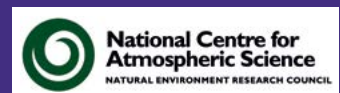




A PRACTICAL GUIDE TO SEASONAL FORECASTS



About this series:

This is a series of short, practical guidance documents with advice on how to interpret and use seasonal forecasts. Seasonal forecasts are a popular forecast product with the added attractiveness of long lead times. However, they are not a panacea, and these guidance documents share the circumstances under which they can be useful for decision-making. This series draws upon lessons from ongoing research on using seasonal forecasts for early action, as well as from the practice of using seasonal forecasts in climate services projects. It is written by people working along different parts of the climate services value chain including - producing seasonal forecasts, interpreting, and disseminating for action - for those who are relatively new to climate services.

Contents:

- **Issue No. 1** – Seasonal Forecasts 101 3
- **Issue No. 2** – How to approach a meteorological service to access and use seasonal forecasts 7
- **Issue No. 3** – How to use seasonal forecasts alongside other information to anticipate and manage risks 14
- **Issue No. 4** – The benefits and limitations of using seasonal forecasts to take action 16
- **Issue No. 5** – Creating feedback loops with forecasters and users 19

Cover picture: Joyce Kimutai, Kenya Met Department Senior Meteorologist, sharing a seasonal forecast.
(Photo: Climate Centre)

SEASONAL FORECASTS 101

By **Dave MacLeod**, University of Oxford and
Sarah Klassen, The Start Network

June 2019

Issue No. 1

This document addresses questions such as: What is a seasonal forecast? What information can it provide, and where can I find one? It also provides the basic information necessary to understand how seasonal forecasts can be interpreted and used, including their limitations.

How are seasonal forecasts commonly presented?

Seasonal forecasts are often presented as 'tercile probabilities', which refer to the probability that we can expect conditions will be above normal, normal, or below normal. Above and below normal are not extreme categories, each constitutes a 1 in 3 year event. These categories are defined based on the historically observed rainfall. Without a seasonal forecast, we assume there is an equal chance that conditions will fall in any of the three categories; thus, there is a 33% chance that any of these outcomes will be reached.

A seasonal forecast uses climate models to predict what the seasonal rainfall might look like, and this prediction is reflected in the forecast by tilting the odds (increasing the probability) in favour of one of these outcomes; for example, forecast models might indicate more rain than usual. This information may be used to increase the probability of the 'above normal' outcome from 33% to 45%; however, if the probability of 'above normal' is 45%, there still exists a 55% chance that it will not be above normal.

WHAT A SEASONAL FORECAST IS	WHAT A SEASONAL FORECAST IS NOT
Information about average seasonal conditions (e.g., 'October to December rainfall is expected to be normal')	Information about conditions on day-to-day variations or extreme weather (e.g., 'The 23rd of November will be wet')
Forecast over a large region (e.g., 'The whole western part of the country may be wetter than normal')	Forecasts with small-scale spatial detail (e.g., 'This village will have a wetter-than-normal season, whilst that village will be drier than normal')
Shifts in probabilities (e.g., 'There is an increased chance of an average seasonal temperature of 25°C above normal')	Definite information (e.g., 'The season's average temperature will be 25°C')

How are seasonal forecasts made?

Several methods have been developed to produce seasonal forecasts. Statistical forecasting calculates relationships between past observations and uses these relationships to project the next season's conditions. Dynamical forecasting employs full, three-dimensional models of the climate to explicitly simulate possible changes in the atmosphere and ocean over the next few months based on current conditions. Analogue methods compare the current state of the

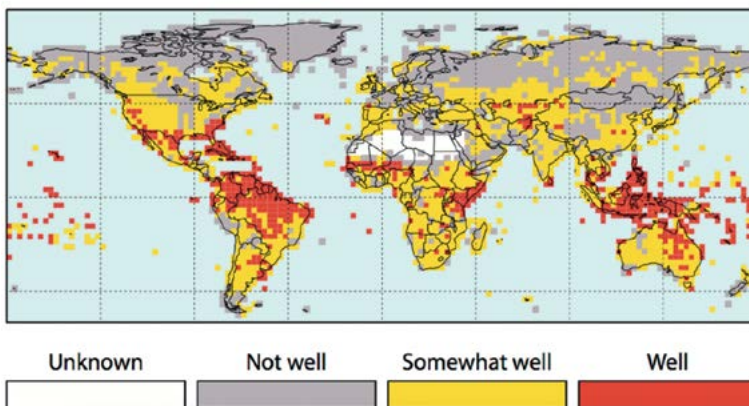
climate system to previous years and assume that this year will evolve similarly to those years it currently resembles. A considerable range of traditional methods also exist, which often employ local ecological indicators to predict future conditions (e.g., the timing of the return of a particular bird species to a region may indicate an early start to that region's rainfall).

Why can forecasts be made for many months in advance?

Seasonal forecasts are forecasts of average seasonal conditions over a region that are made many months in advance due to slowly changing parts of the climate system. One key part of the climate system that influences weather systems is the ocean; for instance, the water's surface temperature may be warmer than normal and still retain that heat over the next few months. When those conditions that differ from the norm (i.e., anomalies) extend over a large part of the ocean, the air above the ocean may consequently be affected. Ultimately, atmospheric circulations and the weather systems over land are affected, as well. Analysing ocean temperatures provides some ability to forecast average conditions for months in advance.

One of the main examples of this phenomenon is the El Niño Southern Oscillation (ENSO), which is the main source of predictability on the seasonal time scale. This means that, when an El Niño or La Niña event occurs, our ability to predict shifts in seasonal average rainfall is enhanced and we should trust seasonal forecasts more. Other sources of predictability exist, and fundamental climate science research helps uncover more sources and improve seasonal forecasts.

How well can we predict seasonal climate?



