The Effects of El Niño on Agricultural Water Balance in Guatemala

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Abstract:

More than half the population of Guatemala lives in rural areas and depends on subsistence agriculture for their well being. This region is vulnerable to many climatic events, one of which is El Niño. This study looks at the effects of El Nino on rainfall patterns at regional scales and specifically quantifies the effects on agricultural water balances in Guatemala. Analysis is focused on maize crops during the Primera growing season (May – Aug, May -Oct). The study builds on rainfall and water balance modeling techniques developed by the Famine Early Warning Systems Network (FEWS NET). The results corroborate previous work, showing that there is a negative relationship between El Niño and rainfall, primarily on the Pacific side of the region and mainly during the months of August and September. The study also found that the related rainfall variations influence long-term (May - October) maize growing areas and could affect the start of the short-term Postrera season (August - October) by extending the Canícula (mid season dry period).

Objectives:

To determine the effects of changes in SST in the El Nino 3.4 region on:

- **Rainfall patterns in Central America.**
- **Agricultural water balance in Guatemala**

Problem

In Guatemala, agriculture is the most important production sector, with 61 % of the population living in rural areas and depending on agriculture for their livelihood. Bad climatic conditions mainly heavy rains and droughts are one of the major problems for agriculture. The most affected products are rice, wheat, maize, coffee, cotton and sugar cane, (Carrera Cruz 2001)

While the effects of El Niño on rainfall patterns have been studied at different scales and are well understood, it is important to know what the effect is on agricultural water balances at the local scale. This information would help determine possible implications on population's food security.

Figure 1. effects of El Niño in Agriculture

Background:

The Food Security Early Warning System (FEWS NET) is characterized by developing applicable tools for monitoring food security and providing timely information to decision makers.

One of these tools is the Water Requirement Satisfaction Index (WRSI) (Verdin, 2002) model for monitoring agricultural food production.

The WRSI model uses rainfall estimates as input to evaluate the availability of water, for the crop, at any time during the growing period.

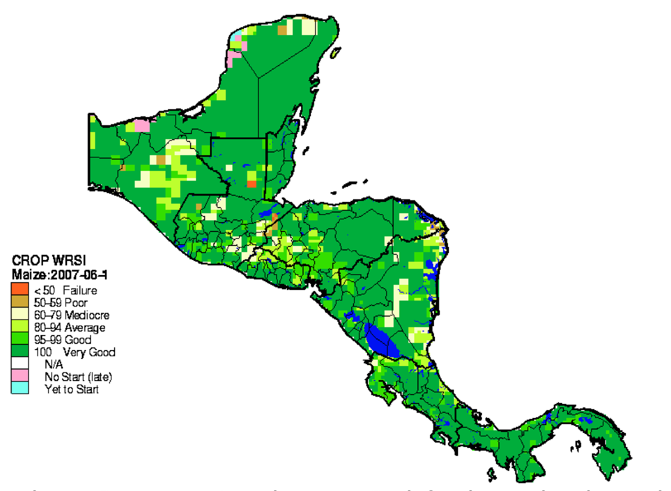


Figure 2. Water Requirement Satisfaction Index (WRSI) helps monitor the Availability of water for crop at anytime during the growing period

Data:

1. Historical rainfall database 1970-2004 ,5x5 km spatial resolution
   - Monthly values for Central America.
   - 10 days totals for Guatemala
2. Historical WRSI
3. Oceanic Niño Index (ONI)

