Chapter 18
Towards Enhanced Resilience: Monthly Updated Seasonal Rainfall "Scenarios" as Climate Predictions for Farmers in Indonesia

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Abstract This paper exemplifies how agricultural production suffers from climate change and how short term seasonal rainfall prediction improves its resilience under tropical lowland rice production in Indonesia. An introduction to and explanations on climate change and long term climate predictions in agriculture form the first parts of this paper.

Two problems haunt seasonal climate predictions for farmers to increase their resilience. These are the skill of predictions and the terminology chosen for monthly updated seasonal rainfall predictions. These "scenarios" are part of climate change adaptation attempts on the islands of Java and Lombok, Indonesia.

Originally, NOAA and subsequently NOAA/IRI monthly ENSO predictions for a period of 3 months were chosen to build planting season "scenarios", because they often explicitly mention Indonesia in their predictions, including recent higher atmosphere convection situations. More recently a check was added on these ENSO predictions, by reading IRI prediction maps for Asia, provided each third Thursday of the month. These maps are more detailed than the written predictions but not more accurate. However, these maps make it possible to separate Java from Nusa Tenggara (region of the islands east of Bali, like Lombok).

The wordings chosen for the monthly SMS messages on seasonal rainfall "scenarios" to farmers use terminology of probabilities as common in daily life. Replies to February 2015 questionnaires show how satisfied farmers are but also how they must get used to this wording.

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Introduction

The planet earth has a unique but complicated climate that presently is changing due to the influence that mankind's activities appear to have on the composition of its atmosphere. It is called anthropogenic (man-made) climate change (e.g. Oreskes 2004; IPCC 2007; Rosenzweig et al. 2008). The world's agricultural systems face an uphill struggle in feeding a projected nine to ten billion people by 2050. Climate change introduces a significant hurdle in this struggle (e.g. Thornton 2012).

There is general and widely held scientific consensus that the observed trends in atmospheric and ocean temperature, sea ice, glaciers as well as climate extremes during the last century cannot be explained solely by natural climate processes and so reflect human influences (e.g. USGS 2014). The argument that what is measured could be natural climate change can also be refuted by the fact that present understanding of cyclic climatology of the past points to a cooling planet without the presence of mankind (Dr. Jim Salinger, private communication 2013; Easterbrook 2014).

On the simplest level, the weather is what is happening in the atmosphere at any given time. The climate, in a narrow sense, can be considered as the "average weather" (WMO 2015a). In a more scientifically accurate way, it can be defined as: "the statistical description in terms of the mean and variability of relevant quantities over a period of time" (WMO 2015a).

The issues are (e.g. Stigter and Ofori 2014a): (i) global warming, (ii) increasing climate variability, (iii) more (and possibly more severe) meteorological and climatological extreme events. Is global warming real? From worldwide observations WMO (World Meteorological Organization) concluded a long time ago that our planet is warming up. This has to be considered a fact (e.g. WMO 2015b).

The atmosphere gets its energy from two sources, both of course related to the basic source of solar energy:

(i) It is warmed from below by solar energy absorbed by the earth surface during the day. This heat gets distributed throughout the boundary layer.
It should here already be indicated that there is a great difference between land and water surfaces. On land, in daytime, a tiny surface layer becomes much warmer, with the very surface becoming hottest, the rate depending mainly on water content. In water the absorption is over a certain depth, decreasing with depth. The water surface therefore does not become very warm from direct

absorption; ocean currents play a more important role here. But indeed most additional heat created is absorbed by the oceans. The large heat capacity of water prevents the oceans from overheating (WMO 2015c).

The second process of how the atmosphere gains heat is:

(ii) Its gases absorb the longwave radiation sent from the earth surface throughout day and night. This prevents the land surface from overheating, but only a part gets out to space.