Source: International Research Institute for Climate and Society

However, it is important to know that making accurate seasonal predictions in all regions—or even during all seasons—is not possible. These predictions depend upon whether or not a region has a strong connection to predictable patterns, such as the ENSO. If a region has no connections to predictable drivers, then seasonal forecasting is likely not possible. The diagram on the left illustrates the regions of the world where predicting rainfall or temperature on the seasonal time scale is indeed possible.

Where can I find seasonal forecasts?

Dynamical and statistical forecasts are produced at Global Producing Centres, such as the European Centre for Medium Range Weather Forecasting (ECMWF) and the UK Met Office, among others. Many forecasts are now freely available, including the main provider of seasonal forecasts in Europe through the EU Copernicus initiative. Through this initiative, seasonal forecasts from the leading global producing centres are now available as both graphical products as well as underlying digital data.

EUROSIP multi-model seasonal forecast
 Prob(highest 20% of climatology) - precipitation
 Forecast start reference is 01/05/19
 Unweighted mean

ECMWF/Met Office/Meteo-France/NCEP/JMA
 JJA 2019

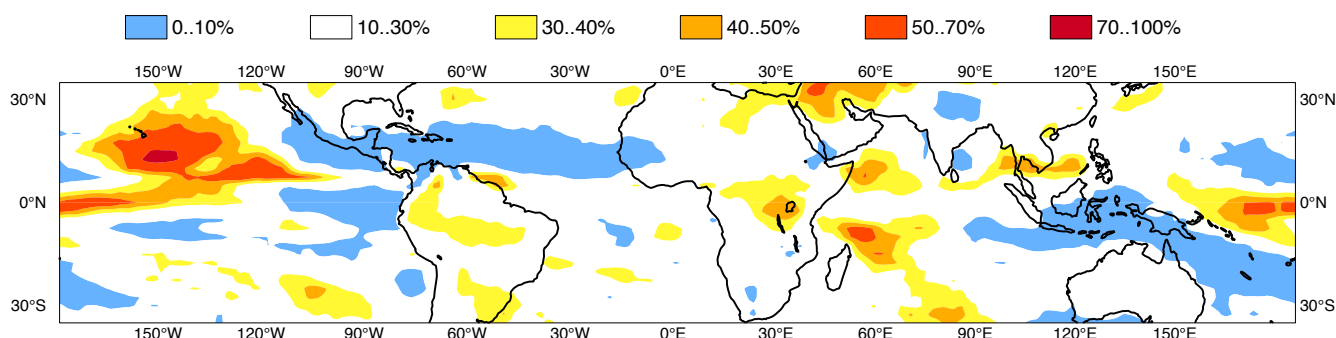


Diagram 1: Example of seasonal forecast products available through the Copernicus portal. The panel illustrates a forecast issued in April for the probability of precipitation for the 2019 June–July–August (JJA) season. The product depicts the probability that seasonal rainfall will be wet (specifically, above the upper tercile—that is, in the top third of the historical distribution of JJA rainfall for each separate location). This forecast indicates that Central Africa might expect an increased risk of wet conditions, while Indonesia and Central America might expect a reduced chance of wet conditions.

What are 'Regional Climate Outlook Forums'?

An important component of seasonal climate forecasting is the Regional Climate Outlook Forums (RCOFs), which are meetings held prior to significant regional seasons around the world and whose attendees include representatives from National Meteorological Services and multi-sectoral stakeholders. As part of the forum, a consensus seasonal forecast is produced. This exercise is conducted by participants from national meteorological centres, in which a wide variety of forecast information is synthesised (generally, a mix of locally produced statistical forecasts and an analogue year analysis combined with global dynamical forecasts and local experience) to develop an agreed-upon consensus outlook for the season, for average temperature, and for rainfall conditions. This consensus is expressed in terms of the probability distribution across the low, middle, and high tercile categories, for which an example is depicted in Diagram 2.

The RCOFs are an important pathway for disseminating seasonal climate information. As with all forecasts, caution should be taken when employing products that have not been assessed for their skill, meaning we have not yet determined how accurate the forecasts are. In general, given the consensus-based method used to produce the forecasts, RCOFs tend to be 'hedged' towards a forecast of normal conditions rather than assert bold probabilities for conditions that differ from the norm—even in spite of the fact that input dynamical forecasts may indicate strong probabilities of unusual events. In addition, the RCOFs often provide a forecast for each rainy season in the region without differentiating between whether or not one season is more predictable than another. For example, in East Africa, there is higher predictability during the October–December season, and thus users might trust a forecast during this season more than one produced during another.

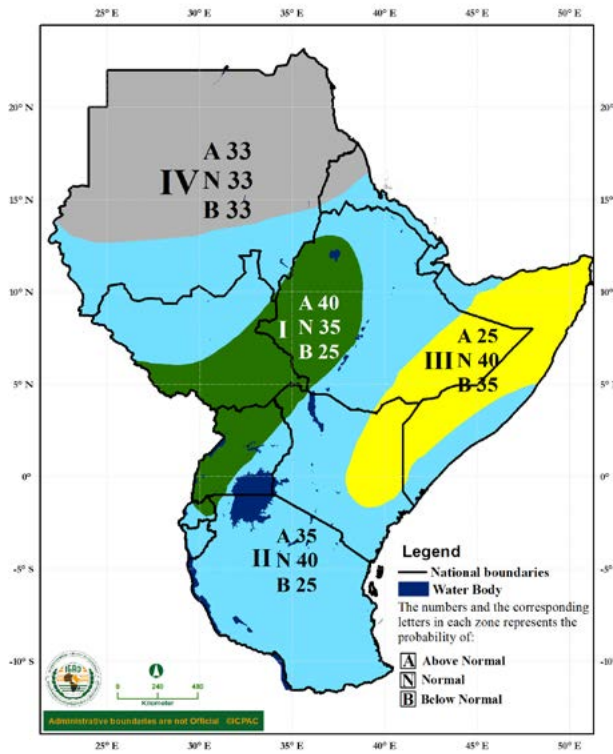


Diagram 2 Consensus seasonal rainfall forecast for the 2018 March-May rainfall season, produced in February by the 51st Greater Horn of Africa Regional Climate Outlook Forum. For each zone, probabilities of Above Normal, Normal and Below Normal are provided (normally, these are 33/33/33). The green zone indicates a shift in probabilities toward wet conditions, issuing 40/35/25. The grey zone indicates an area where it does not usually rain much during this time period.