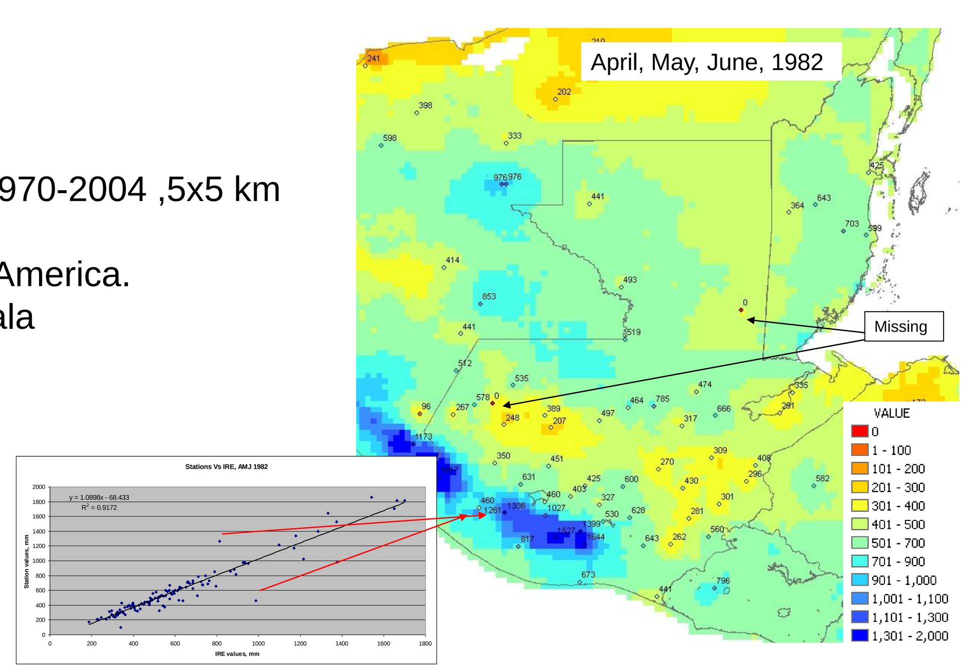
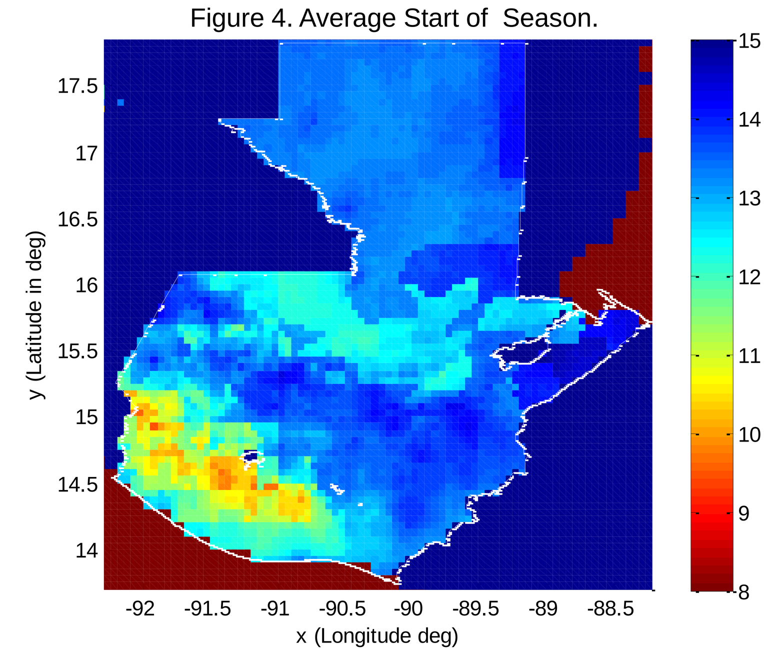


Figure 3. Monthly rainfall fields created by combining climatology and available station.



