THEME ENV.2012.6.1-1

EUPORIAS

(GRANT AGREEMENT 308291)

EUROPEAN PROVISION OF REGIONAL IMPACT ASSESSMENT ON A SEASONAL-TO-DECADAL TIMESCALE.

D41.2_19022016_FINAL_VERSION.DOC

PRELIMINARY GUIDANCE DOCUMENT ON THE EVALUATION OF THE DECISION MAKING PROCESS VALUE

Deliverable Title	Preliminary Guidance Document on the evaluation of the value of DMP	
Brief Description	Preliminary Guidance Document on the evaluation of the value of DMP: This guidance document will be based on a methodology defined to evaluate the qualitative and quantitative value of the DMPs for key stakeholders in specific sectors.	
WP number	41	
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Creation Date Version Number Version Date	Month 31 V2.2 19.02.2016	
Deliverable Due Date Actual Delivery Date	29.02.2016 29.02.2016	
Nature of the Deliverable	X	R - Report
		P - Prototype
		D - Demonstrator
		O - Other
Dissemination Level/ Audience	X	PU - Public
		PP - Restricted to other programme participants, including the Commission services
		RE - Restricted to a group specified by the consortium, including the Commission services
		CO - Confidential, only for members of the consortium, including the Commission services

Version	Date	Modified by	Comments
0	13/04/2015	Melanie Davis	Creation
0.1	25/06/2015	Jean-Michel Soubeyroux	Update
0.2	07/08/2015	Jean-Michel	Update

		Soubeyroux	
1.0	18/09/2015	Jean-Michel Soubeyroux	Update
2.0	27/01/2016	Isadora Jiménez	Automatic template styles edits and inclusion of sample structure
2.1	15/02/2016	Jean-Michel Soubeyroux	Update of contributions of each partner
2.2	19/02/2016	Jean-Michel Soubeyroux	Complete version
2.2	25/02/2016	Isadora Jiménez	Final version with EUPORIAS coordinator comments

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1. EXECUTIVE SUMMARY

GENERAL PURPOSE

In the context of the development of Climate Services (CS), it emerges a new challenge related to the demonstration of their interest and value. For that, we must propose some methods to verify the quality of the decisions made through the different Decision Making Processes (DMP) which are using the Climate Information (CI) as input. However, we have to acknowledge that the CI is only one part of the information leading to decision. And so, in this context, we have to evaluate the quality of the decision considering also the different "external" factors; external meaning information no directly related to climate. So the evaluation of the quality of provided CS must go beyond the current verification used in seasonal forecasting and must address the impact of the use of the CI onto the DMP.

The concept of the value of climate services has been already discussed in some studies and first this report will remain the different results and elements to take into account. In the context of Euporias project aiming to co-design climate services at S2D time scales with stakeholders, several approaches for the "value" assessment have been defined by the different partners through case studies or prototypes experimented in the project :

WEATHER ROULETTE (IC3)

IC3 has chosen the weather roulette methodology (Hagedorn & Smith, 2009) to properly explain the potential economic benefits of adopting probabilistic predictions compared with the current practice of using predictions based on retrospective climatology. The weather roulette is a diagnostic tool created to inform in a more intuitive and relevant way about the skill and usefulness of a forecast in the decision making process, by providing an economic and financial oriented assessment of the benefits of using a particular forecast system. For the wind energy sector both the predictions using climatology and the predictions using seasonal predictions will be compared with the weather roulette providing the results as an effective interest rate. A value that is easier to understand for the general public.

ASSESSING THE VALUE OF SCF THROUGH DECISION MAPS (Univ Leeds)

The **University of Leeds** is using decision maps to understand key farming decisions that will need to be made in the coming months along with the various management options available to the farmers, the overall decision process in which Seasonal Climate Forecasts (SCF) can potentially be used to aid the decision-making as well as the conditions that need to be in place to allow farmers to apply and use SCF in their decisions (cf. Bert et al., 2006). By examining the decision-making context of the farmers involved in the Land Management Toll prototype and the mental processes that they go through when making decisions we will be able to have a greater understanding and insights into the potential value and benefits of using SCF in agricultural decisions.

THE PLACEBO CONCEPT (Météo-France)

Météo-France has tested the placebo concept, well known in medicine to test new medical treatment, and adapted it to climate field. Its principle is to put the stakeholder in a context close to real one, and to ask him to apply its DMP with two inputs: one is a seasonal forecast, the other is a false one (the placebo). This experiment has been lead in collaboration with our stakeholders EPTB Seine-Grands Lacs over a sample of past situations, in order to calculate a performance score.

the decision context (Cet Aqua)

Cet Aqua simulated scenarios with/without seasonal forecast for different river basins in Spain (case studies) and evaluated their value through different key indicators (e.g. probability of water deficit for the different demands; probability of reservoir state). The

methodology used aims to upgrade DMP according to seasonal forecast and the methodology to assess the value of doing it. Preliminary results are presented for the Dam of “La Cuerda del Pozo” situated in the Duero River Basin. The goal of the methodology is to assess the impact of seasonal forecast on DMP and determine their value through different key indicators. The selected indicators are the probability of having water deficit and probability of being in different reservoir state.

COST BENEFIT ANALYSIS (WFP)

In 2012, a Cost Benefit Analysis (CBA) was carried out by **WFP** to assess the economic benefits of the current LEAP system. This initial CBA used a forward looking methodology (i.e. it assessed benefits over the next 20 years). In the context of the EUPORIAS project, through which WFP is testing the integration of seasonal forecasts into the LEAP system, WFP intends to carry out a new, modified CBA of LEAP. This new CBA aims to assess the added socio-economic benefits of using seasonal forecasts in LEAP to trigger early assistance. This CBA will be the basis for WFP’s contributions to several deliverables in EUPORIAS work package 41 (in particular, deliverables D.41.2 and D.41.4).

This CBA aligns with WFP’s wider efforts to provide evidence on the socio-economic benefits of using climate information in humanitarian financing mechanisms. This evidence will serve to support WFP’s innovative work in the area of climate risk financing and loss and damage.

The next best alternative (Met Office)

Met Office has started to explore the way in which the complexity of the next best alternative could be used to define an intrinsic value of a specific prediction once a suitable verification metric is identified.

2. PROJECT OBJECTIVES

With this deliverable, the project has contributed to the achievement of the following objectives (DOW, Section B1.1):

No.	Objective	Yes	No
1	Develop and deliver reliable and trusted impact prediction systems for a number of carefully selected case studies. These will provide working examples of end to end climate-to-impacts-decision making services operation on S2D timescales.	X	
2	Assess and document key knowledge gaps and vulnerabilities of important sectors (e.g., water, energy, health, transport, agriculture, tourism), along with the needs of specific users within these sectors, through close collaboration with project stakeholders.	X	
3	Develop a set of standard tools tailored to the needs of stakeholders for calibrating, downscaling, and modelling sector-specific impacts on S2D timescales.	X	
4	Develop techniques to map the meteorological variables from the prediction systems provided by the WMO GPCs (two of which (Met Office and MeteoFrance) are partners in the project) into variables which are directly relevant to the needs of specific stakeholders.	X	
5	Develop a knowledge-sharing protocol necessary to promote the use of these technologies. This will include making uncertain information fit into the decision support systems used by stakeholders to take decisions on the S2D horizon. This objective will place Europe at the forefront of the implementation of the GFCS, through the GFCS's ambitions to develop climate services research, a climate services information system and a user interface platform.		X
6	Assess and document the current marketability of climate services in Europe and demonstrate how climate services on S2D time horizons can be made useful to end users.		X

Table 1: Project objectives

3. DETAILED REPORT

3.1. INTRODUCTION

In order to assess the value of climate services it is important to account for both the quantitative and the qualitative benefits. Different methods for assessing the value of Climate Services (CS) have been described in the literature. Such a variety is due to the fact that several natural and socio-economic factors control their overall value.

To facilitate the understanding and the comparison of the different results, each method implemented in this report (6) (this being for a specific prototype of CS, a sector or individual end users) will be described using a common structure which includes a CS description, an evaluation of the impact CI has onto DMP, additional value expected and the means implemented to evaluate it.

3.2. BACKGROUND

The conceptualization of the word value can be associated to a multiplicity of meanings and understandings depending on the context and area of research. For example, the definitions listed in The Oxford English Dictionary (1933) can be broadly related to one of three key ideas: 1. as monetary worth and/or as something that represents a fair return in money, services or goods; 2. as something useful, estimable or important; and 3. as a set of beliefs and concepts in individuals.

In the climate literature there are also different understandings of the concept of value in the context of seasonal climate forecasts (SCF). For example, from the broader perspective of National Meteorological and Hydrological Services the value of SCF tend to be understood within a "value chain" which encompasses the different processes of climate information production, the services provided, and the benefits to the users of that information (WMO, 2015). In this context, the outcomes of decisions made are what link the climate services provided to value (ibid).

However, when considering SCF as a piece of information applied in a specific decision-making context the interpretations of what the value of SCF entails can differ. For example, Stern and Easterling (1999) define the value of a SCF as the difference between the outcomes of a decision made with and without a climate forecast. In their conception, the value of SCF is therefore a function of different factors that influence its use and value including the users' activities, how sensitive they are to weather and climate conditions, the time horizon of the decision(s), their strategies and capacity to cope (Stern and Easterling, 1999).

According to Murphy, the value of SCF is acquired "through their ability to influence the decisions made by users of the forecasts [and] to guide their choices among alternative courses of action" (Murphy, 1993, p. 285/6). The value of SCF is described as the benefits that can be yield from using SCF and allow us to consider alternative metrics (e.g. non-economic value) in the assessment of SCF value (cf. Clements et al., 2013). In his review of the economic and social benefits of climatological information, Nicholls (1996) identifies the range of benefits that can be yield from using climate information in decision-making which are regarded as the "marginal change in the outcome for a user" (p. 3). These measures of benefit can include qualitative improvements in the decision, environment, and outcomes as well as quantitative changes to the outcome either in economic value or non-economic value (Nicholls, 1996).

