (agricultural activities highly vulnerable). Previous research has identified Puno as a region that concentrates most of the climate related dangers in Peru (CONAM 2004) and as the region with the highest Climate Vulnerability Index (CVI) for Peru (Sullivan & Meigh 2005)[2].

Despite the existence of environmental orthodoxy present in Puno were the harsh climate and altitude limitation do not suggest viable agriculture Puno has the potential to diminish vulnerability to extreme events and conduct local economic development. Despite its high altitude location, Puno is home to one of the first intensive agricultural societies in the world in which several crops were domesticated for such high altitude environments and extreme climate fluctuations (see Table 3). These crops not only have a high resistance to climate related impacts but also have a high nutritional value (Jacobsen, Mujica & Ortiz 2003). Along with the availability of these crops agricultural techniques that confronted environmental constraints were also developed. Among those are agricultural terraces, artificial swamps and raised fields (Erickson & Candler 1989; D'Achille 1994). From these the raised fields were the most widespread with an extension that ranges from 80,000 – 160,000 ha (Erickson & Candler 1989). The raised fields recreate the temperate effect of Lake Titicaca on the crops keeping those warm at night and capturing solar radiation away from the crops during daytime. The use of these techniques in the cultivation of suitable crops made possible the development of the sophisticated Pre-Columbian Tiwanaku society (Morris 1999; PEISA 2003b).

Table 3: Native plants of the Altiplano region

Name	**Altitude (m.o.s.l.)**	**Extreme event resistance**
Mashua	3000 – 4000	Frost
Olluco	3000 - 3900	Drought and Frost
Macca	3800 - 4200	Drought, frost, hail and strong winds
Quinoa	40 - 4200	Drought and frost
Potato (bitter)	3815 - 4200	Frost

[2] Developed by Dr. Caroline Sullivan. Incorporates 6 components: geospatial, resources, access, capacity, use and environment. For more information on CVI refer to the Center of Ecology and Hydrology web page: http://www.ceh.ac.uk/sections/ph/ClimateVulnerabilityIndex.html

Potato (sweet)	3815 - 3900	Frost
Cañihua	3000 - 4450	Frost

Sources: PIWA 1993; INIA 1997; INIA 2005

It was only after the beginning of the colonial period during the Spaniard rule that many of the native crops were replaced by European crops. At the same time the locally developed techniques were also replaced. The customary worship that the natives offered to some of these crops contributed to its abrupt reduction and replacement for other produce. At present the most important crops in Puno are potato, oca, barley, orange and quinoa; a mix of native and introduced species (DIA 2007). This fact, the introduction of both foreign species and foreign agricultural techniques may have contributed to current negative indicators: the recurrent loss of cultivated land due to emergencies, where Puno is ranked third nationally in the 1995-2005 period (SINADECI 2006), and the high level of malnutrition that includes 32% of children (FONCODES 2007).

Drought events in Puno are usually related to ENSO events like the extreme drought experienced during 1983 ENSO, which brought catastrophic droughts while 1997/98 brought a shorter but intense drought period. Previously the Altiplano region has experienced a severe drought in 1992, heavy precipitation and frosts in 2001 and both severe drought and frost in 2004 (Revista Agraria 2001, 2004). All of these events caused losses in the form of crops, cattle and people and led to food insecurity and a deeper socio-economic vulnerability. There have been recurring droughts, floods and frost during the past years (La Republica 2004a, 2004b), that have brought into question the vulnerability levels to the effects of climate change. Also, it has been extensively discussed that glaciers in South America have been melting in the past decades and this could mean less water overtime for agricultural lands especially in extremely dependent countries such as Bolivia (Mosley-Thompson 1997). Global warming in high mountain regions could lead to disappearance of significant snow and ice surface. Because these areas contribute to river stream flow, this trend also would reduce water availability for irrigation, hydropower generation, and navigation.