HOW TO APPROACH A METEOROLOGICAL SERVICE TO ACCESS AND USE SEASONAL FORECASTS

By **Joseph Daron**, UK Met Office

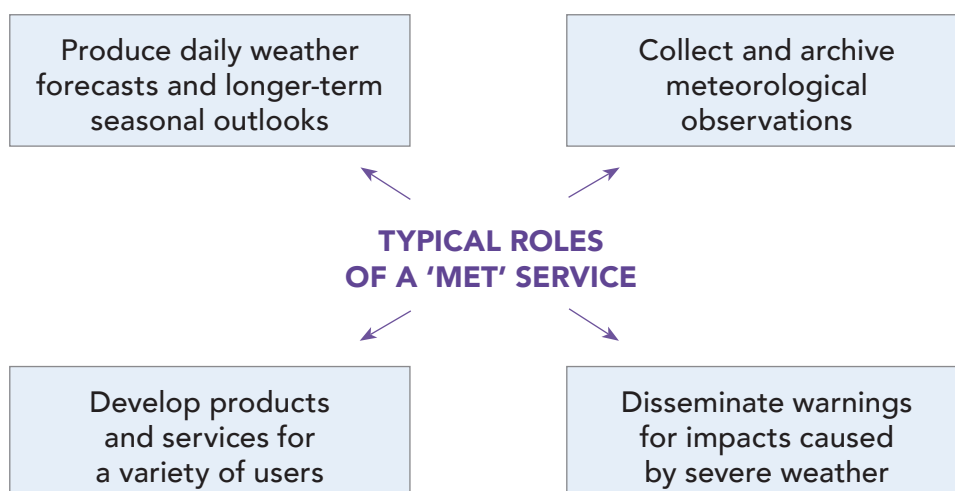
June 2019

Issue No. 2

Seasonal forecasts can play a valuable role in building the resilience of vulnerable people against an increasingly variable and extreme climate. To make seasonal forecasts more usable and impact-relevant, collaboration between producers and users is critical and can only be achieved by effective two-way communication from both parties. This document highlights ways these parties may build relationships as well as avenues for working with a meteorological service.

What is a meteorological service?

National meteorological (or 'met') services are typically the mandated national agencies that provide weather and climate information and services. Their roles and capabilities in several countries differ due to variations in funding, their internal capacity, and their ability to support new initiatives.



Questions to ask yourself before contacting a met service

Before approaching a met service, ensure you are clear on your objectives, capabilities, and requirements. You will find examples of questions to ask yourself or your team below; for further advice, see Issue No. 1 of this series.

How to communicate with a met service

Initiate the conversation. Aim to start the conversation well before the season of interest, as building the foundation for a flow of relevant information takes time. Emailing or calling the met service and asking to be put in contact with a relevant authority is a productive first step. If appropriate, you may invite the met service

IMPACTS

How does weather or climate affect your activities?



Severe droughts can destroy our crops and kill livestock.

High rainfall totals during a season can increase the cases of cholera.

**INFORMATION**

What information would provide the greatest benefit?



Knowing the most likely rainfall amounts this season may help us manage reservoir levels.

We can employ early action efforts if there is a significant risk of floods or droughts.

**OBJECTIVES**

What outcomes do you desire from the conversation?



I want to ensure farmers in my district have the best available information for planning. information.

I would like to receive advice on whether or not I should plan a vaccination campaign. in my region.



to visit you such that you may demonstrate your activities and discuss how weather and climate affects them.

Learn about your local climatology. Seasonal forecasts are often split into 'terciles', which indicate the likelihood of conditions that are above, near, or below 'normal' in the upcoming season. Therefore, understanding average climate risks is crucial (e.g., average temperature, rainfall, or number of rainy days in a season). Try to recall a 'normal' season and identify what (if any) impacts you experienced. Then, recall previous years when the climate was more extreme and consider any associated effects. Understanding a region's climate variability and how it affects you will enable the more efficient use of seasonal forecasts.

Identify useful information. Enquire about seasonal forecasts that have already been produced by the met service and ensure you fully understand them by asking questions such as:

- What timescales are the forecasts for, and when are they issued?
- What geographical scale do they cover? (e.g., national or regional level)
- How is the information communicated and displayed? (e.g., maps or tables showing terciles)
- How can the forecasts be accessed? (e.g., a document sent by email or a web platform)
- How are the forecasts updated or tracked? (e.g., a mid-season update, or ten-day bulletins)
- Is a seasonal forecast for average rainfall or temperature relevant for your decision? If not, do not use the forecast (e.g. a forecast for above normal rainfall is not an indicator that there will be many storms this season)

Recognise when to trust a forecast. Ask the met service if they evaluate the skill of their seasonal forecasts. Skill is a technical term used in meteorology to describe how well the forecasts performs in comparison to the real outcome. If skill is assessed, ask how accurately the forecasts perform for the season or weather element of interest. This enquiry will produce additional information to help determine whether or not a seasonal forecast may add value for your applications.

Evaluate whether a seasonal forecast will add value. Think of whether a seasonal forecast to aid with your decisions, and consider how different probabilistic scenarios would affect the choices you ultimately make. You may discover through talking to the met service that seasonal forecasts do not provide the most relevant type of information for you or that there may be new ways in which long-term decision-making processes can be adapted to more effectively take advantage of such forecasts.

TOP TIPS FOR A POSITIVE CONVERSATION

Do your research. Where possible, use online resources to gain background information on the met service. Aim to identify what they do and whether or not they produce seasonal forecasts. They may focus on a specific sector, such as aviation or shipping, and may consequently not have the answers to your questions; however, they may still provide scope for useful discussions.