In some studies, the onus of the analysis is to understand the (potential or real) qualitative benefits that using SCF proportionate the user in their decision-making rather than

quantifying the economic value that SCF can yield when used to support decision-making (Clements et al., 2013; WMO, 2015). Table 1 below lists some examples of qualitative and quantitative benefits (both converted and non-converted to economic values)

Qualitative benefits	**Quantitative benefits**	
	Not converted to economic values	***Converted to economic values***
Planning actions (e.g. selection of crop type, pesticide spread, type of livestock)	Improvements (or loss reduction) in income return (e.g. tonnage of crops, volume of surplus reservoir water)	Improved earnings or reduced losses
Improve design (e.g. facilities for food and livestock, for human health and comfort, protection against damage/disaster)	Improvements in production efficiency through better resource control (e.g. dates of crop spraying, frequency of irrigation)	Net financial savings or benefits to cost ratios
Reduce wasted operational efforts (e.g. transportation, spraying, distribution, irrigation, application of fertiliser, optimisation of storage)	Improved prediction of demand (e.g. number of retail goods, medical supplies, power and water supply, road salt, tourist accommodation)	Net present values
Facilitates good justice (e.g. insurance conditions, liability cases)	Through optimise design of structures and systems reduce power consumption, reduce maintenance, reduce hazard risk	
Improve overall health, welfare and economy	Reduction of death and disease	
Widens options available to decision-makers		

Table 2: General qualitative and quantitative benefits of climatic information (adapted from Nicholls, 1996).

Although the majority of studies looking at the value of using climate information (and SCF in particular) to support decision-making tend to focus on the economic quantification of value there are numerous other potential benefits (including those more qualitative in nature) that can and should also be addressed when performing this type of examinations.

3.2.1. **Factors influencing the value of SCF**

The value of SCF is associated to the use (or hypothetical use) of that climate information in a particular decision-context. As such, the quality of the SCF such as the level of accuracy,

timeliness, resolution, uncertainty, and accessibility are all factors that influence the usability and –consequently- the value of SCF (Hill and Mjedle, 2002; Clements et al., 2013).

However, from the point of view of the user non-technical factors such as the his/her technical capacity and expertise to assimilate and use the SCF, their beliefs and knowledge, and their level of risk aversion are all important factors that will allow them (or not) to use SCF and thus be able to yield value or benefits (Bruno Soares and Dessai, forthcoming; Lemos et al., 2012). Ultimately, the (potential) value of SCF can only be realised if the information fits and is able to support the user in the context of the decision to be made (Lemos et al. 2012; Sarewitz et al. 2000). As such, a thorough understanding of the decision-making context is also an important element in the assessment of the value of SCF (Katz and Murphy, 1997; Clements et al., 2013). This include aspects such as organisational structures, flexibility of management decisions, regulatory framework, existing norms and practices, and existing collaborations with the knowledge providers (i.e. producers/providers of SCF).

Although these aspects should be considered when assessing the value of SCF in decision-making the ways in which these are addressed and accounted for can vary depending on the methods selected to perform the analysis (see below).

3.2.2. **Methods for assessing the value of SCF**

Assessing the value of SCF in decision-making can be pursued through a range of methods which span from quantitative studies such as econometrics and modelling simulations to more qualitative methods such as participatory studies. The majority of the literature on the valuation of SCF focuses on the assessment of the economic value of using the information in decision-making (Nicholls, 1996; Clements et al., 2013). In addition, there is a predominance of studies in agriculture compared to other sectors and the main geographical scope of these studies tends to be on the value of SCF when considered at 1) the individual or organisational level; 2) sectoral level; and 3) regional or national level (cf. Clements et al., 2013). Below we introduce some of the main methods currently used to assess the value of SCF in decision-making.

Decision theory-based models

Decision theory is an interdisciplinary area of research encompassing contributions from economics, statistics, physiology, philosophy and management (Rubas et al., 2006). In its simplest form decision theory involves a single actor or entity who have to make a decision to maximize (or minimize) a specific objective based on either a utility function, cost-loss model, production function, or other economic model (Rubas et al., 2006). In this context, it is assumed that the decision-maker solely decides based on the potential payoff that can be gained from that decision. In this view, the value of the SCF is defined as the difference between the expected outcome (e.g. economic payoff) of a decision made with the forecast and the expected outcome of the decision made without the forecast or just with climatology (Letson et al., 2005; Meza et al., 2008).

This kind of studies is normally combined with management or production models (e.g. crop growth models) in order to identify the most optimal decisions under different (climate) scenarios (Hill and Mjelde, 2002).

Meza and Wilks analyzed the use of sea surface temperature anomalies (SSTA) for potato fertilization management using a soil-crop atmosphere model and a decision model (Meza and Wilks, 2004). Their study has showed that the potential economic value of hypothetical perfect SSTA information for the most optimum potato fertilization regime in the Valdivia region in Chile can be estimated around the 20$/hectare.

Equilibrium models

General equilibrium models (GEM) are another economic approach that can be utilized to understand the potential value that climate information can have in specific sectors. GEM are based on the idea that the choices of different decision-makers are interlinked and affect each other (WMO, 2015). For example, the use of SCF by an increasing number of farmers can potentially change the overall production which in turn can influence price (Rubas et al., 2006).

Although this type of models has not been used to assess the value of SCF due to their intrinsic complexity, some studies have used some of the principles of GEM to develop partial equilibrium models or sector models to understand the potential effect of SCF in a particular market or economic sector (Rubas et al., 2006). For example, Hill et al. (2004) examined the international wheat trade using a partial equilibrium model. The aim of their study was to assess the effects of SCF based on ENSO could have in the international wheat market and, in particular, its effects on prices, exports, storage and benefits in three countries (USA, Canada and Australia). The simulation model they developed is dynamic and stochastic to represent the complexity and based on different components of analysis (e.g. incorporation of storage and trade). This allowed them to examine the effects related to the use of SCF in the wheat trade. Their study has shown the potential increase of producers' economic surplus in exporting countries when using SCF although an annual variation in the distribution of these benefits should be expected.

Contingent valuation

Based on economic theory, the contingent valuation method (CVM) aim was to develop a method capable of assessing the value of public goods (i.e. not traded in private markets) in the context of public policy decision-making (Mitchell and Carson, 1989).

The CVM is a survey-based method for "estimating the monetary benefits of non-marketed goods and services" (Smith and Sach, 2010; p. 91). It is used to elicit the maximum amount (in monetary value) that individuals would be willing to pay (WTP) for a non-marketed service or good or willing to accept (WTA) compensation for the gain or loss of that service or good (Bateman et al., 2002; Clements et al., 2013). CVM uses hypothetical markets to estimate the benefits of the service or good being considered (Rollins & Shaykewich 2003; Mitchell and Carson, 1989).

A number of studies have applied CVM to examine the WTP for weather services. For example, Anaman and Lellyet (1996) surveyed householders in the Sydney metropolitan area to examine the economic value given to public weather forecasts and warnings. Their findings showed that in average the annual WTP for the service was $24 per person (approximately four times the cost of producing the service). Looking specifically at the value of SCF Makaudze (2005) estimated that the WTP for this type of climate forecasts from farmers in Zimbabwe ranged from $0.44 to $0.55 and that lower WTP was consistently found in wetter districts.

Benefit transfer

The benefit transfer method is based on the transfer of the estimated economic values from existing studies (the "study site") to a different context of analysis (the "policy site") (WMO, 2015). As it requires less financial resources and time it tends to be more used than other methods (e.g. CVM) as it builds upon "(…) existing case studies (…) to 'borrow' the resulting economic values and apply them to a new context." (Bateman et al, 2002). However, despite commonly used this method is also largely criticised by intrinsic methodological challenges related to issues of transfer validity and reliability (e.g. based on the transfer method chosen and inferences made based on existing information) (Johnston and Rosenberger, 2010).

Using a benefit transfer approach Frei (2010) examined the socio-economic benefits of meteorological and climatological information across a number of sectors in Switzerland. He used existing studies in the literature to extrapolate the values of economic benefits of meteorological services in his analysis. He found that the cost/benefit ratio of the meteorological services in Switzerland is around 1:5 and that the estimated benefits, although varied across sectors, were in the order of millions of US dollars.

Participatory and qualitative studies

This type of studies is less commonly used to assess the value of SCF in decision-making and these tend to focus on smallholdings in developing countries (Mezza et al., 2008). In addition, this type of approaches can be used to analyse the value and benefits of SCF in a more qualitative manner i.e. those benefits that are difficult to express or be quantified in monetary value (WMO, 2015). In these studies the decision-maker can be involved, to different extents, in the process of analysis.

Using a mixed-methods approach Changnon (2002) examined the impacts of the failed Midwestern drought forecast in the summer of 2000 in the agriculture and water sectors. Using interviews, focus groups, survey, and studies on market and insurance he analysed the effects of the failed drought forecast on agribusiness practices, crop insurance and grain market choices. He found that almost 50% of the producers changed their crop marketing practices which ultimately led to significant losses in revenue. In the water sector actions resulting from the forecast such as conserving water resulted in little cost and were considered as beneficial.

In their study of pastoralists in Southern Ethiopia and Northern Kenya, Luseno et al. (2003) set out to assess the value of SCF to those individuals. Using qualitative and quantitative methods the authors explored the potential value of these forecasts with regard to their usefulness to the pastoralists in those regions (e.g. skill of the SCF but also other factors such as level of understanding, previous methods used to forecast, awareness of existing SCF, etc). In this context, the value of SCF is conceived as something potentially useful and important to the pastoralist community.

3.3. THE WEATHER ROULETTE (IC3)

3.3.1. Resilience prototype

Prototype description

RESILIENCE is a semi-operational prototype that aims to provide robust information on the future variability of wind power resources based on probabilistic climate predictions. In order to reach this objective, the RESILIENCE prototype operates at seasonal time scales providing seasonal wind speed predictions for the energy sector. These predictions provide an estimate of wind speed, in terms of three categories: normal wind (an average level of wind speed for that region), below normal wind (low wind speed for what is usual in that region) and above normal wind (high wind speed for what is usual in that region). RESILIENCE provides the likelihood of wind speed falling inside of each of those three categories during the upcoming months. The predictions are accompanied by skill scores, which numerically illustrate how the performance of RESILIENCE's predictions in the past was and guide users about the performance of the future forecasts.

Decision making context

Understanding and quantifying wind resources is a key element to multiple user profiles in the wind energy sector both in pre and post-construction. Operations and Maintenance (O&M) teams of offshore wind farms need to schedule operations during the less windy periods in order to minimize the risk of storms and swell conditions. For grid operators, being aware in advance of the amount of renewable energy that will go into the grid can help schedule traditional power plant operations. For the financial teams running the wind farm business, having a budget of the energy they will produce in the coming months is of crucial importance to anticipate cash flow. In all of these cases the decision makers in each user profile use a retrospective climatology to have an estimation of the expected wind. Indeed, combining long-term reference datasets with on-site measurements by means of dynamical and statistical downscaling methodologies to forecast the future conditions has become quite standard in the wind industry (Landberg et al. 2003, Sanz Rodrigo 2010).