This radiation loss from a cooling surface (and the cooling air due to this) may be recognized from nights without a cloud cover. When there are clouds, they send roughly as much longwave radiation back to the earth surface as they receive from that surface and no or appreciably less cooling occurs. So it must be concluded that our planet is actually heating up mainly because of this absorption of radiative heat by the greenhouse gases in the atmosphere. Increasing greenhouse gases mean additional heating. Among many others, IPCC (the Intergovernmental Panel on Climate Change) has indeed been stressing, with increasing confidence over the years, that the cause of this heat gain is an increase of greenhouse gases in our atmosphere (e.g. IPCC 2007).

The main source of this increase of carbon dioxide, methane and nitrous oxide appears to be human activities on this planet: e.g. generating electricity from coal, producing cement and driving cars are presently the main culprits (e.g. IPCC 2007). As to carbon dioxide, measurements show that it has increased from the start of the industrial revolution, but that changes in land use have also played an important role by large scale cutting of vegetation, including trees (e.g. Fearnside 2000). This is also why Indonesia has become a large contributor, by felling trees (sinks of carbon dioxide) in large scale (mostly illegal) logging, often planting oil palm trees instead, with appreciably less carbon dioxide absorption per hectare.

Climate Predictions

Recently a number of case studies have appeared that show that climate change is already affecting yields of various crops. In Box 1 it is illustrated how quantitative knowledge is helping to find the way to policies serving the purpose of adapting to the consequences of climate change. In the case of Arabica coffee, a solution could be to go to higher, still colder grounds, although this disrupts living conditions and biodiversity patterns (Craparo et al 2015; Stigter 2015a).

Box 1: Some Illustrative Data of Climate Related Predictions

IPCC (2007) shows that somewhere near 1800 the carbon dioxide concentration was something as 280 ppm, while it has recently reached 400 ppm. It also shows how steeply the curve is presently rising in comparison to a slow rise through time till roughly 1800.

As to temperature, from 1960 till 2010 the increase is estimated to have been less than a degree Celsius, but the projection for the next 50 years is in the order of 1 °C, with the emissions kept within the range of the IPCC (2007) scenarios. When all greenhouse gases and aerosols were kept constant at their 2000 levels, this heating would be half as much (WMO 2015b). It is generally accepted that, if for this century the temperature increase can be limited to 2 °C, the damages will remain much more limited than when the scenarios give a 4 °C increase at the end of this century (e.g. Pidcock 2014).

What do such figures mean in practice today? Here is an example for Arabica coffee grown on the slopes of the Kilimanjaro (Craparo et al. 2015). Coffee is the world's most valuable tropical export crop. Recent studies predict severe climate change impacts on *C. arabica* production. However, quantitative production figures are necessary to provide coffee stakeholders and policy makers with evidence to justify immediate action. Using data from the northern Tanzanian highlands, it was demonstrated that increasing night time (Tmin) temperature was the most significant climatic variable responsible for diminishing *C. arabica* yields between 1961 and 2012. The minimum temperature in that region of Tanzania rose in that half century by between 1 and 1.5 °C. The projection for the next 35 years for that region is 1.5 °C.

With the minimum temperature at 14 °C, the yields were about 500 kg beans per hectare. A non-linear (sigmoid) model constructed from data from local areas with different minimum temperatures gave the following results. With the night minimum rising to 15 °C, this would become about 450 kg ha^{-1}. With a night minimum temperature at 16 °C this decreases to about 300 kg ha^{-1}, while for 17 °C this becomes about 100 kg ha^{-1}. This means a prediction of average coffee production diminishing to 145 kg ha^{-1} by 2060 in those areas of Tanzania. Climate prediction was reduced here to prediction of minimum temperatures.

Consequently, without adequate adaptation strategies or substantial external inputs, coffee production will be severely reduced in the Tanzanian highlands in the near future (Craparo et al. 2015).

But for the lowland tropics, there is no way out apart from crop diversification and finding more heat (and drought) tolerant varieties (Stigter et al 2015). Box 2 shows how bad the situation is.