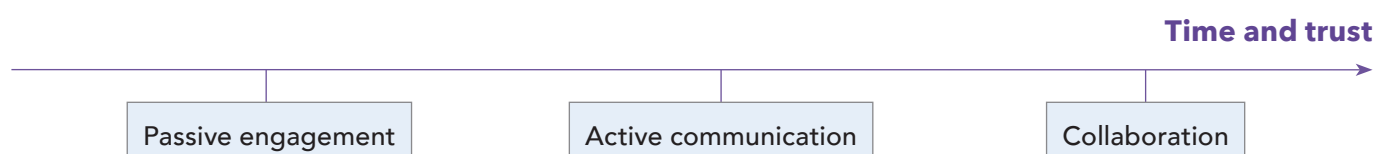
Be prepared for jargon. Although you will be communicating with trained scientists and experts, they will not always be experts in *communicating* science. Ask them to elaborate upon any unfamiliar terms, and likewise, try avoiding jargon specific to your sector.

Understand the technical limitations. There are physical limits to the atmosphere's predictability, and accurate weather forecasts are not possible beyond two weeks. Seasonal forecasts therefore cannot provide the same level of detail as can daily weather forecasts. Rather, they provide information on the *likely* conditions averaged over several months; for example, seasonal forecasts will tell you if the next season is more likely to be drier than a 'normal' season, but they will not tell you exactly where or when dry spells might occur.

Be modest in your demands and expectations. Enter the meeting with the ambition of making better use of the met service's *existing* products rather than demanding entirely new products; this approach will be a win-win for both partners and will be met by a more positive exchange. If new products are required to meet your needs, then engaging in a longer conversation over many years may be the result.

Levels of engagement

Depending on your requirements and technical capacity, you may consider how to most beneficially engage with the met service. Modes of engagement can be divided into three levels:



Passive engagement typically involves one-way communication wherein the met service would disseminate a seasonal forecast to the user, who would then receive, interpret, and apply the information independently.

Active communication involves more regular two-way communication. Seasonal forecasts can be difficult to understand, and met services support users as they interpret the available seasonal forecasts and improve their knowledge of limitations and uncertainties. Interpreting the information correctly will allow that users practice more informed and robust decision making. Having knowledge of the user's requirements will enable the met service to provide access to existing and more relevant forecasts that may not be widely available.

Collaboration involves working together to ensure the provided forecasts meet users' long-term needs. It can be a time-consuming and involved process that can potentially lead to valuable and sustainable partnerships. By working together, met services and organisations learn from one another and pursue opportunities to 'co-create' services and products tailored to user requirements. One such product is an impact-based forecast that directly translates a forecast into an action plan. Furthermore, the user's observations and experiences can be useful to the met service by expanding their knowledge of weather and climate impacts whilst assisting with the further development of their services.

HOW TO USE SEASONAL FORECASTS ALONGSIDE OTHER RISK INFORMATION TO ANTICIPATE AND MANAGE RISKS

By **Catalina Jaime**, Red Cross Red Crescent Climate Centre;
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Joseph Daron, UK Met Office;
Meghan Bailey, Red Cross Red Crescent Climate Centre

June 2019

Issue No. 3

This guidance document is for disaster risk managers, humanitarian and development project managers, local partners and people who would like to use seasonal forecast information as part of a system to take early action before a risk (e.g. flood, drought) materialises.

Information from seasonal forecasts about a hazard is not enough to trigger action by itself. Because disasters arise from a complex interplay between the hazard itself, and vulnerability and exposure. The integration of forecast information with other types of information is critical for facilitating decisions about what needs to be done, by whom and when.

This document provides guidance and examples on how to use seasonal forecasts in conjunction with other climate/hazard and non-climate/hazard risk information. There are many different types of information that might be used alongside a seasonal forecast including short-term weather forecasts and monthly outlooks, vulnerability assessments, and exposure and historical disaster impact information. To address these risks, local level knowledge, scientific knowledge and other sources of knowledge can be used together. This document is structured as a series of questions to ask yourself when using such data for risk management.

1. What is the hazard that I am trying to predict, and at which lead time am I trying to predict it?

Selecting the appropriate forecast depends on the hazard of interest and how far in advance of the event you need the information; this second aspect is known as the lead time. The forecast should provide relevant information for the hazard and will be at either a short-term, sub-seasonal and/or seasonal lead time. For example, you may want to determine whether there is a high risk of flood events in the coming season. You might use a seasonal forecast (with a lead time of approximately one month before the season begins) to extract information on the intensity of seasonal rainfall (e.g., the frequency of very wet days). This is not always available in all seasonal forecasts, so it would be important to check with your forecast provider to gather this information. A high frequency of very wet days would provide an early indicator for a wet season. However, it wouldn't tell you when in the season or at what specific location a flood may occur. If you wanted to predict the likelihood of a flood event in a particular location, you would need to monitor short-term (1-10 day) forecasts every week to see if there is a forecast for a heavy rainfall event or flood. However, if you have the prior knowledge that it is likely to be a wet season, you could be more vigilant about monitoring short-term forecasts. This is one way of combining forecast

information at different lead times—seasonal forecasts for overall wetness and short term for upcoming rainfall or flooding—in order to fit your needs. How feedback loops can improve forecasting

2. What types of information sources could be combined with seasonal forecasts to inform anticipatory decision-making and funding for measures that reduce risks (e.g., stockpiling food ahead of an anticipated drought)? Determining which languages are most appropriate for the communication of forecast information;

Depending on the risks of interest, you may have a different combination of data sources that will be useful for informing your decision-making. For example, for droughts, seasonal forecasts are analysed together with food price fluctuation, soil moisture and health data at the local level, among other sources. These are used in conjunction to determine the critical thresholds at which a lack of rainfall turns into impacts on communities, such as the point at which it causes a spike in prices or negative health outcomes. This information can help determine the climate and non-climate indicators that should be used for early warning and early action.