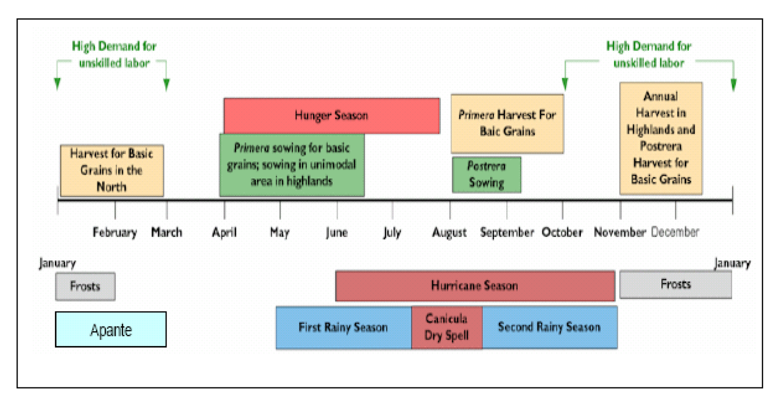


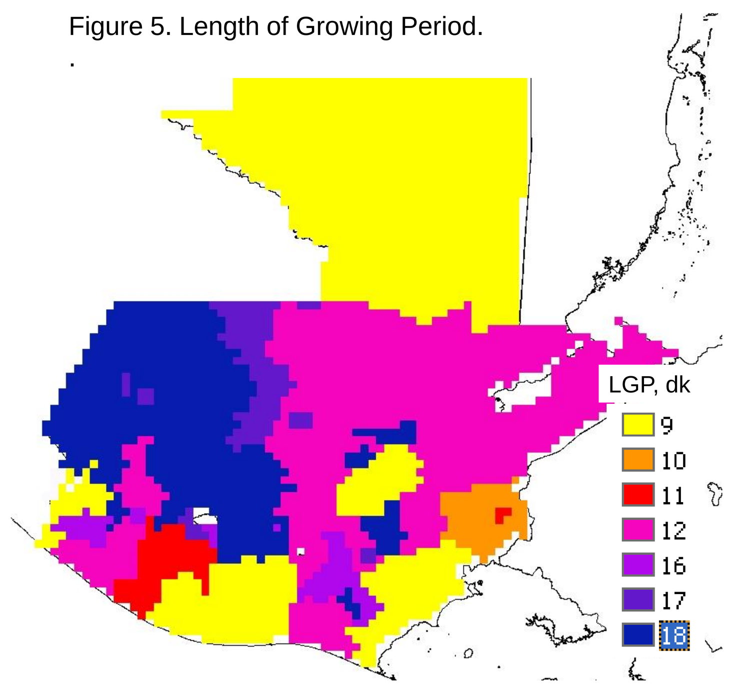
Figure 6. Calendar of agricultural events in CA

Method:

A new monthly rainfall database was developed for the years 1970-2004. A monthly rainfall field is the result of the combination of the FEWS Climatology (FCLIM), a 5km resolution raster dataset, with existing stations for each month (Funk, 2007). The relationships between SST and rainfall, for the entire region (Southern Mexico to Panama), were first established. Gridded monthly rainfall data for each latitude/longitude pixel was correlated with the ONI. Separate statistics were calculated for each month during the rainy season. The value for each of the parameters of the analysis; correlation coefficient, p-value and slope coefficient was used to create new maps, with the same dimensions as the original gridded rainfall fields, depicting the spatial distribution of the given parameter.

Furthermore, the FEWS NET GeoWRSI tool was used to calculate the seasonal WRSI for Guatemala for every year between 1970 and 2004. Correlation parameters were calculated for each month over the period April – September to determine how the SST during each of these months affected the seasonal water balance for Primera season. Even though there was a mismatch when relating monthly ONI with the seasonal WRSI, the fact that SST is persistent during the period may reduce the error.

Figure 5. Length of Growing Period.