A common assumption in these methods is that future conditions will be similar to past conditions. This assumption entails two inherent shortcomings. The first one is that past conditions can be highly variable, which can make them of limited use when guessing the future. The second one is that climatology cannot predict events which have never happened before, i.e. extreme events, which can be particularly harmful and whose prediction is of special interest for stakeholders. Our knowledge of climatology is based on a finite sample of past events. This sample is limited in time, and doesn't need to be fully representative of what can happen. Moreover, a climatological approach does not take into account changes in atmospheric dynamics, such as those caused by climate change. Climate change may render past conditions useless for predicting future events, as they may no longer hold true.

Concept of value

Despite being relevant to multiple roles in the wind energy sector, the primary user of RESILIENCE is the energy trading sector. Nowadays, practically no country can cover its energy needs from its own sources increasing the significance of energy trading not only for supplying energy but also for buffering the risks of supply shortages or price fluctuations. Supply and demand are the determining factors for the market and important decisions must be made in order to attain adequate load balancing between production and consumption. Production and its costs are variable and depend on many factors, such as wind speed for wind energy, fuel prices for thermal energy and rainfall for hydro power. This scenario is further complicated by the variability of demand itself. Energy traders must make their choices based upon which course of action will be the optimal in terms of expected production from renewable sources, fuel prices, water shortages, energy prices, etc.

One of the difficulties trading analysts face when dealing with probabilistic predictions is conciliating an array of probabilities with a yes/no decision (Cloke and Pappenberger 2009). To overcome this situation, several methods exist to translate probabilities into monetary risk, which is the expected value of losses or profits. Flood risk management, for instance, is a field where probabilistic forecasting is gradually being adopted. Risk-based approaches calculate the expected monetary values and adequate thresholds are fixed and thus a consistent decision-making policy can be defined (Dale et al, 2014). However, to promote the incorporation of probabilistic predictions in the decision-making process of climate analysts in energy trading firms the first step is to demonstrate the added value of these predictions compared to current practice.

The primary value of the predictions is how many times the prediction is in agreement with the actual category observed, i.e. the “hit rate”. Retrospective climatology assumes that the probability of future wind speeds being below-normal, normal, and above-normal is equal (one third each). By using RESILIENCE’s probabilistic predictions the users are provided an improved characterisation of the probability of the wind speed falling into each of these three categories.

The goal of the RESILIENCE prototype within WP41 is to show to the potential users that - for the regions where the prediction system is skilful- the hit rate of RESILIENCE can be greater than mere climatology and thus increase the perception of value for climate predictions promoting their inclusion in the decision making processes that require wind resources assessments.

3.3.2. Methodology

Name of the methodology/study: Weather roulette

Background

Nowadays, the sector of weather and climate services is increasingly facing the challenge of communicating the value of its products to companies and stakeholders. Many scientific diagnostic tools exist to assess such quality, including widely used forecast skill scores. However, such measures are not well known by people outside the scientific community, which poses a great hindrance to communication. The need of intuitive diagnostic tools becomes evident, especially when dealing with customers which need not be experts.

Whereas one cannot expect decision makers to be familiar with the statistical techniques employed by the scientific community, and their results, economic and financial knowledge is widespread in the corporate world, and terms such as “profit”, “interest rate” or “returns” are commonplace. For this reason, conveying forecast quality in such terms is a very appealing communication tool for bridging the gap between the scientific world and private companies.

The weather roulette methodology (Hagedorn & Smith, 2009) is a diagnostic tool created to inform in a more intuitive and relevant way about the skill and usefulness of a forecast in the decision making process, by providing an economic and financially oriented assessment of the benefits of using a particular forecast system. It is called weather roulette because it is defined as a bet between two opponents. Each of the two opponents bets that their prediction system is better. The roulette’s slots are each of the possible categories the prediction system predicts, and each probability is the probability of the ball falling into each of the slots.

After the imaginary roulette has been defined, each of the players bets an equal symbolic amount of money, and the roulette is spun. The resulting slot is the slot where the real observations fell. At that moment, the player whose prediction system provided the highest probability for that slot wins, and receives payment.

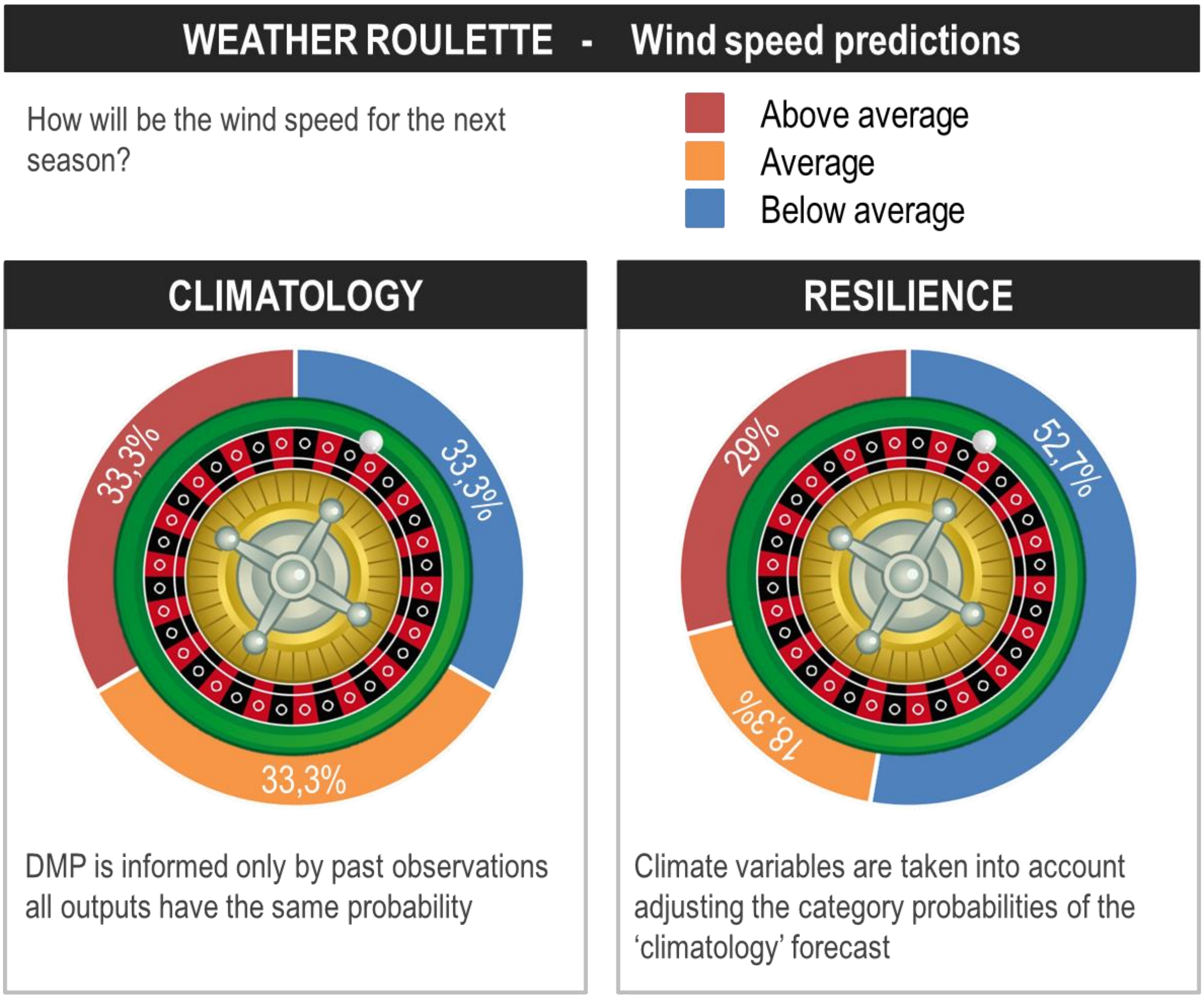


Figure 1: Visual representation of the Weather roulette concept. The outcome has a very clear element of chance, but it shows how adapting the probabilistic framework will influence the number of times a category is well predicted (adapted from a slide courtesy of Tim Hewson).

The weather roulette is then spun for a certain amount of runs, and then the results are expressed with two simple measures: an interest rate, and the accumulated imaginary gains over a period. The interest rate is the equivalent interest rate that would be necessary to build up the final capital after several runs. The accumulated gains are the sum of all the losses or gains during the previous runs. By employing such attractive and simple measures, comparing two forecast systems becomes immediate, by just checking which of the two produced more gains after a certain amount of time. The gains can also be plotted against time to show how their performance increases or decreases as we place more bets).

The weather roulette can also be used to illustrate the goodness of different aspects of a prediction system, for example, for comparing the results from two different locations, or lead times.

Applying the methodology

Using the weather roulette we will compare the gains produced by a forecast system based on climatology alone, and another one based on our own RESILIENCE prototype, and thus show how, over time, the interest rate and accumulated gains over time obtained by seasonal predictions outsizes those produced by climatology alone. The methodology was specifically created to compare forecast systems; therefore few changes to the original

methods have been done. The original paper describing the method uses weather forecasts as example but there are large similarities in both types of forecasts.

Data for climatology predictions:

Climatology predictions will be computed from the ERA-Interim wind speed values in th period 1981-2014/15.These predictions are given by three categories in which the probabilities of wind speed being below-normal, normal, and above-normal are fix and equal to one third for each event.

Data for RESILIENCE predictions:

The RESILIENCE's predictions are based on the calibrated forecasts from the ECMWF's System 4 seasonal prediction system. The predictions have 51 ensemble-members and they are calibrated with a variance inflation technique (Doblas-Reyes et al. 2005) to minimise the forecast errors that are linked to the inability of the prediction systems to perfectly reproduce all the relevant processes responsible of climate variability (Doblas-Reyes et al. ,2013).

The predictions are given in terms of probability. The probabilities are computed as the percentage of ensemble members under the lower tercile (below normal wind speed), the percentage of members between the upper and lower terciles (normal wind speed) and the percentage of memebers above the upper tercile (above normal wind speed). The lower and upper terciles has been computed based on the wind speed values from ERA-Interim in the past.