Box 2: Some Other Agricultural Upheavals

Here is another example of trouble: Maize (Thornton and Cramer 2012; Stigter and Ofori 2014a). The results are from something as 20,000 trials at 123 stations all over the world of CIMMYT (CGIAR, Columbia):

– Increased temperature significantly effects maize yield ($P < 0.01$).
– Possible gains in yield with warming at relatively cool sites.
– Significant yield losses at sites where temperatures commonly exceed 30 °C (corresponding to areas where the growing season average temperatures are >23 °C or average maximum temperatures are >28 °C).
– Daytime warming is more harmful to yield than night-time warming.
– Drought increases yield susceptibility to warming even at cooler sites.
– Under 'optimal' conditions yield losses occur over ca. 65 % of the harvested area of maize.
– Under 'drought stress' yield losses occur at all sites, with a 1 °C warming resulting in at least a 20 % loss of yield over more than 75 % of the harvested area.

And here is one more example: Rice. Data are obtained from a CGIAR umbrella study, the same as used for maize (Thornton and Cramer 2012; Stigter and Winarto 2013).

Temperatures beyond critical thresholds not only reduce the growth duration of the rice crop, they also increase spikelet sterility, reduce grain-filling duration, and enhance respiratory losses, resulting in lower yield and lower-quality rice grain. Rice is relatively more tolerant to high temperatures during the vegetative phase but highly susceptible during the reproductive phase, particularly at the flowering stage.

Unlike other abiotic stresses, heat stresses occurring either during the day or the night have differential impacts on rice growth and production. High night-time temperatures have been shown to have a greater negative effect on rice yields, with a 1 °C increase above critical temperature (>24 °C) leading to 10 % reduction in both grain yield and biomass. High day-time temperatures in some tropical and subtropical rice growing regions are already close to the optimum levels. An increase in intensity and frequency of heat waves coinciding with sensitive reproductive stages can result in serious damage to rice production.

The climate predictions that are exemplified in the Boxes 1 and 2 are long term predictions of which knowing the trends is an important indicator for adaptation to the consequences of climate change, food policies, crop planning, variety breeding and screening, farming system adaptations and modifications, extension policies and all other planning related to agriculture that has to be made to face climate change. For farmers these are important issues (e.g. Stigter 2015b) that can be discussed at "Science Field Shops" for their long term decision making (Stigter et al. 2015). But what about the shorter term?

Further Matters That Should Be Known

It is interesting to note that since the very end of the previous century, the rate of global warming has reduced by at least half of the rate in the last 50 years of that previous century. This has been baptized "the hiatus", a lack of continuity in the up going trend of global temperature. So climate change rates reduce. Is this going to change our thinking?

Stigter and Winarto (2014) stated that "Our lack of knowledge and understanding is best illustrated with the very recent discussion on the present global warming "hiatus" (e.g. Wikipedia 2014). Observations have shown that global warming presently takes place at a lower rate. Some deny its very existence (see for example Anonymous 2013a) but accurate worldwide measurements and comparisons show that this "hiatus", this break in continuity, is there, since the late 90s. Already four quantitative(!) reasonings in fully fledged or partly explanations may be found:

(i) more volcanic particles in the atmosphere (Stark 2014);
(ii) extremely strong large scale western winds in the Pacific (Milman 2014);
(iii) much warmer water being transported to deeper layers of the ocean (Anonymous 2013a, b);
(iv) indeed being in a down going phase of the Pacific Decadal Oscillation and/or another of such oscillations as atmospheric variations/imbalances (e.g. Anonymous 2013c, d; Wyatt and Curry 2013).

It is likely that all of these four explanations may actually be involved, if not more processes. But there is no clue about the ratios of their contributions, while in the last case the complexities are enormous".

There is a quarrel on the volcanic contributions. There was no one enormous contribution, but it was proposed recently that many smaller volcanic eruptions can cause such cooling (reduction of heating). But others think that this will not add up to more than 15 % of the cooling (e.g. Kalaugher 2015).