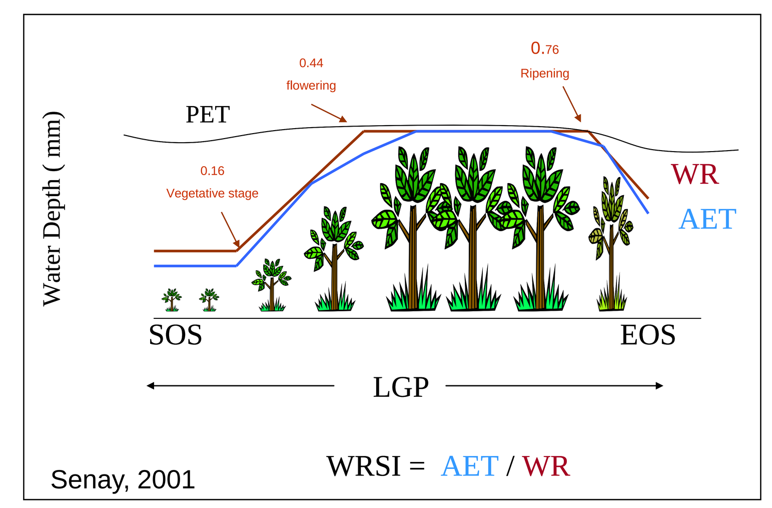


Figure 7. Variability of hydrological needs during the growing period

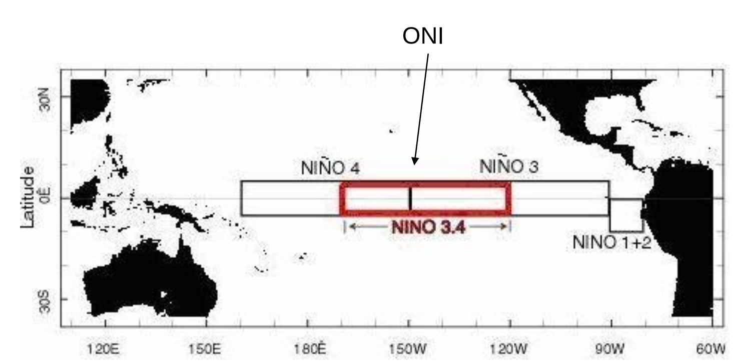


Figure 8. El Nino regions.