Prediction systems comparison:

The probabilities for the three categories will be compared between the two different prediction systems (climatology and RESILIENCE's predictions).The roulette will be "spun" for several occurrences, which will be the available data from 1981 up to 2014/15. The calculation of the interest rate and the accumulated gains will follow the formulae described in Hagedorn & Smith (2009)

These occurrences will be further repeated by replicating the results for several world locations of interest for wind energy stakeholders as central US, the North Sea, a region in China and a region in the Northeastern of Brazil.

In addition, the weather roulette is going to be applied for the four seasons of the year (DJF, MAM, JJA and SON) in order to identify the possible differences in the performance of the predictions for each particular season.

This methodology is going to be replicated for quintile events (much below normal, below normal, nomal, above normal and much above normal wind speeds) instead of terciles events. This assessment is important in order to explore the performance of the two different prediction systems when more detailed categories are required to include the wind speed information in the decision-making process of the wind energy industry.

Stakeholders feedback

Although the evaluation method is not defined yet it is crucial to have the feedback of the users after seeing the comparative between climatology and the climate forecast in order to assess if the analysis changes the perception of the relevance of climate predictions against climatology. This evaluation will also take into account the user's feedback to the results presented in D42.2 that assessed punctual performance of RESILIENCE in key events in the past. The objective is to understand how different forms of reporting a prototype performance and value modify the user's perception towards a new forecast system and their willingness to incorporate them to their decision-making process.

3.3.3. **Implementation, results and next steps**

We are currently defining in collaboration with one stakeholder the exact locations in each region to perform the analysis. Once this is set we will generate results and figures and prepare the poster that will be presented in EGU2016 in the Session CL5.11 climate Services – Underpinning Science. Then we will interact with one stakeholder to comment the results and user-relevant aspects. With their feedback we will write a report documenting the results and highlighting how the methodology informs on the added value of seasonal predictions compared to the use of climatology. In the final step we will evaluate the potential changes in the stakeholders' perception of the added value of RESILIENCE climate predictions.

3.4. DECISION MAPS (Univ of Leeds)

3.4.1. Land management tool prototype

Prototype description

The Land Management Tool (LMT) is a semi-operational prototype that aims to provide relevant and usable climate information to land managers in the Devon region in the UK. The prototype is being coordinated by the Met Office together with partners at the University of Leeds, The Netherland Met Service, the University of Lisbon and the Clinton Devon Estate.

Currently this prototype provides 14-day forecasts for both temperature and rainfall (updated every 6 hours) covering different weather stations in the region as well as 3 month outlooks for both temperature and precipitation (updated monthly) for the whole region. Both forecasts are provided to all the land managers (20 in total) involved in the prototype which can access the information via an online micro-site developed for that purpose (Figure 2).

Figure 2 – The Land Management Tool micro-site.

The development of this prototype started in the winter of 2014 and, although initially, only land managers working in the Clinton Devon Estate were involved. Other land managers from that region (linked to the National Farmers Union) were then also involved in order to increase the sample of the stakeholders involved.

A range of activities have been pursued since the start of the prototype, including:

- Initial interviews with a small pool of farmers (n=5) – to help us understand the type of land management activities and practices in place as well as current use of weather information and potential use of seasonal climate forecasts for their decision-making;
- Preparation of the first version of the seasonal climate forecasts for the winter of 2014/2015 (Figure 3);
- Feedback from land managers on the seasonal forecasts;
- Involvement of other land managers through the National Farmers Union (NFU);
- Survey on similar aspects from those explored in the initial interviews to larger farming community (both within Clinton Devon Estates and also other farmers from the NFU);
- Refine the seasonal climate forecasts (based on land managers' feedback) as well as preparation of 14-day forecasts as requested by the land managers (Figure 4);
- Preparation of online feedback regarding both types of forecasts. Feedback questions are embedded in the webpages for each of the forecasts making feedback easier and quicker for the land managers;

- Survey on ways of visualising both types of forecasts in order to improve their presentation;
- Workshop with the land managers to improve both forecasts in terms of content, presentation as well as set out the foundations for exploring the value of seasonal climate forecasts in their decision-making processes.

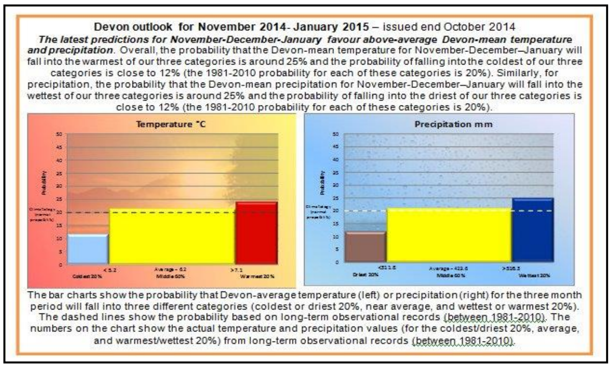


Figure 3 – Seasonal climate forecasts provided to the land managers in the winter months of 2014/2015

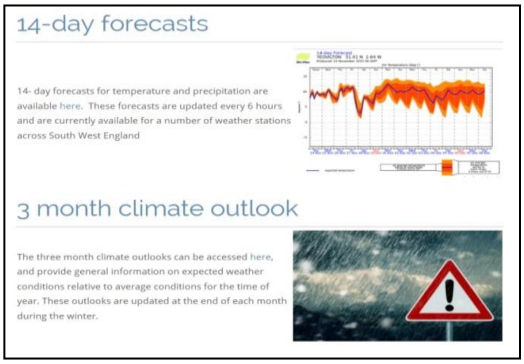


Figure 4 – Seasonal climate forecasts and 14-day forecasts provided to the land managers in the winter and spring months of 2015/2016.

Following from the workshop which took place in January 2016, the team is now working on improving both forecasts based on the outcomes and feedback received during the workshop. It is expected for both the forecasts to continue being provided until May 2016 (i.e. the last seasonal forecast will be provided in March covering the 3-month period covering Mar-Apr-May and the 14-day forecasts will be provided until the end of May).

Decision-making context

The decision-making contexts within which the value of SCF will be assessed are those of the land managers involved in the prototype. Their farming activities are varied (e.g. livestock, arable crops, dairy, mixed farming) and involve complex processes of decision-making. As a result, and as a way of narrowing down and selecting key decisions that will need to be made by these land managers, we selected key decisions through an interactive session with the land managers at the workshop held in January 2016.

During this interactive session, each of the six land managers present were asked to (based on Bert et al., 2006 and Jones et al., 1998):

- List the main decisions they will have to make in the next 3 months (Feb/Mar/Apr);
- Describe when these decisions are normally made (i.e. month(s), weeks, days);
- Choose the two most important decisions and briefly explain why they are important to them/their farm(s); and describe:
    - What are the weather events that influence this decision? Why and how do they affect the decision?
    - What other factors also affect this decision? Why and how do they affect the decision?

The information collected during the workshop will be used to develop decision maps of those critical decisions which will then be used to further examine the potential value of the SCF being provided in the next few months against the decisions that need to be made.

Concept of value

In this context, the notion of value is related with the potential to use this type of forecasts to help support the processes of decision-making and associated benefits (e.g. potential increase in yield, income). Given the complexity and risk involved in the decisions being made by the land managers as well as the low reliability of SCF in the Devon region, we will explore the potential value by examining the entry points within specific decision processes where SCF could be of use (or not) and the reasons why.

3.4.2. **Methodology**

Name of the methodology/study: Decision maps

Background

The methodology is participative in nature and the analysis of the value of SCF to support decisions is based on qualitative methods i.e. workshop and in-depth interviews.

SCF are relatively new in Europe and little is known about its use (Bruno Soares and Dessai, 2015). In addition, the lack of reliability of this type of forecasts across different regions in Europe can hinder its use (cf. Lemos et al., 2012). As a result, in order to understand the value and benefits of using SCF to help support farming decisions it is important to identify key management decisions where different management options can be made in order to take advantage of existing forecasts (Sonka et al., 1987). Those key decisions need to be identified through close interaction with the land managers given their in depth knowledge of the practices and management decisions in place (Stone and Meinke, 2006). In addition, the first step to determine the relevance of SCF "(…) is to identify the existence of entry points for climate information into the decision-making process." (Bert et al., 2006).

Applying the methodology

Our methodology is based on a participative approach to understand the key farming decisions that need to be made in the coming months, the different management options available to the land managers, the different entry points in the decision process in which SCF could be of use and the conditions that need to be in place to allow the land managers to use it in their decision-making processes (cf. Bert et al., 2006; Jones et al., 1998). The first stage of the analysis i.e. the identification of the critical decisions in the coming months was achieved through the development of decision maps (cf. Bert et al., 2006) during the workshop (see above).

The next stage will involve conducting in-depth interviews with those land managers present at the workshop. Our aim is to identify the extent to which the SCF that are being provided to the land managers have influenced (or not) the decisions that they need to make in the coming months. To achieve that, we will use the decision maps developed during the workshop as well as the SCF provided to the land managers as a starting point for exploring key issues when considering or using SCF to inform those specific decisions. This will include understanding to what extent the SCF has influenced their process of decision-making, analysing the factors enabling or constraining the use of SCF in that specific decision-making as well as further exploring the potential value of SCF with the land managers and what needs to be in place to allow that to happen.

Table 3 below provides a simple example of a critical decision identified by one of the land managers during the workshop. Using these critical decisions identified by the land managers we will explore the process of decision-making that will take place in March particularly focusing on the role that SCF have played in it (or not). Through this analytical process we aim to understand the (potential) qualitative benefits (e.g. planning actions, reduced wasted operational efforts; cf. Table 3) that the SCF provided to the land managers over the past few months may have had in the decisions identified at the workshop.

Critical decision	Planting wheat in spring
When to make decision	March
Weather/climate conditions influencing decision (6 months ahead; vary week by week)	Rainfall (i.e. not too wet)
Other factors influencing decision (6 months ahead)	Purchase seeds Greening agenda Market forecast (need to change from wheat to barley?)

Table 3 – Example of a critical decision identified by one of the land managers during the workshop

Stakeholders engagement

The next step of stakeholders' engagement will be pursued via in-depth interviews with the land managers present at the workshop.

3.4.1. **Implementation, results and next steps**

The next steps for this analysis involve preparing the interview protocol to be applied during the in-depth interviews with the land managers and, later on, conducting the interviews. The interviews with the land managers will take place next March/April and the results are expected to be analysed in April/June.

3.5. THE PLACEBO CONCEPT (Météo-France)

3.5.1. RIFF prototype

Prototype description

The RIFF prototype of MF aims to provide useful information to inform dam management, based on seasonal hydrological forecasts : see http://riff.euporias.eu/en.