It is presently most likely that the cause of this hiatus is indeed more warmer water going to deeper layers, resulting in a (temporarily?) relatively cooler ocean. This also shows how important oceanic surface temperatures are for determination of our climate. It is one of the weakest rings in the chain towards climate predictions.

So much less is known about how the sea surface temperatures are determined by currents and deep waves than has been understood on the atmospheric resultants. Indeed, for decades radiosondes with balloons have been sent into the atmosphere, but only very recently have buoys been placed in the Pacific Ocean, particularly in those parts used for climate prediction purposes.

But looking at the early predictions of the 2014/2015 originally weak El-Niño (see below), it appears that the atmosphere sometimes does not want to behave the way it is known. That makes the little that is predictable suddenly also unpredictable.

Short Term (Seasonal) Climate Predictions: A Case Study in Indonesia

So, unpredictable ocean currents and deep waves that are not understood in sufficient detail, create the signals for El-Niño's to occur. They are very important in short term climate predictions (1–3 months). Now, it appears that the frequency of these phenomena, and how they follow each other, has changed in recent times! However, these actual changes cannot be simulated with the models that summarize our understanding, which at this moment is still very insufficient (e.g. Stigter and Ofori 2014b).

As a consequence of the above, simple growing season rainfall scenarios are very difficult to derive from existing raw or simplified (e.g. outlook fora, WMO 2015d) climate predictions. Two problems haunt seasonal climate predictions for farmers to increase their resilience, (1) the skill of predictions and (2) the terminology chosen for these monthly updated seasonal rainfall predictions.

Such "scenarios" have been made part of climate change adaptation attempts on the islands of Java and Lombok, Indonesia (UNIID-SEA 2014; Stigter et al. 2015). One approach is to follow the monthly El-Niño predictions NOAA (2015) is giving (these days together with IRI, see Appendix 1 for an example), because that influential phenomenon has been well unraveled (e.g. Gross 2014). These are monthly renewed predictions for a period of 3 months. They were chosen because they often explicitly mention Indonesia and/or the western equatorial pacific in their predictions, including recent higher atmosphere convection situations. They also express skills of the predictions where appropriate. These issues are exemplified in Appendix 1.

Every third Thursday of the month the International Research Institute for Climate and Society (IRI) at the Earth Institute of the University of Columbia (USA) issues updated maps on multi-model probability forecasts for precipitation (IRI 2015a) and updated quick look ENSO forecasts (IRI 2015b). These maps are more detailed than the written predictions but not more accurate. However, these maps make it possible to separate Java from Nusa Tenggara (region of the islands east of Bali, like Lombok) and other regions in Indonesia. As was exemplified earlier (Stigter et al. 2013), the way the NOAA monthly "ensemble" climate prediction knowledge, as presently brought to the participating farmers in Indramayu and Lombok, is given in a more client friendly wording that may be called an agrometeorological advisory. It is tried to derive the most likely start of the main rainy season and also indicate whether the dry season may be expected to be normal. However, this advisory, given as a scenario for the seasons concerned, remains a qualitative one, based on the raw climate prediction knowledge that is obtained from NOAA/IRI (Appendix 1).

As to these wordings in which the monthly SMS messages on seasonal rainfall "scenarios" are brought to farmers, terminology is used of probabilities as common in daily life. The tercile percentages system used in most Outlook Fora predictions are not used but the way in which for example doctors express chances of recovery of their patients is preferred. On 6 March 2015 Stigter wrote to Winarto: *The atmosphere is somewhat better adapting to ocean temperatures, which would mean that we will have somewhat more chance of actual but weak El-Nino effects, but the convection in the atmosphere is more conducive to rainfall above Indonesia. To this must be added that (northern hemisphere) spring predictions are usually low skill. This keeps the rainfall seasonal scenario conservative as*

"Most likely near normal rainfall for the coming months but more likely somewhat at the drier side of normal. Low skill should be admitted".

This part between quotation marks was then in translation sent by SMS to participating farmers. Replies to February 2015 questionnaires show how satisfied farmers are but also how they must get used to this kind of wording.