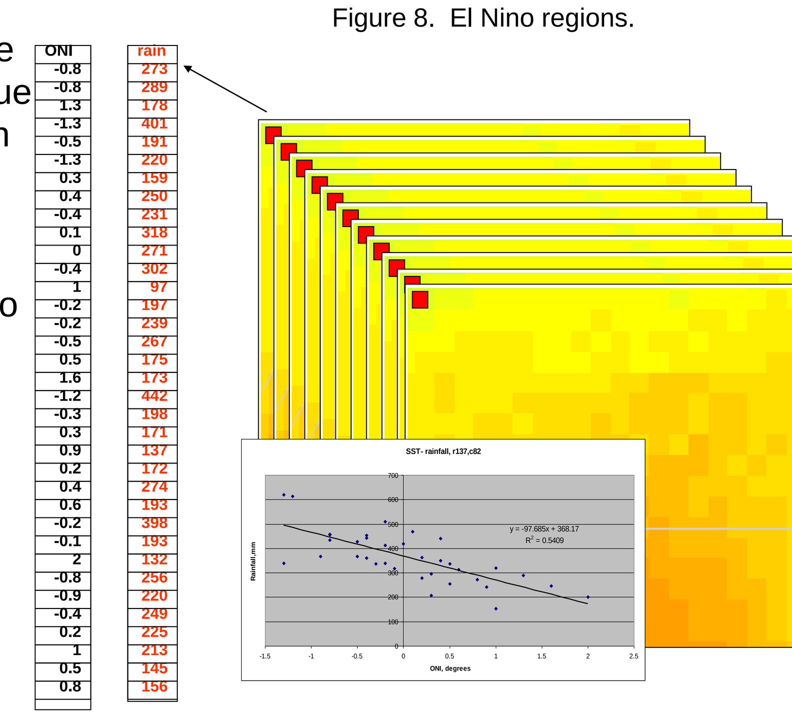
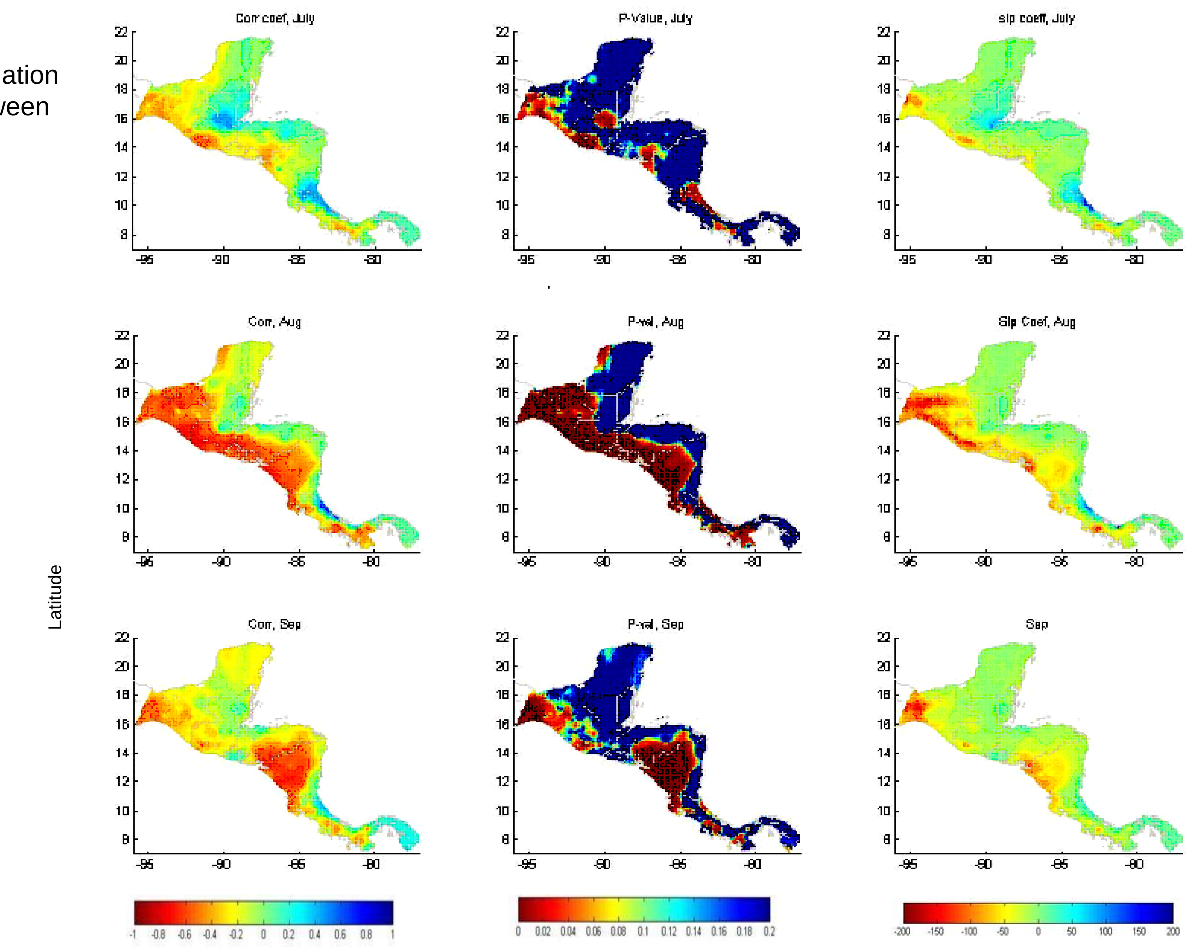


Figure 9. Statics were obtained from historic rainfall and ONI for each pixel.

Results:

A – Effects of changes in SST on rainfall patters in Central America.

Figure 10. correlation parameters between rainfall and ONI.