Downscaled near surface temperature and precipitation coming from the Météo France operational system for seasonal forecasting are used as input to an hydrological suit, named SIM (a refined SVAT model at an 8-km resolution coupled with a river flow routing module) to produce probability forecast of river flows with different lead-times and for specific stations along the rivers. The first investigations conducted in Météo France (Ceron et al. 2010, Singla et al. 2012, PhD Thesis Singla 2012) have demonstrated the predictability of the hydrological system in France. It has also demonstrated the added value of using a seasonal meteorological forecast instead of a random atmospheric forcing.

River flow forecasts provided by RIFF Prototype have been tailored to fit critical thresholds, for crucial seasons for which decision making processes are established. The stations and critical thresholds have been defined in liaison with stakeholder warning system and decision making processes (warning or crisis thresholds or near wet or dry quintile or decile ...). The crucial decisional periods are typically May/beginning of June for the low flow period and the end of Winter/beginning of Spring for the reservoir refilling periods. It should be noted that the same periods are also relevant to the energy suppliers.

The decision to first focus on summer season has been made in agreement with our stakeholder EPTB Seine-Grands Lacs (EPTB SGL). In close collaboration with EPTB SGL, MF has designed a set of products. The usefulness of these products is assessed by the stakeholder over past situations, using a specific metric.

Decision making context

Water management decisions are very sensitive to climate information and have to take into account societal, institutional and economic issues associated to each decision:

- Societal issues: decision makers are requested to anticipate floods and drought conditions which could impact the ability to supply of fresh water to a region as large as Paris urban area
- Institutional issues: decision makers must fulfil their institutional duties and meet their assigned objectives.
- Economic issues: they have to take into account the potential consequences of a wrong anticipation of drought (or flooding risk) that could lead to damage or agricultural losses.

To deal with these hazards (droughts and floods), hydrological simulations based on general climate information are already used in decision making processes (Figure 5). Tailored seasonal forecasts integrating the current state of the river flows and others hydrological components as soil water content or mountain snow water equivalent constitute new information to assess all possible scenarios over the following season and plan the best reservoir draining plan.

The main objective of EPTB is to prevent river flow from falling under a pre-defined threshold, called “vigilance threshold”. To meet this goal, it has to plan the slow emptying of its four lake-reservoirs, in order to sustain river-flow.

Among the 4 reservoirs, we have chosen to focus on the Marne reservoir (http://seinegrandslacs.fr/eptb-seine-grands-lacs/les-4-ouvrages/lac-reservoir-marne). This is

the largest reservoir of the basin, with 349 million m^3. It has been put into service in 1974, so we dispose of a long operation period. The downstream monitoring station is Gournay, a few kilometers from the confluence with the Seine (and from Paris). Each year, at the beginning of May, EPTB has to build an emptying plan of its reservoirs for the dry season. The corresponding curve, validated in Consultative Committee with all water resources users of Seine Basin, is actually considered as the decision.

In practice, to draw this curve, ETPB relies on the one hand on the last observed information concerning the reservoir filling status and the river flow (upstream and downstream); and on the other hand on tools simulating dry season scenarios based on historical hydrological and meteorological information. Note that this plan is rectified (if needed) in June, and could be readjusted every 15 days up to October and especially at the beginning of September to anticipate the end of the low flow period.

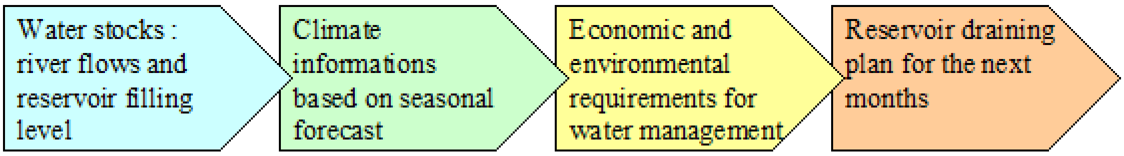


Figure 5: Decision Making Process including Seasonal Forecast for dam management in Seine Basin

Concept of value

It is difficult to measure the direct economic value of EPTB SGL decisions. A bad decision could lead to perturbations like restrictions on the water use for population for example. So we have together decided to define a metric relative to the number of days when river flow is so low that it could lead to problems for sharing water resources with all users. The threshold we have used is called “vigilance threshold”, and the main objective of EPTB SGL is to avoid being too close to it.

3.5.2. **Methodology**

Name of the methodology/study: Placebo

Background

The placebo concept, well known in medicine to test new medical treatment, and adapted it to climate field. Its principle is to put the stakeholder in a context close to real one, and to ask him to apply its DMP with two inputs: one is a seasonal forecast, the other is a false one (the placebo). This experiment has been lead in collaboration with our stakeholders EPTB Seine-Grands Lacs over a sample of past situations, in order to calculate a performance score (Viel et al, 2015).

Applying the methodology

To ensure a maximum objectivity, MF has compared decisions made with RIFF to decisions made with “classical” products operationally used by EPTB, in the same context (i.e. with the same external factors, potentially influencing the decision). That is why we first have asked EPTB to retake some past decisions without any forecast information, instead of simply compared to real past decisions. For example, we know that the occurrence of a very critical dry event in previous years could strongly influence the decision, and in a way could bias the resulting emptying curve. This experiment is called WF (“without forecast”).

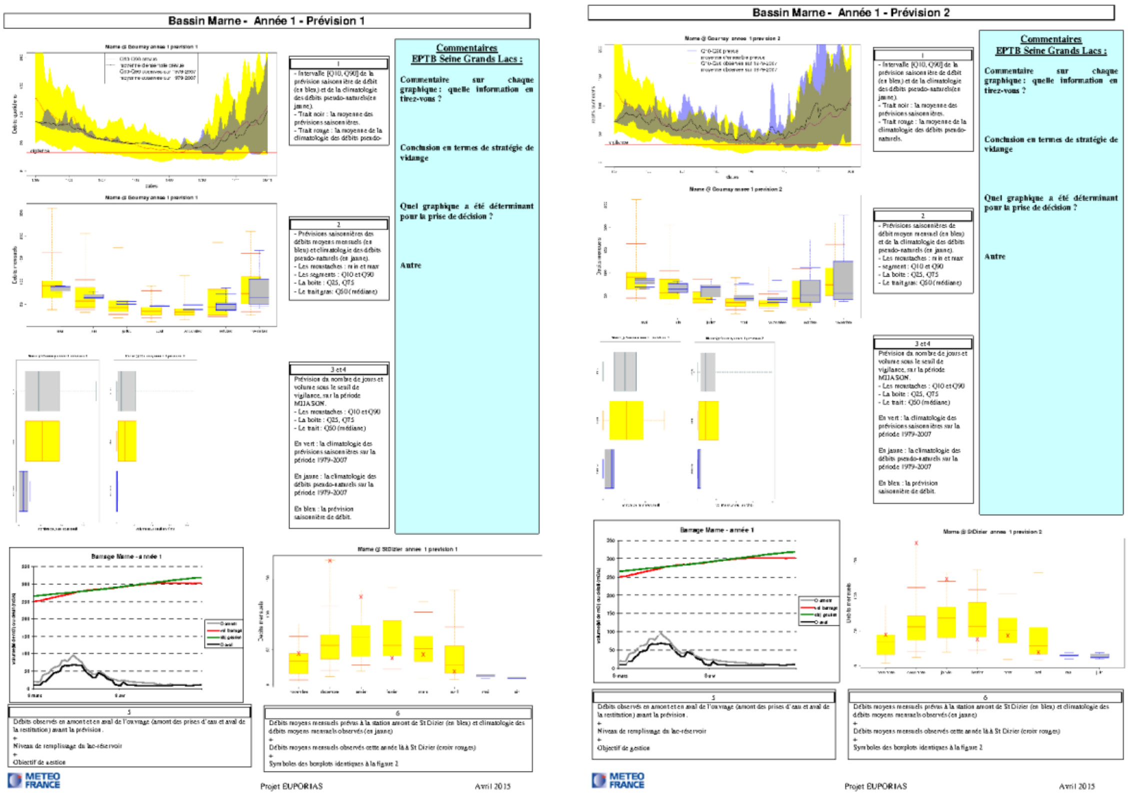


Figure 6: Example of seasonal forecast and placebo (right and left, or vice versa…) for the same year.

Secondly, MF built seasonal and placebo forecasts (figure 6). The seasonal forecasts (SF) are based on SIM forced by ARPEGE-System 3, in order to constitute a long hydrological hind-cast (1979-2006). The placebo forecasts (RAF for “Random Forecasts”) are obtained from random draw (with release) in a 1979-2006 meteorological observed dataset, which are used to force SIM, to deliver some “forecast-like” river flows.

Note that all those experiments are made “blind”. It means that EPTB don’t know which year it processes, it only knows the context (recent past and initial conditions) and of course the forecasts for SF and RAF experiments.

3.5.3. **Implementation, results and next steps**

The Placebo protocol has been tested with May and June initial conditions. It means that EPTB SGL has replayed past decisions with SF and Placebo. Beforehand the replay, MF has calculated and provided to EPTB SGL all the statistical scores about the performance of tailored product used to know confidence and uncertainties according to the forecast ranges. The results from May and June initializations will be discussed on D41.3.

This experiment need to be extended to other basins and other periods. This is why we are now in contact with another stakeholder, SMEAG (Garonne basin). We also have to test it in real context, not only on past situations with hind-cast data. A specific ongoing work aims to develop a real-time version of RIFF, with the ambition to test it next summer with EPTB SGL and SMEAG

3.6. . S-CLIMWARE (Cet Aqua)

3.6.1. **S-CLIMWARE case study**

Case study description

The objective of the case study S-CLIMWARE is to incorporate seasonal forecast in dam management and water system management in Spain. The value will be evaluated through different key indicators calculated by simulating in hindcast mode (e.g. reduction of the probability of water deficit for the different demands; higher probability of having a convenient reservoir state). This report presents the results for the tests performed for the Dam of “La Cuerda del Pozo” situated in the Duero River Basin. The tests are currently being extended to other basins and for other DMP; this is commented at the end of this report.

Decision making context

In Spain, the aim of the operational managers of a dam is to ensure sufficient water is guaranteed to all downstream sectors e.g. agriculture, urban, industrial) from the beginning to the end of the hydrological year (October to September). This management is currently based on the state of the reservoir for the month considered and, to some extent, scenarios of future inflows to the system in the next months. These scenarios are commonly based on historical information only (e.g. historical inflows) and physically based climate forecast are not considered. The different indicators that characterize the available resources in the systems (e.g. reservoir levels, groundwater levels, current river flows and past precipitations) are calculated monthly and summarized in key indicators for each system. Based upon the value of these indicators the management of the resources will follow different institutional procedures detailed below.