Puno's long history with climate related impacts has made farmers aware of recurrent diversity of consequences coming from a variety of impacts. This variability have also influenced on the development of adaptation strategies. In spite of not using specific climate forecasts they rely on direct environmental observation of changes in fauna and flora to determine the crop season[3]. This awareness has contributed to the development of adaptation and coping practices. The most common is parcel zoning diversification where one household works on two or more parcels located on different ecological zones so in case of drought impacts in one area they would still have the crops obtained in the second and/or third parcel. One of the main constraints for adaptability is the lack of irrigation and parcel size. The last agricultural census (INEI 1995) shows that in Puno only 3.67% of agricultural land has access to irrigation and 27% of parcels are

[3] Personal communication, field surveys 4/11/07-4/15/07

less than one hectare in size and usually they contain small quantities of two or three crops. These aspects plus the lack of diversification limit enormously the coping capacity and adaptability of the farmers.

In the event of climate change, the Andean areas that would suffer the greatest impact would be those dedicated to agricultural production, due to the uncertainty of natural cultivation conditions. However climate change could bring positive news for at the national scale including Peru. Shah (2004) suggested that under some Intergovernmental Panel on Climate Change (IPCC) climatic models for 2080 cereal production would actually increase for countries like Chile (>50%), Peru (20-50%) and Ecuador (1-5%); just to mention those with consistent results through all the models. However, Bolivia (located mostly in the Altiplano), will experience losses under two of the models.

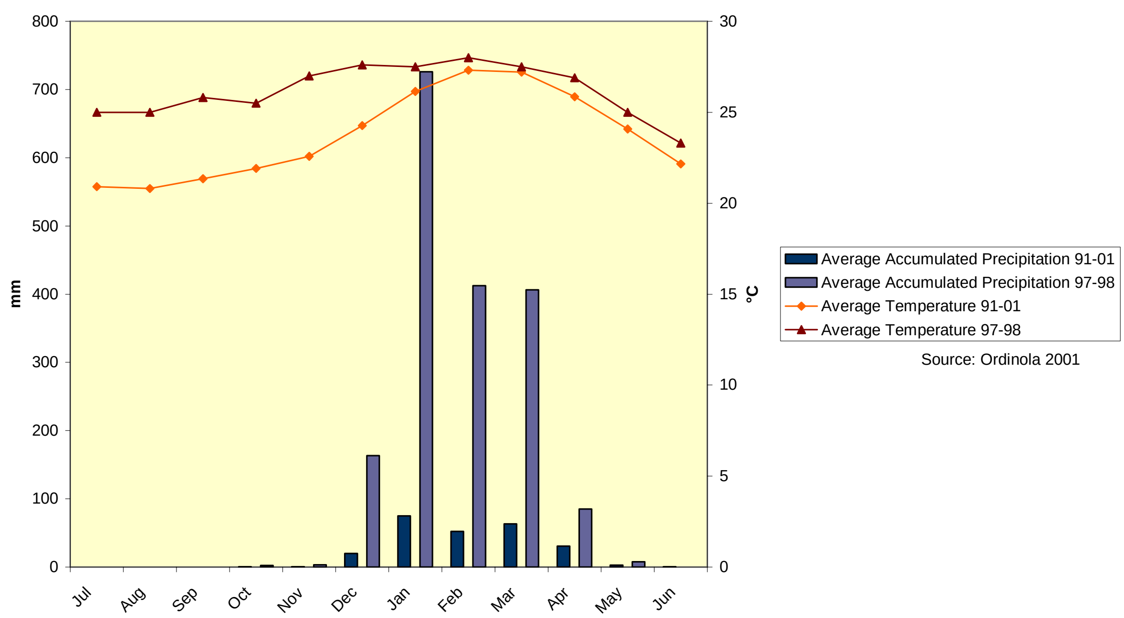
In the case of Puno, agriculture remains one of the most important economic activities, behind only manufacturing (INEI 2002), and this is despite the lack of artificial irrigation and its subsistence nature. Moreover, present research at the global level contradicts its historic agricultural importance because it identifies highland areas as unsuitable for agriculture. This is an example of an environmental orthodoxy that could be challenged with research at the local level. I argue than rather than incorporating western agricultural techniques to improve agrarian conditions and diminish vulnerable conditions it will be more effective to return to local crops that were developed for high altitude environments. It will also be more useful to return to locally developed agricultural techniques such as raised fields, artificial swamps and terraces that have proved quite effective in improving agricultural outputs.