Farmer Questionnaire on the Monthly Updated Seasonal Rainfall Scenarios Provided

In February 2015, a questionnaire was used to interview 42 farmers in the project villages of Indramayu, NW coastal Java, that received the monthly seasonal scenario regularly for 6 months or more, and 42 farmers in the same villages that did not receive these scenarios as a control group. Reception of the seasonal scenarios is shown in Table 18.1. Of those receiving these scenarios, more than half received them for more than 2 years and 85 % for more than a year (Table 18.2).

Of the target group of farmers, more than 93 % received the seasonal scenarios via SMS on their mobile telephone while for more than 81 % this was the only way they received that knowledge.

Of the number of farmers receiving the seasonal scenarios, 55 % understood them regularly or better (see Fig. 18.1 for this terminology) but 42 % understood them only sometimes. This shows the necessity to improve the scenario messages as to the understanding required. It could be observed that those receiving the scenarios for at least 2 years had a much higher regular or better understanding than the others (Fig. 18.1).

Table 18.1 Reception of seasonal scenarios by interviewed farmers that participated in the project

Valid	Frequency	Percentage	Cumulative percentage
1. Every month	24	57.1	57.1
2. Often	9	21.4	78.6
3. Regularly	3	7.1	85.7
4. Sometimes	3	7.1	92.9
5. Never	3	7.1	100.0
Total	42	100.0	

Table 18.2 Length of period that interviewed farmers received the seasonal scenario

	Frequency	Percentage	Cumulative percentage
1. More than 2 years	20	47.6	47.6
2. More than 1 year	13	31.0	78.6
3. Less than 1 year	5	11.9	90.5
4. Less than half a year	1	2.4	92.9
5. Never received seasonal scenario	3	7.1	100.0
Total	42	100.0	

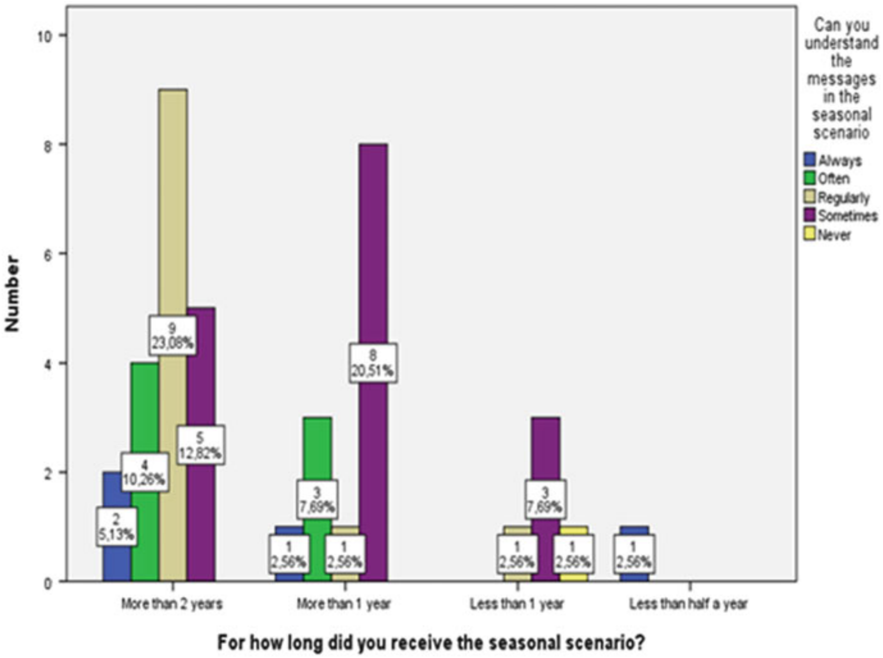

Fig. 18.1 Correlation of the period of receiving the seasonal rainfall scenarios with the understanding of the scenarios' contents. With three farmers not receiving the scenario, there were 39 replies

The difficulties were mainly of two kinds: (i) scientific terminology and (ii) the use of "below normal, normal and above normal" qualifications. Our farmer facilitators, selected from among the farmers by their peers, had the role of continuing to explain this, but that has apparently been insufficiently successful.