B – Effects of changes in SST on agricultural water balance in Guatemala

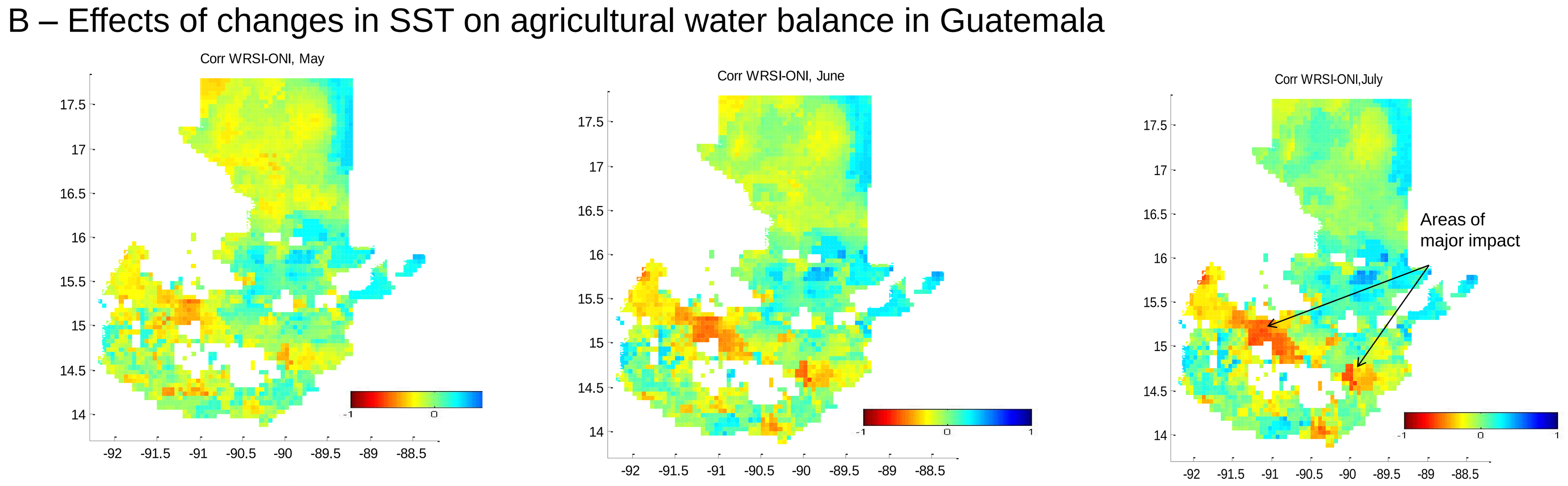


Figure 11. Correlation coefficient for end of season WRSI and ONI

Conclusions:

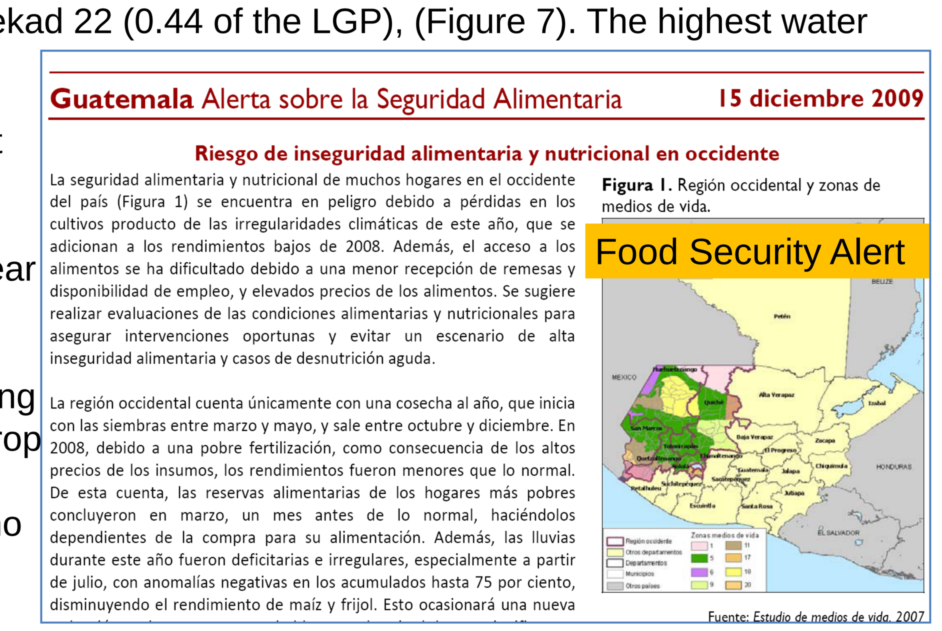
-We corroborated previous work showing that changes in SST in the Pacific Ocean affects rainfall patterns in Central America. The period showing most significant effect is Jul-Oct.