Diagram 1. Hazards, exposure and vulnerability sources of data in conjunction to Seasonal forecast to support decision making

- Local Knowledge
- Scientific- Knowledge
- Other Knowledge

Historical disaster impact data:

Post Disaster Needs Assessments, national DRR registries, EM-DAT, DesInventar. Etc

Coping capacities data:

Internet users, mobile celular subscriptions, government effectiveness, physicians density

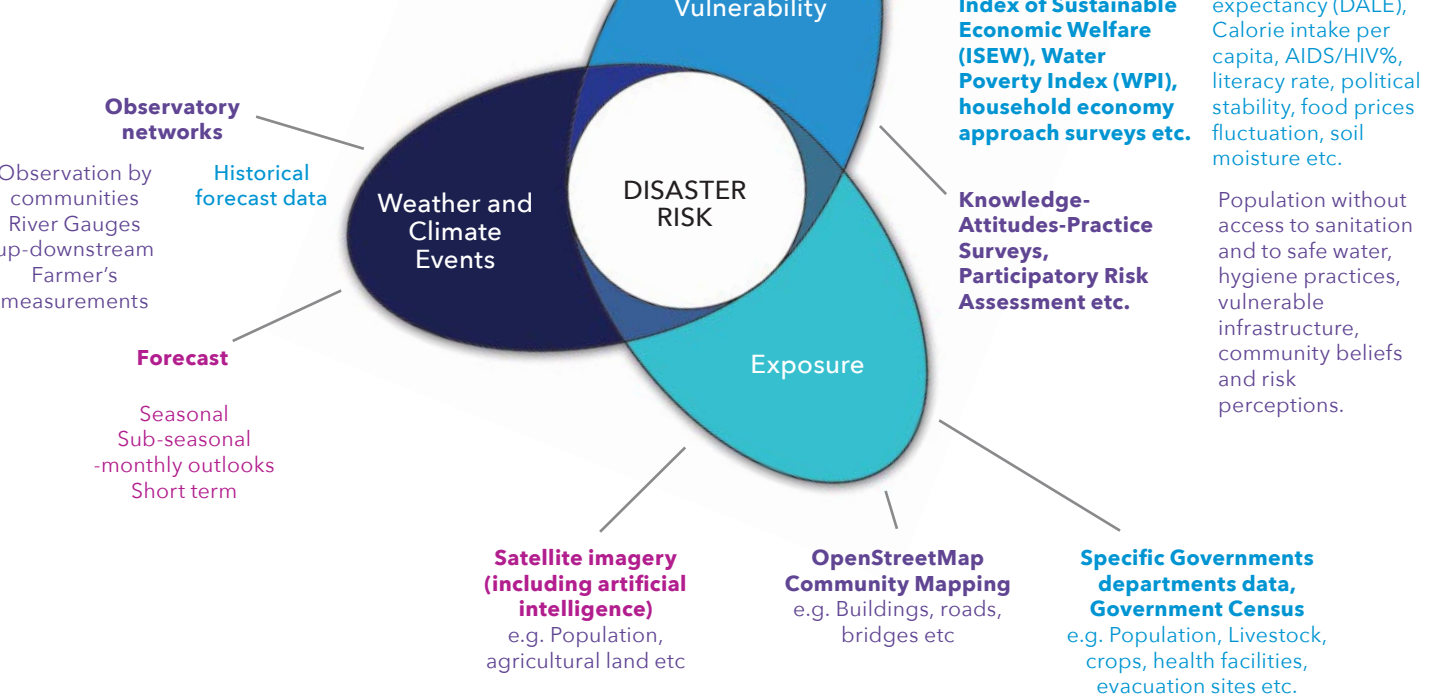


Diagram 1 shows some of the data sources and types of information than can be used alongside a seasonal forecast.

There are two main types of information that pertain to disaster risk:

2.1 Climate and weather information

As mentioned earlier, this information is often distinguished by timescale and can vary from very short term and specific (e.g., a one-day weather forecast for the rainfall amount in a town) to long term and less specific (e.g., a seasonal forecast for rainfall over three months, described using probabilities).

In addition to forecasts, another important type of climate information is climatology. The climatology of a region is the average climate, which includes the average temperature range, the average amount of rainfall during different times of the year and the average onset and cessation dates for the rainy season(s). Climatology can help climate service practitioners understand what 'above normal' and 'below normal' rainfall mean in a certain region. Climatology can also be conditional on other factors, such as El Niño. Some examples of climatology products are the [historical probabilities](#) produced by the International Research Institute for Climate and Society for rainfall during an El Niño event and those [produced by the Global Flood Awareness System](#) (GloFAS) for river flow.

2.2 Vulnerability, exposure, impact and coping capacity information

It is often not enough to look only at hazard information, because a disaster occurs only when people are vulnerable and exposed to a particular hazard. As such, it is key in risk management to understand which populations are most exposed to different types of hazards (e.g., people living near river banks are more exposed to riverine flooding, while those living near the coast may be more exposed to storm surge flooding) and also who is most vulnerable (e.g., people who lack the capacity to cope with even small shocks or stresses). Communities that are both highly exposed and vulnerable to a particular hazard might be prioritised for early action. For this, sources of information vary across countries. Reliable sources that can be bundled with seasonal forecasts to paint a credible 'picture of risk' include government censuses, participatory risk assessments, satellite imagery, national disaster registries, post-disaster needs assessments (PDNA), OpenStreetMap and existing vulnerability indices (e.g., the water poverty index).

3. What other contextual factors should be considered alongside seasonal forecasts in order to inform humanitarian decision-making?

Understanding local power structures and culturally-informed risk perceptions is crucial. Local knowledge of the environment and the climate often directly relates to and informs adaptive skills and ways of dealing with and anticipating risk. Humanitarian and development organizations should consider these aspects in the decision-making process when using seasonal forecasts. In addition, it's important to think about other socio-political contextual factors, such as a changing political environment (e.g., an upcoming election) and potential trigger events (e.g., conflict) and how these elements may impact vulnerability in the future.