Under normal conditions, the Reservoir Releases Commission (Comisión de Desembalse) will meet in ordinary session and will define some actions relative to reserve management, revision of ecological flows and ground water abstraction and definition of precautionary water allocation schemes. All these measures affect farmers, hydropower units, environment, urban users and others (Garrote 2007). The Commission meets in October to decide upon the proper filling level of the reservoirs during the wet season and at the beginning of spring to decide upon the allocation of reservoir releases during the dry season. The commission’s recommendations must take into account the water supplies expected to be available and the licenses held by water users (Bhat 2004).

Under potential drought situation (based on the value of the key indicator) and the pre-defined thresholds from the Drought Management Plan (DMP) different mitigation measures are proposed for each system. The measures are then implemented and adapted if necessary. The types of mitigation measures are presented in Table 4 and include different restriction measure, affecting the different uses.

TYPES OF MITIGATION MEASURES							
Indicator	1-0.5	0.5-0.4	0.4-0.3	0.3-0.2	0.2-0.15	0.15-0.1	0.1-0
Status	Normal	Pre-alert		Alert		Emergency	
Objective	Planning	Information-control		Conservation		Restrictions	
Type of measure	Strategic			Tactics		Emergency	

Table 4: Types of mitigation measure (Estrella 2008)

From the water user perspective, it is also important to know the evolution of the system state and the possibility of restriction in the future. This information could be useful to change pro-actively some decisions such as the type of crops to be seeded, or to get information such as the potential incomes from hydropower production.

The decisions of interest are the ones of the Reservoir Releases Commission. The table below provide some examples of the decisions taken in October and March for some variables. In general, the management plan specified some basic values for these variables that could later be updated by the commission according to the context (but this is not always possible).

	OCTOBER	MARCH
Minimum safeguards in December, January, February, March and April	since 2012: 53 hm3 for December, 11-22* for april (*if snow)	
Minimum discharge from October to April	2012: Reduce for drought since 2014: Use of the standard discharge specified in the Management Plan	
Maximum discharge from October to April (in normal state)	since 2014 : 60m3/s	
Minimum volume in dam by the end of September		2011: 70hm3 2012: 30hm3 (reduce since drought)
Irrigation period beyond September		2013: allowed in October due to the delay in seeding corn

Table 5 : Example of decisions from the Reservoir Releases Commission of La Cuerda del Pozo dam

Concept of value

The current DMP are based on past events (basic rules defined from a risk-adverse perspective) and climatology (operational rules or adjustment of the basic rules according to the context). By using S-CLIMWARE's probabilistic predictions the Reservoir Releases Commission can benefit from a better knowledge of the potential state of the system and the associated risks, and can therefore adapt better some operational rules. The end-users (domestic uses, agriculture, tourism…) would directly benefit from and improved management of the resources. Also, if they know the potential risk on the systems, the end-users could participate in the realization of pro-active measures (e.g. change the type of crops to be seeded in November according to the prediction on the winter period).

3.6.2. **Methodology**

Name of the methodology/study: S-CLIMWARE

Background

Seasonal forecast bring new information to water operators but its integration into decision making process is also challenging on different aspects:

- The evaluation of future risks, currently based on historical records, has to be updated according to probabilistic, uncertain and limited forecast
- Decision making processes, well-structured and established between stakeholders, has to be modified to incorporate new inputs

To answer these challenges and elaborate a complete methodology to insert – beneficially - seasonal forecast into decision making process, interactions with stakeholders are essential.

Brown et al. (2010) developed a general climate risk management approach that could be adapted to the purpose of discussing and determining with stakeholders the best way to integrate seasonal forecast into decision making. The climate risk management approach consist of three steps:

1. assess hydroclimatic risk
2. make probabilistic water supply projections incorporating climate information
3. determine a portfolio of options to manage hydroclimatic risks.

Based on the work of Brown et al. (2010) a step by step methodology has been proposed and is currently applied with the stakeholders through regular meeting and workshops; a first workshop was organized in 2014 and a second has been organized in October 2015. The methodology consists of different exercises of increasing complexity allowing defining the best way(s) to integrate seasonal forecast into decision making process (Figure 7).

The methodology consists of four different steps:

1. **Skill score of the forecast**: this consists in explaining to the stakeholder the seasonal forecasts produced and compared them with historical data. In this case study, this part is managed by the AEMET.
2. **Potential benefits of using Seasonal Forecast**: this consists in analyzing together the forecast with the situation of the water system at the beginning of the forecasted period. This allows having a first idea on the potential uses of the forecast (percentage of year where forecast could have been useful, etc.). This part is detailed below.
3. **Simulations: comparison of risks using forecast and climatology**. This part is detailed below.

4. **Simulations: update of DMP**. This part consists in determining the precise decisions that could be upgraded and simulate the potential benefits that they could bring (in hindcast mode). This part is currently ongoing.

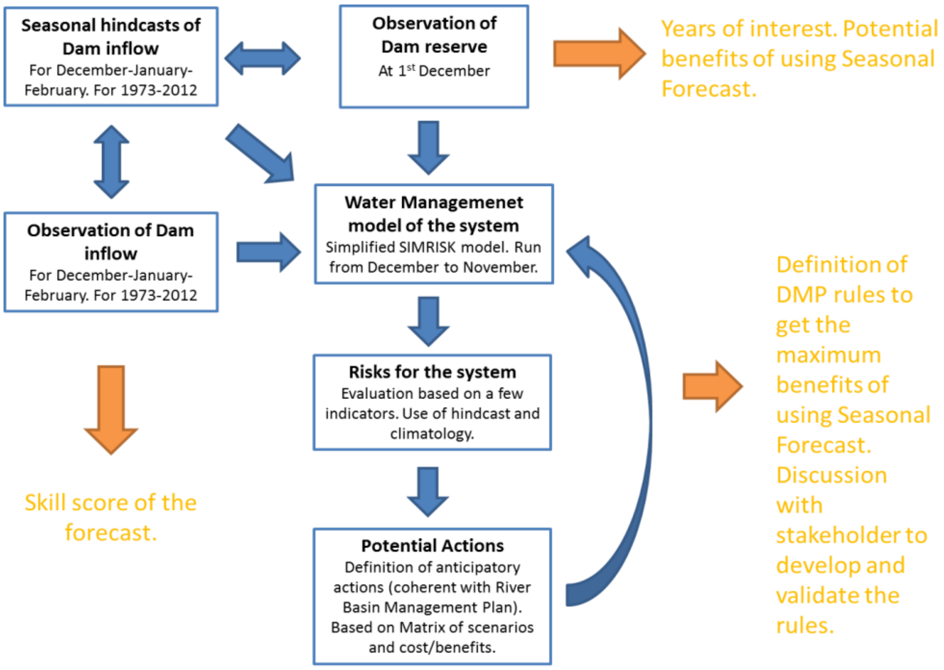


Figure 7: General framework for the analysis of Decision Making Process Value for dam management in Spain.

Potential benefits of using Seasonal Forecast

The following information has been gathered to initiate the discussion with our stakeholders:

1. Hydroclimatic risk: extensive studies have already been done in every river basin (River Basin Management Plans) which are turned into management rules connected to different indicators describing the current state of the system. As a first approximation we could use these indicators to provide information on the potential risk. A simple indicator commonly used is the state of the reserve in dams. According to the reserve available in the dam, the situation is categorized (e.g. Normal or Emergency) and different pre-defined and recommended actions have to be applied if necessary. This information is shown in Figure 8 below.
2. Probabilistic projection: as a first approximation we could make the hypothesis of perfect forecast using the historical tercile category (NN = Near Normal, BN = Below Normal or dry, AN = Above Normal or wet). This information is shown in Figure 8 below.
3. Possible changes in decision making: a first round of discussion could be done with the stakeholders: “If you have the information on future inflow for the period DJF, what decision seems more reasonable to be taken on the 1st of December?”

Year	Inflow	Dam reserve
	Observed DJF Category	Observed 1st Dicember
1973	NN	32
1974	BN	43
1975	BN	49
1976*	AN	71
1977	AN	151
1978	AN	131
1979	NN	119
1980*	BN	105
1981	AN	105
1982	NN	70
1983	NN	43
1984	AN	155
1985	NN	107
1986	BN	82
1987	AN	64
1988	BN	127
1989	NN	70
1990	BN	49

LEGEND

Inflow - Observation

Tercile limits calculated using 1950-2011

Dry trimester

Normal trimester

Wet trimester

Dam Reserve - Observation

Thresholds from the Drought Plan of 2007, based on the % of filling of the dam compared to average values (period 1973-2010)

- Reserve > 50% (Normal Situation)
- 50% ≥ Reserve > 30% (Prealert situation)
- 30%≥ Reserve > 10% (Alert situation)
- 10% ≥ Reserve (Emergency)

Figure 8: Scenario of perfect forecast for La Cuerda del Pozo

The expected actions in each situation could be determined with the stakeholders, and a comparison could be done with the actions taken without considering the forecast.

As an example, the rules of management corresponding to drought situation (Table 6) could be delayed or anticipated thanks to the forecasts (Table 7):

- When in Alert situation, the actions to be implemented could be made more strict (if low flow forecasted) or more relaxed (if high flow forecasted)
- When in Normal situation, the actions to be implemented could be made more strict (if low flow forecasted) or an adjustment could be done to use more water for hydroelectricity or other uses (if high flow forecasted)

	Reserve in the Dam (1st of December)				
Seasonal inflow forecast (DJF)	Extremely Low (Emergency)	Very Low (Alert)	Low (Prealert)	Normal	Wet
Low(dry or BN)	**Drought emergency**	**Drought emergency**	**Drought alert**	**Drought pre-alert**	**Normal**
Normal (NN)	**Drought emergency**	**Drought alert**	**Drought pre-alert**	**Normal**	**Increase industrial use**
High (wet or AN)	**Drought alert**	**Drought pre-alert**	**Normal**	**Increase industrial use**	**Flood control**

Table 6: Change in decision making for La Cuerda del Pozo – DMP

	Reserve in the Dam (1st of December)				
Seasonal inflow forecast (DJF)	Extremely Low (Emergency)	Very Low (Alert)	Low (Prealert)	Normal	Wet
Low(dry or BN)	**Drought emergency**	**Drought emergency**	**Drought pre-alert**	**Normal**	**Flood control**
Normal (NN)	**Drought emergency**	**Drought alert**	**Drought pre-alert**	**Normal**	**Flood control**
High (wet or AN)	**Drought alert**	**Drought pre-alert**	**Drought pre-alert**	**Normal**	**Flood control**

Table 7: Base scenario for La Cuerda del Pozo - DMP

Simulations: comparison of risk using forecast and climatology

This step could be explained through the example discussed with the stakeholders in the workshop in October 2015. Figure 9 describes the results of two sets of simulations done with the software SIMRISK based on a simple representation of the water system (dam, demand and simple rules of management).