- Changes in SST in the El Nino 3.4 region have a negative impact on the agricultural water balance in parts of Guatemala. The area of highest impact is the Altiplano (see Fig. 11).

Discussion:

The agriculture water balance highlights important links to Pacific SSTs, especially in the region located in the southern part of the Altiplano (Figure 11). This mountainous region has a long growing season (180 days) (Figure 5), starting in Mid-May, dekad 14th, (Figure 4). The southern Altiplano region shows a decrease in seasonal WRSI as SST increases starting in the month of June, and the correlation gets stronger in the months that follow (Figure 11). Based on the length of the growing period (Figure 5) and the planting time in this area, a typical maize crop would begin the vegetative stage in dekad 17 (0.16 of the LGP) and the flowering stage would start in dekad 22 (0.44 of the LGP), (Figure 7). The highest water requirement would take place between dekads 22 and 27 (August-September), thus water stress during this period has the highest impact on yields. High SSTs in El Niño 3.4 in June are related to a rainfall deficit during the period August-September, with correlations near -0.6 to -0.8. Persistence in the Pacific SSTs, combined with the high water requirements during this time, due to the length of the growing period of the crop, may produce predictable crop water deficits.

These results were corroborated during El Niño 2009 where many farmers were under risk of food insecurity as reported by USAID/FEWS (Figure 12)


Guatemala Alerta sobre la Seguridad Alimentaria **15 diciembre 2009**

Riesgo de inseguridad alimentaria y nutricional en occidente

La seguridad alimentaria y nutricional de muchos hogares en el occidente del país (Figura 1) se encuentra en peligro debido a pérdidas en los cultivos producto de las irregularidades climáticas de este año, que se adicionan a los rendimientos bajos de 2008. Además, el acceso a los alimentos se ha dificultado debido a una menor recepción de remesas y disponibilidad de empleo, y elevados precios de los alimentos. Se sugiere realizar evaluaciones de las condiciones alimentarias y nutricionales para asegurar intervenciones oportunas y evitar un escenario de alta inseguridad alimentaria y casos de desnutrición aguda.

La región occidental cuenta únicamente con una cosecha al año, que inicia con las siembras entre marzo y mayo, y sale entre octubre y diciembre. En 2008, debido a una pobre fertilización, como consecuencia de los altos precios de los insumos, los rendimientos fueron menores que lo normal. De esta cuenta, las reservas alimentarias de los hogares más pobres concluyeron en marzo, un mes antes de lo normal, haciéndolos dependientes de la compra para su alimentación. Además, las lluvias durante este año fueron deficitarias e irregulares, especialmente a partir de julio, con anomalías negativas en los acumulados hasta 75 por ciento, disminuyendo el rendimiento de maíz y frijol. Esto ocasionará una nueva

Figura 1. Región occidental y zonas de medios de vida.

Food Security Alert

Fuente: *Estudio de medios de vida, 2007*

Figure 12. Food security alert in Guatemala.

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