Although seasonal forecast information can be valuable, it can still be unclear what the potential impacts and severity of the potential disaster could be. To know not only what the weather will **BE** but also what the weather will **DO**, cooperation between climate and risk data scientists, communities at risk, disaster risk managers, information managers and sectoral experts (water, health, food security, infrastructure, etc.) is essential. [Participatory Scenario Planning](#) (PSP) in Kenya provides an example of how understanding the cultural, socio-economic, environmental and political context is essential for effective decision-making.

CASE STUDY: USING SEASONAL FORECASTS TO REDUCE DZUD-RELATED RISKS IN MONGOLIA.

Dzud is a Mongolian term for a unique climatic phenomenon where severe drought is followed by an extreme winter, causing large-scale livestock mortality. In the summer of 2017, over 70 per cent of Mongolia was experiencing severe drought. This left herders without reserve fodder and hay. Continuous harsh conditions put at risk millions of livestock animals, which are the only source of food, transport and income for almost half of the population of Mongolia.

A *Dzud* risk map—developed by the National Agency for Meteorology and Environmental Monitoring (NAMEM), the Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE) and Japan's Nagoya University—is the basis for triggering Forecast-based Financing (FbF) action for Mongolia. The *Dzud* Risk Map incorporates seasonal forecasts for snowfall and temperature and other scientific indicators, such as rainfall deviation and risk of drought. Embedded within the *Dzud* Risk Map, there is an approximation of the pre-winter vulnerability of herds, based on observations of summertime pastures and the density of animals registered as living in specific areas. From these data sources, the vulnerability of animals going into the winter season is estimated in the form of an approximation of how much hay could be prepared given the summer pasture conditions and how much hay would be needed to support the animal population of the area until the following spring. In combination with meteorological forecasts for the season, this estimation of pre-winter vulnerability is used to map the risk of elevated livestock death for the coming winter.

In the 2017 drought, the decision-making process to agree where (i.e., in which districts) to implement early actions was made by using the *Dzud* Risk Map. The decision of who (which herder households) to support was made selecting herder households that meet specific vulnerability criteria from within the geographic areas highlighted within the *Dzud* Risk Map. The household vulnerability criteria included the number of animals within a household's herd, whether the household was headed by an elderly person, whether the household was headed by a single person, whether there was a high dependency ratio (ratio of children to adults) within the household and whether anyone within the household was considered to have a disability. This data was accessed from district-level government authorities, who keep such records updated. The Mongolia Red Cross staff worked with local government authorities to identify which households met the criteria for support within the areas highlighted by the *Dzud* Risk Map. Early action could be taken to reach the herders well before the loss of their livestock, not after. The best time to support herders is before their animals become weak, giving any action the chance to avert livestock loss and reduce the impact of *Dzud* on the livelihoods of vulnerable herders.

4. Is all 'vulnerability, exposure, impact and coping capacity information' useful?

There is an abundance of information in the world, but not all information is useful. To identify what could be used in combination with seasonal forecasts, you must know both quality *and* granularity. *Quality* refers to how accurate and reliable the information is. For example, a 2007 census likely does not offer a real representation of what is happening in 2019. Post-disaster needs assessment (PDNA) data that was collected without minimum standards would likely have errors that may misrepresent the real disaster impacts. Therefore, it is crucial to have quality standards for selecting which information to use.

In contrast, *granularity* in data refers to the scale at which data is gathered. The lower the administrative level, the most detailed the information is. In most of the developing world, *vulnerability, exposure, impact and coping capacities information* exist only at a very high administrative level. To address this issue, it is crucial to investigate what information could provide a good enough picture of the context at the lowest administrative level possible, ideally at the household level. When overlaying seasonal forecast data with these other sources of information, if there is not quality and granularity, there is a potential to increase the level of uncertainty in the decision-making process.

QUESTIONS TO INVESTIGATE QUALITY AND GRANULARITY

Quality:

- When was the information produced?
- Was it generated by trained people?
- Is there any chance that the information has a bias towards a specific issue?
- Is the information complete?

Granularity:

- For which administrative levels is the information available?
 - What information is available at household level? At the community level? At the municipality level?
 - Is the information complete for an entire at-risk geographical area?
-

THE BENEFITS AND LIMITATIONS OF USING SEASONAL FORECASTS TO TAKE ACTION

By **Roop Singh**, Red Cross Red Crescent Climate Centre and **Dave MacLeod**, University of Oxford

June 2019

Issue No. 4

This document provides some considerations on using (or not using) seasonal rainfall forecasts to take action before a climate hazard occurs, based on the inherent benefits and limitations of this type of information. It is intended for humanitarian and development staff who may be considering setting up a climate information service or using seasonal forecasts to trigger anticipatory actions.

In a perfect world, we would be able to predict, three months in advance, exactly when seasonal rainfall will start and stop, whether or not there will be dry spells or torrential downpours that could result in droughts or floods and exactly how much rainfall will fall in total over a season. Seasonal forecasts provide almost none of this information, and in fact, much of this 'perfect information' is not something scientists can currently predict at all. Rather, seasonal forecasts give us something akin to a blurry photograph of the upcoming three-month season. However, that blurry photograph is often better than no photograph at all and can be used as part of a Forecast-based Action approach (FbA). In an FbA system, forecast probabilities above a pre-set threshold trigger predefined actions that are listed in a standard operating procedure (SOP). Seasonal forecasts can be one type of forecast input for such a system.