The Case of Piura

The Department of Piura is located in the Peruvian north coast and has a varied physical geography with two major regions. The first region is the coast, and is predominantly desert plains. The coast has the biggest desert in Peru: the Sechura Desert. Other important features in the coastal region are the dry watersheds, which only become active during high precipitation periods such as during El Niño episodes. The second region is the mountain region to the east, which reaches to the Andes. It has deep and eroded valleys making this second region very vulnerable to flooding and erosion. This region relies heavily on the agricultural sector that represents 9.25% of its GDP (INEI 2002). During the last episode of El Niño a 150 km long and 3m deep lake formed in the Sechura desert, normally one of the driest deserts in the world. This lake was called La Niña and it became the second largest lake in the country after Lake Titicaca (Woodman 1998).

During the last ENSO event (1997/98) there was a significant increase in temperature and an extraordinary increase on precipitation reaching 5000% increase in the area of Paita (Ordinola et al. 2001) and other significant increases in other areas of this region (see Figure 2). Despite the implementation of an early alert system and the recurrence of ENSO in the region a limited focus of only dealing with the physical aspects of the event, the problem of flood vulnerability will continue unabated. Many problems related to El Niño events cannot be resolved through a seasonal forecast. Problems such as poverty or centralism are generally structural in nature and must be addressed in the long term. The vulnerability problem in Piura is increasing and it cannot be solved with only a technical response to an early alert (Zapata 1999).

Figure 2: Climate Comparison in Piura: Normal vs. ENSO 97/98



In the case of Piura, many people tend to relate climate change impacts only to heavy rain, but not to resource management and basin management that might exacerbate vulnerability. The political ecology in Piura has the government and public in general paying more attention (in the form of public investment) to urban zones, leaving the rural zones poorly attended (CTAR 1998). This unbalance causes land degradation. Also taking into account political ecology, during the last ENSO in Piura there were important criticisms of policy that illustrate the role of the government in creating vulnerability in relation to agriculture. Because of forecast of high rainfall associated with El Niño the government decided to promote rice rather than cotton by providing seeds and machinery. There was an overproduction problem (Remy 1998), that translated into bankruptcy for the farmers due to the price drop. According to a former mayor[4] of the district of Morropón and director of the development project of local governments of the Centro de Investigacion y Promocion del Campesinado (CIPCA), usually Piura has a rice area limited to 10,000-12,000 ha, but it had increased to 25,000 ha. When the prices went down dramatically the peasants lost their investment, their coping strategy failed. There was no choice for the

[4] personal communication 10/7/01

peasants, other than to cultivate rice due to the believe that the heavy rains will damage everything else. The idea of adaptation to climate change impacts in Piura focuses mainly on engineering infrastructure construction and reinforcement (reinforcement of bridges, cleaning of riverbeds among others), without taking into account economic and social conditions (Franco 1998).

In Piura during El Niño 1997/98, political economic structures influenced the way people interact with the environment. Centralism permeates the Peruvian political structure and constraints local decisions. For example, centralism acted to inhibit the local government and people in Piura from gaining national resources and political power or to decide what to cultivate or what mitigation works to implement. The Peruvian political system has also limited capacity of generating either formal jobs or formal housing for its growing population (De Soto, 1989).

Despite their limitations, climate forecasts had an enormous importance in developing strategies to cope with El Niño. In July 1997, El Niño forecasts provided the opportunity to develop a prevention plan in Peru that included agricultural planning, credits for housing reinforcement, prevention works and relocation of population at risk. Overall, El Niño 1997/98 short terms impacts provided a good example of forecast accuracy (Stern & Easterling 1999).