Simulations start at 1st of December considering the initial condition at that period (basically the reserve in the dam) and go until the end of the irrigation period (October). The historical inflow time series to the dams are used (for the Cuerda del Pozo dam, around 60 series were available). For the simulations using climatology, the historic inflows to the dam are use as input times series for all the period. For the simulations using the forecasts, the results of the forecasts are used in the period December-February to weight the input times series in this period, while in the period March-October, the historical time series are used with the same weights.

As a result, it is possible to get the potential risks that could be forecasted at 1st of December and comparing the results of the two dataset.

As an example, for the year 1976, the reserve are low at 1st of December (71hm3) but since the seasonal forecast indicates a wet winter (48%probability being in the wet tercile) the resulting risk is low (e.g. only a 13% probability of having less than 70hm3 in reserve at 1st of October). By using the climatology, the risk calculated is much higher (e.g. probability of 39% of having less than 70hm3 at 1st of October). Due to this perception of a high risk is it very likely that the decisions on the dam management have not been optimum: we can see from the historic time series that the dam outflows at the beginning of winter (December and January) have been zero (very likely impacting on the environment) and that a very high release have been necessary in March (very likely to avoid flooding).

FORECAST

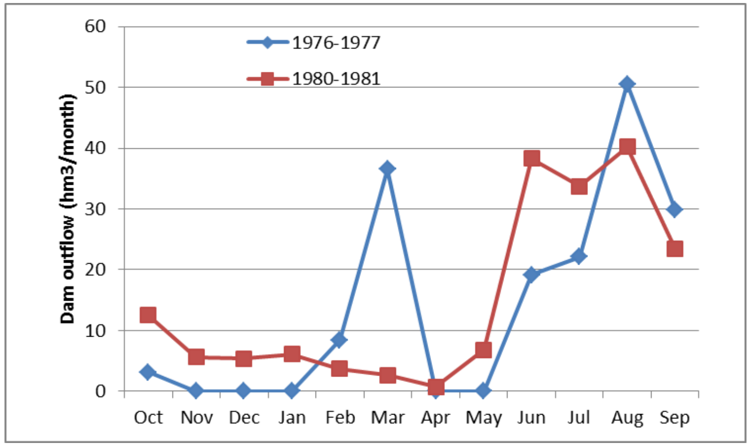
Using each TS probability (complete forecast)

Year	Inflow				Dam reserve				Demand deficit
	Seasonal Forecast (Dic-Jan-Feb)			Observed DJF	Observed	Forecasted 1st Octuber		Forecasted. 1st March	Forecasted 1st Octuber
	% BN (Dry)	% NN	% AN (Wet)	Category	1st Dicember	Proba < 30Hm3	Proba < 70 hm3	>98% Vol max	Fallo>5%
1976	9	43	48	AN	71	**3%**	**13%**	**42%**	3%
1980	41	37	22	BN	105	**7%**	**25%**	**8%**	7%
2007	41	39	20	BN	132	**0%**	**12%**	**18%**	0%
2009	20	37	43	AN	147	**0%**	**0%**	**59%**	0%

Using climatology

Year	Inflow				Dam reserve				Demand deficit
	Climatology			Observed DJF	Observed	Forecasted 1st Octuber		Forecasted. 1st March	Forecasted 1st Octuber
	% BN (Dry)	% NN	% AN (Wet)	Category	1st Dicember	Proba < 30Hm3	Proba < 70 hm3	>98% Vol max	Fallo>5%
1976	33	33	33	AN	71	**13%**	**39%**	**18%**	**13%**
1980	33	33	33	BN	105	**5%**	**18%**	**20%**	**5%**
2007	33	33	33	BN	132	**0%**	**8%**	**33%**	**0%**
2009	33	33	33	AN	147	**0%**	**0%**	**41%**	**0%**

OBSERVATION



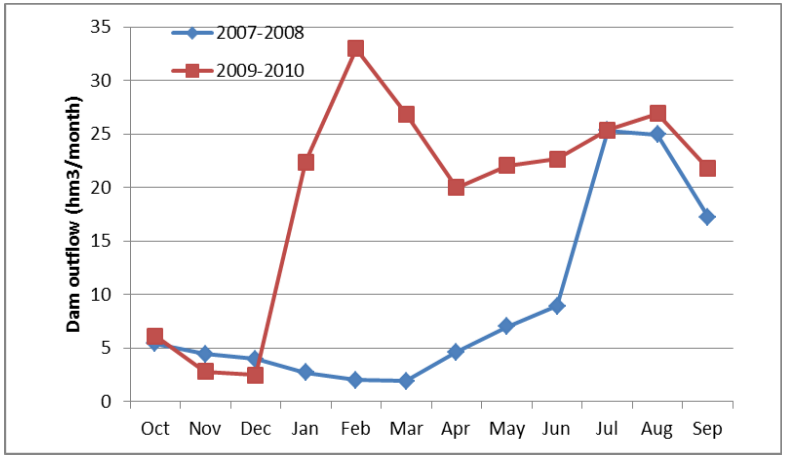


Figure 9: Comparison of predicted risks using climatology and forecast

Applying the methodology

As explained before, this methodology has been developed especially for the purpose of this study, based on previous publications and recommendations on climate risk management in water systems such as Brown et al. (2010). This methodology is currently being applied. The stakeholders are strongly involved in the application of the methodology. Interaction is done with stakeholder through regular meeting and workshops.

3.6.3. **Implementation, results and next steps**

While the forecasts in the period DJF could be useful to update some decisions, there is not so much room for improvement in the decision making process for the dam management for the catchment initially considered. In that catchment, seasonal predictions of dam inflows and reserves could be more useful for agriculture and other uses.

The project team is currently updating the methodology to be able to integrate other seasonal forecast inputs (E-Hypes simulation results) and forecast over a wider period (not only DJF)

The methodology will be tested in other water systems where the DMP of the dam management could be more significantly linked to the seasonal forecasts.

The simulation using climatology and the ones using seasonal predictions will be compared in terms of key performance indicators to determine their values.

3.7. COST BENEFIT ANALYSIS (WFP)

3.7.1. The LEAP Prototype

Prototype description

In Ethiopia, the process of early warning, assessment, appeal and response typically takes around eight months, by which time significant livelihoods losses have already occurred (Hobson and Campbell, 2012). This appeal-based process suffers from two main problems: it is slow, and the assistance is unpredictable and unreliable as it is based on voluntary contribution. Appealing governments therefore have limited knowledge about how much funding will be available, when it will be available, in what form and who will receive it, and are therefore unable to act upon early warnings in a timely manner (Haile, 2005).

However, in the past decade, the Government of Ethiopia has made significant efforts to improve the timeliness of drought response, shifting from a purely relief-based approach to a risk management approach. The Livelihoods, Early Assessment, and Protection System (LEAP) was developed in 2008 by the Ministry of Agriculture's Disaster Risk Management and Food Security Sector (DRMFSS) in partnership with WFP and the World Bank, and is a central component of this policy shift. LEAP is a food security early warning system that enables early response to drought-related food crises, using monitoring information to project anticipated beneficiary numbers. The drought index produced by LEAP serves as one of the triggers for the disbursement of funds. Modelled on weather index-insurance models, this mechanism seeks to increase the predictability and timeliness of response, by ensuring that funds are released automatically once an objective, pre-agreed drought level is reached.

The LEAP Model

Figure 10 shows how LEAP should, in theory, reduce the response time to severe droughts. Note that while the LEAP structure is in place, it has not yet been used to trigger an early response, which is why the proposed analysis presented here is based on idealized scenarios rather than on impact evaluations.

LEAP emerged as an attempt to address the failure of existing food security EWSs to translate warnings into action. It was therefore not designed as a standalone EWS, but as an integrated early warning-early action framework, based on three pillars: early warning, contingency planning and contingent financing. Figure 11 describes the LEAP mechanism.

The early warning component is provided by the LEAP software, which combines crop, weather and climate data to estimate future yields, for all of Ethiopia's main crops. Knowing production levels well before harvest time allows the government to plan and respond early to an impending crop failure. Data from both weather station and satellites are fed into the software every ten days throughout the growing season, enabling continuous monitoring. Yield estimates are considered highly reliable about one month before harvest.

Based on these yield projections, the software estimates the number of people in each woreda (district) in need of assistance. These preliminary estimates then trigger early (field-based) needs assessments. LEAP's clear outputs, which feed directly into the government's established risk management mechanism, seek to avoid the danger of warnings being either misinterpreted or ignored.