Before deciding to integrate a seasonal forecast into an FbA system, it is important to understand the benefits and limitations of seasonal forecasts:

- 1. Seasonal forecasts only give a general sense of the character of the season by providing a forecast of seasonal rainfall totals.** The seasonal forecasts are for whether *cumulative rainfall totals over three months* are likely to be normal, above normal or below normal. This gives a general overview of the season, but it does not elaborate on possible day-to-day weather fluctuations. Although it does not happen very often, it is possible for an area to receive a months' worth of rainfall in one day and thus suffer from floods while still ending up having a seasonal total of *below-normal* rainfall, consistent with the seasonal forecast.
- 2. Seasonal forecasts give us more time to prepare than weather forecasts.** Having an early warning that a rainy season might be wetter or drier than normal means we have more time to prepare.
- 3. Seasonal forecasts do not give us information about exactly when, where and how rain might fall in the way that a regular weather forecast does.** Therefore, we should continue to monitor forecasts on shorter-term timescales (e.g., weekly and daily weather forecasts) to gain more certainty and detail on where and when an extreme event might occur.
- 4. Seasonal forecasts do not provide any detailed spatial information.** Weather forecasts are like a high-definition picture, giving detailed information on exactly

where rainfall is likely to occur. Seasonal forecasts, however, are more big-picture, offering only a coarse resolution. Thus, it is not possible to make inferences about precisely where there are risks of increased or decreased rainfall.

5. Seasonal forecasts are not perfectly certain. All forecasts contain uncertainty and are inevitably 'wrong' some of the time. Seasonal forecasts are presented using probabilities in order to convey the most likely outcome. If you had no forecast, you would have no idea of whether rainfall during the coming season would be normal, above normal, or below normal, and so each of these three possible outcomes would be equally likely and have a probability of 33 per cent. Seasonal forecasts can tell you if one of those three categories is more likely than the others. However, probabilities for less likely events should not be ignored, as they can still occur.

Integrating seasonal forecasts into an FbA system

Using seasonal forecasts as part of a Forecast-based Action system requires knowledge of how the forecast relates to the impact you are trying to minimize. For example, if you are interested in flooding, even an 'above normal' rainfall season can have less flooding than a 'normal' rainfall season, depending on the character of the rainfall (i.e., if it is spread out over many days or weeks vs. if it falls all at once during a several-hour period). Thus, it would not be appropriate to use seasonal rainfall forecasts to take specific flood-prevention actions. However, if a humanitarian agency is looking to engage in anticipatory humanitarian action for a drought and there is a forecast for below-normal rainfall, then they may use the seasonal forecast to decide to increase staff time spent monitoring the situation on a weekly basis. They might also set up monthly staff meetings to discuss rainfall performance so far in the season and to decide to raise an alert (e.g., using the Start Fund) when there is a more granular sub-seasonal forecast or other information that indicates deteriorating conditions. In this way, the seasonal forecast would be used to trigger initial, internal action, which would then support the use of shorter-term forecasts to take more specific budget decisions and anticipatory actions.

The impact of too little or too much rainfall also depends strongly on non-climate factors. For instance, food insecurity can still follow normal rainfall if the surface hydrology, vegetation or market conditions are initially poor. Conversely, a single poor rainfall season may not lead to large impacts if other indicators are healthy. In such a case, it would be unwise to act only based on the seasonal climate forecast information alone. See *Issue No. 3* on using seasonal forecasts with other information.

Deciding to take action

The decision of whether or not to take preparatory action depends on your risk appetite. Because a forecast is probabilistic, there is always a chance that a predicted event won't occur. For instance, if the forecast is for the event to occur with a 60 per cent probability, the probability the event won't occur is 40 per cent. To put it another way, if you take action when the probability is 60 per cent, there is a 40 per cent chance you will act in vain. If you are particularly risk averse, you would likely choose a higher threshold upon which to act, acknowledging that you may miss the opportunity to act on some events. If you have a higher risk tolerance, you may choose a lower risk threshold, acknowledging that you may act in vain more often because of this.

How is science changing or improving? Can we expect seasonal forecasts to get better?

Our ability to make good seasonal forecasts depends on two things. Firstly, it is limited by our imperfect understanding and modelling of the climate system. As we understand more about different parts of the system and how they interact and bring predictability, we can model them more effectively and take advantage of predictability sources (e.g., from land or sea-ice processes). We might also improve by better understanding our forecast systems themselves, allowing us to know that in some situations we can trust the model more than in others. In addition, as technical modelling capacity improves (e.g., improved spatial resolution), we can better represent small-scale processes and reduce errors. This can lead to improved predictions

However, predictability is also fundamentally a function of reality. Predictable parts of the climate are the engine of predictive skill. An example is El Niño events in the Pacific, which are predictable months ahead and persist for months. When these events are strongly connected with distant regional climates (a phenomenon known as *teleconnection*), such as rainfall during the East African short rains, it is possible to predict these local impacts. However, where these teleconnections do not exist, no amount of extra research or computing power will lead to predictability. Yet as of now, it is impossible to know if the lack of knowledge of such a link is due to absence in reality or due to our imperfect knowledge. In addition, a significant amount of current climate research suggests that teleconnections may change, strengthen or weaken over time. So, while our ability to make seasonal forecasts in one region may decrease in the future, whole new regions may become predictable.

CREATING FEEDBACK LOOPS WITH FORECASTERS AND USERS

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This document explains the importance of utilising feedback loops for seasonal forecasts, provides examples of how these can help improve forecasts or increase users understanding of forecasts, as well as details some guiding principles regarding how these loops may be established.

The importance of feedback loops

Seasonal forecasting has the potential to play a significant role in enhancing end users' resilience to the impacts of climate change and variability. Smallholder farmers, for example, are vital to the economies and food security within the majority of the developing world, yet they are confronted with increasingly scarce resources, changing weather patterns, and extreme events that pose significant threats to the stability of both production and income. Seasonal forecasts can provide this key stakeholder group with information to support their decision making regarding which crops they should plant, when to plant and harvest, and when to apply fertiliser and other inputs to maximise their yields and mitigate their losses.

In order for seasonal forecasts to support decision making, a range of requirements must be met, as forecast accuracy is central although insufficient on its own; the information must be:

- relevant to the needs of the users at whom it is targeted;
- provided on a timescale that allows users to take action;
- communicated in a way that is accessible, understandable, and inclusive;
- trusted by users; and
- clearly connected to user actions and impacts.