Of those farmers receiving the scenarios, 51 % used them regularly or better but 45 % only sometimes or never in their decision making (Table 18.3). The main reasons for not using the scenarios are that others make the farming decisions (40 % of those providing a reason) or that rain is not their main source of water (26 % of those providing a reason). For only 6 % the scenarios were not useful when followed.

Table 18.3 Use of the seasonal scenarios when received

	Frequency	Percentage	Cumulative percentage
Valid	39 interviewed farmers received the seasonal scenario[a]		
1. Always	9	21.1	21.1
2. Often	5	13.2	34.3
3. Regularly	8	21.1	55.4
4. Sometimes	10	26.3	81.7
5. Never	6	18.4	100.0
6. Never received seasonal scenarios	3		
Total	42	100.0	

[a]One farmer was ill during the interview, he could not continue answering the question

Of those that used the scenarios, which are 32 farmers (Table 18.3), 84 % was satisfied regularly (16 %), often (28 %) or always (41 %) (Fig. 18.2). And only 16 % was satisfied only sometimes.

Of the many positive reasons given for this satisfaction, 69 % mentioned the high accuracy of the scenarios and the positive role they plaid in improving farmers' anticipation.

From the control group that did not receive our seasonal scenarios, the most important answers wanted were whether they received other seasonal scenarios regularly and in that case whether they used them. Of the 41 answers received, 26 farmers (63 %) of this control group did not receive any (other) seasonal scenario (Table 18.4).

However, only 33 % (5 of 15) of those receiving these other seasonal scenarios (37 %) did use them regularly or better (Table 18.4), making the total number of control farmers using other seasonal scenarios at least regularly only 12 %. For our target group that received our seasonal scenarios, those receiving other seasonal scenarios were only 17 % and those using them were slightly over 9 % of the total group, similar to the figure of the control group.

Conclusions

Placing short-term climate predictions (1–3 months) in the context of climate change and long-term climate predictions, it could be appreciated how difficult shot-term climate prediction is. A case study on the Indonesian island of Java, on its NW coast, shows how far the progress was in the first 2 years of introducing such predictions. Monthly updated NOAA/IRI ENSO predictions were used to make our monthly seasonal rainfall scenarios. It was observed that those receiving the scenarios for at least 2 years had a much higher regular or better understanding than the others. The difficulties farmers had with the predictions were mainly of two kinds: (i) scientific terminology and (ii) the use of "below normal, normal and above normal" qualifications. Of those that used the scenarios, 84 % was satisfied