In general, geographers have made important contributions to natural hazard and vulnerability research primarily by contributing to the understanding of human interrelations with the environment (Hewitt, 1983; Mitchell 1989). This interaction is based in four variables: risk, exposure, vulnerability and response/adaptation. These variables can be examined in Piura in the context of El Niño. Regarding risk, Piura is physically located at the focus of ENSO impacts in Peru in which Piura suffers from major anomalies in temperature and much heavier precipitation during El Niño events (Peisa 2003). Second, the concept of exposure includes a population at risk of more than 1.6 million people. Third, the vulnerability of this population is not well understood due to the lack of research in the zone and the focus on physical risk and structural damage. Nevertheless, since a high percentage of people in Piura are poor: 60.5% (INEI 2007), they may be hypothesized as highly vulnerable. Fourth, the response/adaptation factor should switch from a structural and engineer focus to agriculture contingency measures to avoid a direct and critical impact on people’s livelihoods.

The agricultural sector is one of the most vulnerable to El Niño because strong precipitation and floods destroy crops and farmland. The last agricultural census for Piura (INEI 1995) shows that 89% of the farmers own small parcels with low productivity. 18.7% of the parcels are less than one hectare in size. However, 89% of the parcels have access to irrigation, aspects that contributes to lower vulnerability.

The 1997/98 El Niño (change in sea surface temperature and increased precipitation) had very serious impacts in Piura. By February 11, 1998[5] the damages involved a large percentage of the economic infrastructure. These included the following:

- 16 deaths
- 1,000 ha damaged in the Chira valley
- 80% of fishing ships in Talara were lost
- Decline of 50% in fishing production
- 1,800 houses destroyed
- 3,500 damaged houses
- 15% of port infrastructure damage
- 1,000 ha lost in middle and low Piura valley
- 38% of social infrastructure damaged
- Decline of 40% in manufacturing production

Conclusions

The key to overcome climate change related impacts is adaptation in the form of impact mitigation in the short term and livelihoods diversification (less dependency on agriculture and/or in a single crop) in the medium-long term. Strategies for adaptation should focus on agrarian activities due to its economic relevance in the study areas.

In the case of Puno, adaptation strategies should focus on agriculture viability as the main goal rejecting environmental orthodoxy that suggest unsustainable agriculture. Medium and long term policies should focus on reverting land degradation, land fragmentation and unsuitable practices and crops. The region of Puno has proven its capacity to sustain a complex society such as Tiwanaku through the use of pre-Columbian techniques and high-altitude developed crops. Puno has some uniformity advantage due to the fact that most of its territory lies on the mountain region and lacks of the huge contrasts present in the Piura coastal/mountain dichotomy. Regional policies may only need minor adjustments throughout its implementation in Puno due to its societal similarities.

In the case of Piura, the government should provide incentives to local and regional initiatives regarding agricultural development due to its importance in the region. It should help to develop adaptation strategies were agricultural diversification at the household level should be seen as an alternative. The political ecology framework helps to identify misguided procedures, like the rice campaign during El Niño, that not only contributes to poverty, but also contributes to land degradation. It is important to listen to local authorities and technocrats who know well the Piuran territory. In addition, the recurrence of El Niño in Piura requires wiser policies. At the local level, historical knowledge about El Niño in Piura can be put to better use in policy formation. One knows that it will happen again and

[5] http://www.cipca.org.pe/cipca/nino/index.htm (July 2002)

is aware of the way in which this natural phenomena impacts in the region through high precipitation and floods.

New technologies such as in-advance forecasts should be an advantage rather than a disadvantage. Wiser policies related to credits for disaster preparation are an urgent need. The situation of the agrarian sector deserves special attention. This sector involves 89% of the Economic Active Population and it is the most vulnerable sector in regards to ENSO due to the societal impacts of crops losses due to floods. The government should provide options for the peasants and wiser specific policies to protect and develop this sector.

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