However, determining the extent to which seasonal forecasting meets these requirements is complex. Evaluations tend to be based upon yield and income results, but these indicators cannot provide the full picture. Yield and income can vary depending upon factors independent of the forecast, including market price fluctuations, the occurrence of household or local shocks that may influence farmers' decision making, and the effectiveness of the wider system through which forecast information is communicated. Additionally, it is challenging to determine who does and does not have access to seasonal forecast information due to the diffusion of information through social networks (which may be incomplete or distorted). This uncertainty complicates the drawing of meaningful comparisons between farmers who have received seasonal forecast information and those who have not.

Feedback loops enable seasonal forecast producers to accurately determine whether the information being generated is achieving its desired impact. Incorporating feedback loops into the design and implementation of seasonal forecasting production and dissemination helps stakeholders to measure which information is accessed, understood, and adopted by users can be measured. Additionally, farmers' perceptions of forecast information's accuracy and impact on their yield and income—including both loss prevention and growth—can be procured and captured via regular dialogue. This exchange in turn allows that meaningful baselines be established, progress monitored, and changes made to support the continual improvement and development of seasonal forecasting.

How feedback loops can improve forecasting

1. **Identifying the information that is relevant to users.** For example, farmers in Niger reported that they did not receive forecast information regarding strong winds, crop pests, or dry periods, which were vital aspects for their decision making.
2. **Determining useful spatial scales.** How geographically specific must forecast information be in order for users to be confident in it?
3. **Assessing accuracy.** Feedback loops present the opportunity to assess how users perceive the forecast's accuracy as well as how they were impacted by the weather and the actions they did or did not take.
4. **Identifying other influential factors.** Weather's impact on yields and incomes is also affected by changes in land use, the market, and value and supply chains. Feedback loops can identify where it may be useful for forecast producers to coordinate with other agencies and departments as well as produce more holistic forecast information (e.g., how a nearby infrastructural project may interact with forecast rainfall).

How feedback loops can increase users understanding of forecasts

- Determining which languages are most appropriate for the communication of forecast information;
- Identifying effective methods for communicating forecast information (e.g., use of images, colours, percentages, comparisons to past events or projected impacts);
- Identifying which formats (written, verbal) and platforms (radio broadcasts, community groups, fliers, SMS) effectively reach diverse user groups;
- Determining which socio-economic factors (e.g., gender, age, ethnicity) significantly affect and address one's access to, understanding, and uptake of seasonal forecast information;
- Building trust between user groups and producers of seasonal forecast information, especially in contexts wherein this trust may be very low.

Guiding principles on establishing feedback loops

In order for a feedback loop to be effective, it must be accessible to the targeted stakeholders, which requires the identification and utilisation of the various communication channels that are preferred by those stakeholders, thus ensuring that the range of preferences are accommodated. Focus group discussion approaches, for example, may need to be adapted to ensure that marginalised and less visible stakeholders are afforded space to be heard. In-person household surveys may be preferred in some contexts, whereas phone surveys may be more convenient or facilitate more candid responses in others.

CASE STUDY: CLIMATE SERVICES IN NIGER

In Niger, forecasters may receive feedback through mobile phones in a few different ways. They may call and interview the farmer, which is most convenient—although difficult to scale—for those who are new to the system. Forecasters may also send a farmer a question and ask that he/she respond. In this case, the farmer will need an appropriate amount of time and support to become familiar with this process. If the farmer is asked an SMS question, he/she can respond via SMS or voice recording. If interactive voice response (IVR) is used, he/she can immediately record a response, in which case the method can be made cost free to all farmers.

Another option may involve farmers spontaneously sending an SMS or voice feedback (e.g., ‘it rained hard today for three hours’; ‘the soil is waterlogged’). Local radio may be another way to collect feedback by way of inviting listeners to call in and share their views. The recording may then be sent to the national meteorological service and other stakeholders.

In Niger, a key recommendation involved mainstreaming climate information services transmission and feedback into the mandate of existing structures at the local level, particularly through the SCAP-RU (Systèmes communautaires d’alerte précoce et de réponse aux urgencies)—which was set up as part of the Famine Early Warning Systems Network—and Maison du Paysan (advisory, finance, and other business services for smallholder farmers).

It is vital that the feedback loop both be inclusive of groups who are marginalised and facilitate their representation and participation. Feedback mechanisms should ensure that stakeholders’ characteristics are documented such that missing groups can be identified; for instance, is feedback being received from women, from ethnic or religious minority groups, or from younger and elderly users? Marginalisation is context specific and intersectional; user groups are not homogenous and an educated woman from a dominant religious or ethnic group may not be able to effectively represent the perspectives of, for example, a woman from a marginalised minority community who is illiterate. If any marginalised groups are missing, clear steps to include these voices must be taken (e.g., by holding specific focus group discussions or reaching out through specialised community-based organisations).

The regularity and frequency of data collection are also key considerations, as a balance must be struck between how often collecting feedback is useful and how often providing user feedback is practical. The collection of too much data limits its usefulness for forecast producers and places an unreasonable burden on users. Additionally, there may be times during the year when users are unavailable to provide feedback due to other obligations. While it may be useful, for instance,

to gather feedback immediately following a harvest, farmers will not have time to spare. A constantly open feedback loop may be useful in some contexts although overwhelming or underutilised in others. The frequency and the actual content that is being collected must agree with the user population and be revisited and refined as needed in order to optimise the utility of the feedback mechanism.

Finally, and most importantly, feedback must be demonstrably and transparently acted upon. Responses to feedback may in some cases be determined in partnership with user groups. In all circumstances, seasonal forecast producers should ensure that they regularly report back to users to communicate what feedback has been received and how it is being addressed; regular follow-up is also necessary to monitor how successful a response is in addressing feedback. This process will support the identification of both more and less useful information that is procured through the feedback loop such that the process may be streamlined as appropriate. This procedure should also be applied to the feedback mechanism itself to ensure it remains open to improvements based on user experiences.

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