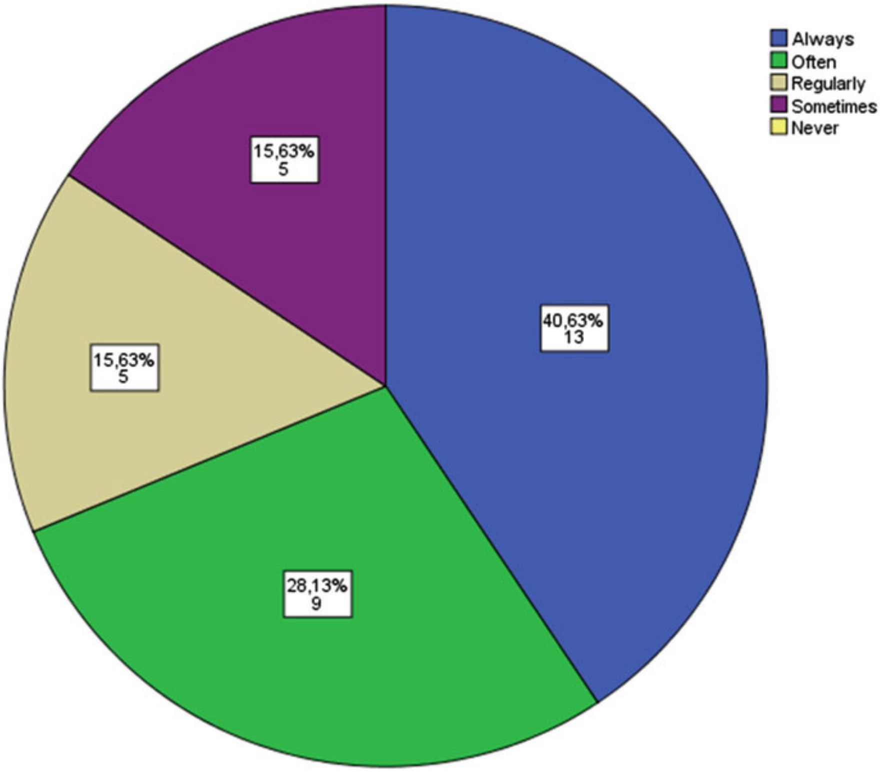

Fig. 18.2 Use of seasonal scenarios as a percentage of the total number of 32 farmers that received them. The "Nevers" have not been shown. One farmer of the target group could not be interviewed

Table 18.4 Use of (other) seasonal scenarios by the control group not receiving our seasonal scenarios

Valid	Frequency	Percentage	Cumulative percentage
1. Always	2	4.9	4.9
2. Regularly	3	7.3	12.2
3. Sometimes	3	7.3	19.5
4. Never	7	17.1	36.6
Sub-total	15	36.6	
Did not receive "Other Seasonal Scenarios"	26	63.4	
Total	41	100.0	

regularly (16 %), often (28 %) or always (41 %). And only 16 % was satisfied only sometimes. Of the many positive reasons given for their satisfaction, 69 % mentioned the high accuracy of the scenarios and the positive role they plaid in improving farmers' anticipation. Other seasonal scenarios played hardly any role.

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Appendix 1: Example of the Monthly NOAA/IRI ENSO Advisory/Prediction

EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

issued by
CLIMATE PREDICTION CENTER/NCEP/NWS
and the International Research Institute for Climate and Society
5 March 2015
ENSO Alert System Status: El Niño Advisory

<u>Synopsis:</u> **There is an approximately 50–60 % chance that El Niño conditions will continue through Northern Hemisphere summer 2015.**

During February 2015, El Niño conditions were observed as the above-average sea surface temperatures (SST) across the western and central equatorial Pacific became weakly coupled to the tropical atmosphere. The latest weekly Niño indices were +0.6 °C in the Niño-3.4 region and +1.2 °C in the Niño-4 region, and near zero in the Niño-3 and Niño-1 + 2 regions. Subsurface temperature anomalies increased associated with a downwelling oceanic Kelvin wave, which was reflected in positive subsurface anomalies across most of the Pacific. Consistent with weak coupling, the frequency and strength of low-level westerly wind anomalies increased over the equatorial Pacific during the last month and a half. At upper-levels, anomalous easterly winds persisted across the east-central Pacific. Also, the equatorial Southern Oscillation Index (EQSOI) remained negative for 2 consecutive months. Convection was enhanced over the western equatorial Pacific and near average around the Date Line. Overall, these features are consistent with borderline, weak El Niño conditions.

Compared to last month, several more models indicate El Niño (3-month values of the Niño-3.4 index equal to or greater than 0.5 °C) will continue throughout 2015. This is supported by the recent increase in subsurface temperatures and near-term model predictions of the continuation of low-level westerly wind anomalies across parts of the equatorial Pacific. However, model forecast skill tends to be lower during the Northern Hemisphere spring, which contributes to progressively lower probabilities of El Niño through the year. In summary, there is an approximately 50–60 % chance that El Niño conditions will continue through Northern Hemisphere summer 2015 (click CPC/IRI consensus forecast for the chance of each outcome).

Due to the expected weak strength, widespread or significant global impacts are not anticipated. However, certain impacts often associated with El Niño may appear in some locations during the Northern Hemisphere spring 2015.

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