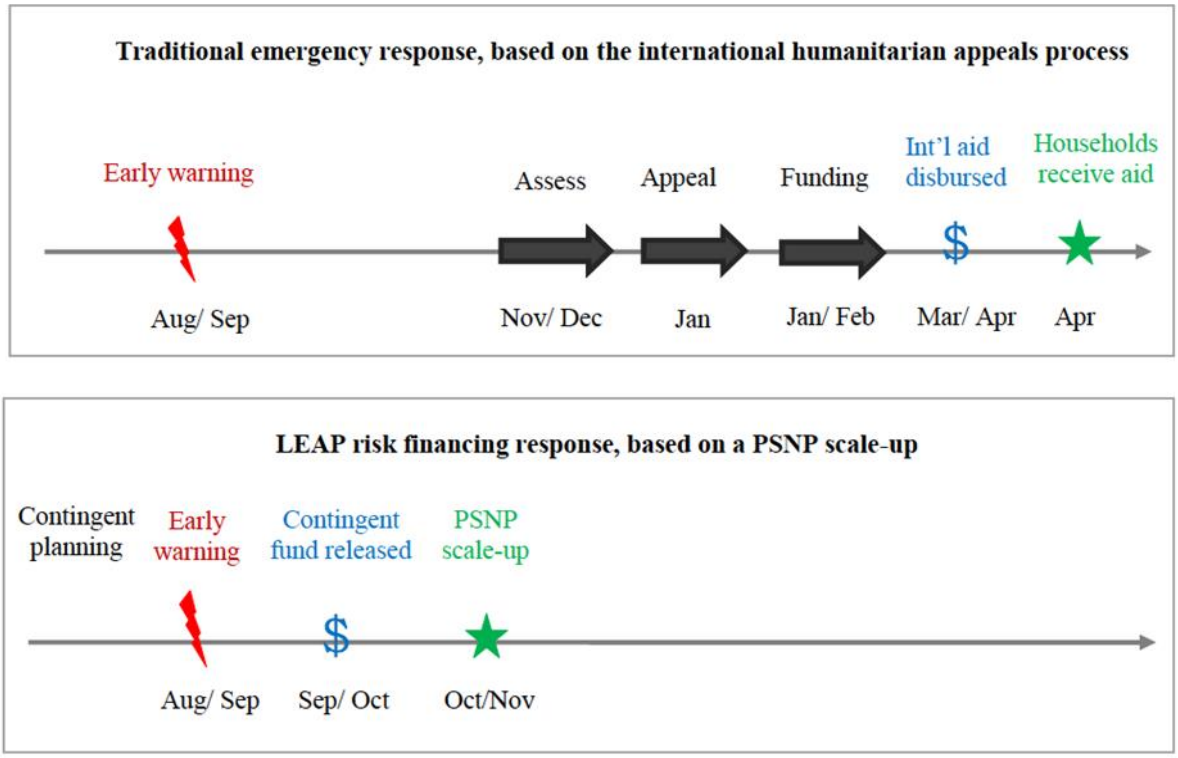


Figure 10: Speed Benefits of a LEAP Triggered Response to a Meher Season Drought Compared to the Current Emergency System

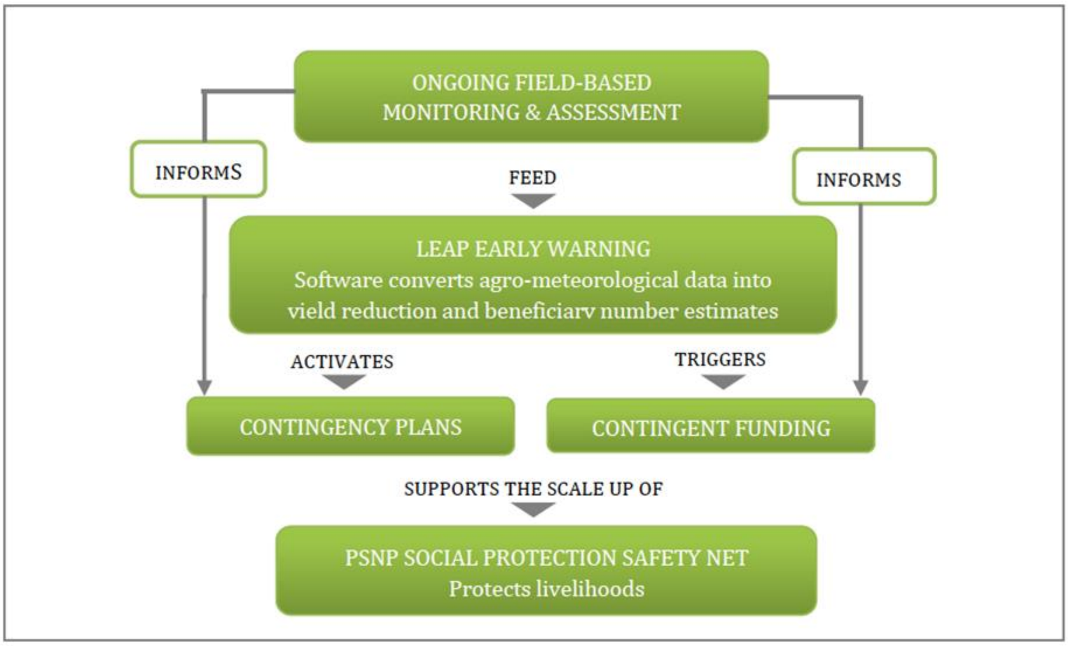


Figure 11: The Key Components of the LEAP Early Warning-Early Action Framework

LEAP is unique among existing EWSs in that it triggers early response through the scale-up of a national social protection safety net, rather than through conventional food or cash hand-outs. The contingent funding component is part of the wider Ethiopia's Productive Safety Net Programme (PSNP) architecture. The PSNP was originally established in 2004 to

support the country’s 8 million chronically food insecure people in normal years. LEAP uses the PSNP’s established food/ cash-for-work programs to assist the additional spikes in transiently food-insecure people who need assistance in case of drought. The contingency budget is designed to respond rapidly to low-level and unexpected transitory food insecurity among both PSNP and non-PSNP households by providing temporary additional employment/resources through the Public Works and Direct Support institutional structures. The contingency amounts to 20 percent of the PSNP's base program cost (15 percent is held at the regional level and five percent at the woreda level). The contingency budget, which should be critical to LEAP’s effectiveness as an early response tool, seeks to bypass the inefficiency of the traditional international humanitarian financing process.

Decision making context : Cost Benefit Analysis 2012

A Cost Benefit Analysis (CBA) of LEAP was undertaken in 2012. The analysis compares three scenarios: a baseline “business as usual” humanitarian emergency response scenario, and two early response scenarios in which LEAP is used to trigger a PSNP scale-up. In this CBA, it was assumed that the LEAP software is able to issue a reliable early warning of production failure two months before harvest (though this is now estimated to be one month before harvest). The scenarios are based on the timing of response relative to this early warning.

Baseline Emergency response: This scenario models a “typical” late emergency response to drought, 8 months after the early warning, or 6 months after harvest failure. This late response leads to a humanitarian disaster, characterized by high relief costs and significant long-term livelihood losses. At this point, it is assumed that most households have started engaging in harmful coping strategies, in particular selling productive assets and reducing consumption.

Ideal LEAP response: This models an idealized scenario in which LEAP successfully triggers the timely release of contingent financing for a PSNP scale-up, 2 months after the first early warnings, or at harvest time. Aid costs are calculated using the per capita cost of assistance under the normal PSNP. Almost all long-term livelihood losses are avoided, as intervention is assumed to be sufficiently early for households not to have started engaging in harmful coping strategies yet.

Delayed LEAP response: This models a more realistic early response scenario, in which response occurs 5 months after the early warning, or 3 months after harvest failure. LEAP triggers a response earlier than in the emergency scenario, but not as early as in the Ideal scenario, due to delays between early warnings and disbursement of contingent funds, or between fund disbursement and delivery of assistance at the household level. The cost of aid is also calculated using the PSNP transfer costs, and is therefore assumed to be the same as in the Ideal scenario. However, livelihood losses are higher, as more households are assumed to have started engaging in negative coping strategies.

The analysis focused on agrarian regions, rather than pastoral ones, since LEAP currently only predicts crop yield reductions, not pasture productivity, and therefore cannot trigger early livestock interventions.

The only additional cost of a LEAP-triggered early response, relative to a baseline emergency response, was assumed to be the cost of the LEAP system itself. The analysis was done both for a single drought, assumed to happen today, and over a 20-year time frame, assuming a severe drought every 5 years.

Rationale for an updated Cost Benefit Analysis

This document outlines the proposed methodology for building on and updating the previous CBA. Key additions and/or changes to the analysis will include:

• Unlike the initial LEAP CBA, which looked into the next 20 years, this will be a retroactive CBA, using hindcasts of seasonal forecasts, i.e. looking at historic events, and modelling the predicted impact if we had had the LEAP prototype all this time. This will allow for greater analysis of the degree to which more accurate forecasting allows for earlier and more effective/accurate response.

• In addition, the analysis will seek to build out the additional benefits of seasonal forecasting through greater investment in early action/resilience building measures that can mitigate the impact of a drought to the extent that data is available and through consultation with the DRMFSSS.

3.7.2. Methodology

Name of the methodology/study: Cost Benefit Analysis

Background

In order to perform the analysis, we need to be able to compare the scenario without seasonal forecasts, to a scenario with seasonal forecasts using LEAP. In the case of this analysis, three scenarios will be considered:

- Counterfactual – post disaster humanitarian response.
- LEAP Current - LEAP as it currently exists, with predictions of number of people in need of assistance at the end of the crop season (August/September). It is assumed that response is still largely composed of humanitarian aid through early cash and food transfers via the PSNP.
- LEAP Plus - LEAP with seasonal forecast, 6 months in advance of 'LEAP Current' and approximately four months before the first failed rains (February/March). Under this scenario, although the accuracy of the forecasted needs is affected by the range of uncertainties that are implicit in climate forecasts, it is assumed that early forecasting allows for greater use of early action and resilience building measures, thereby improving the benefit of operations conducted at a given fixed cost.

The LEAP platform can provide hindcasts over the past 20-30 years. However, it is difficult to compare beneficiary numbers before and after 2005, when the PSNP was started. It is therefore suggested that the analysis looks at a 15-year time period from 1990-2005.

A model will be built for the 15 years of analysis for each of the three scenarios described above. The costs of LEAP will be combined with the costs of PSNP, as the two programmes are designed to work together, and therefore the full measure of benefits is attributable to the combination of the two programmes. These costs will be offset against the benefits/avoided losses of using end of season crop estimates (LEAP Current) and seasonal forecasts (LEAP Plus), as per the parameters described in the following sections. Hindcast data will be used to construct at least three drought magnitude categories (normal year, low magnitude drought and high magnitude drought) to help construct the analysis. Net benefits will be discounted at 10%.

Counterfactual: Post disaster humanitarian response without seasonal forecasts

This scenario assumes that traditional humanitarian response takes place without any forecasting, arriving post disaster when humanitarian needs are high.

Number of beneficiaries: Historical data will be used to construct the number of beneficiaries that required assistance for the period 1990-2005.

Cost of response: The cost of response will be estimated based on WFP figures on the cost of post disaster humanitarian aid for food and non-food items.

Livelihood losses: The model baseline scenario will consider the cost of relief only. However, livelihood losses can represent a very significant component of the impact of drought, and therefore the model will also consider a scenario with best estimates on livelihood losses, if available.

The same approach as the original CBA LEAP can be used, in the absence of more robust estimates, though it should be noted that those data may not be the most accurate representation of losses. A benefits transfer method was used to estimate the monetary livelihood loss from other studies, including the ARC CBA. To the extent that further evidence is available, these figures will be updated. However, it is likely that best estimates will be fairly tenuous and therefore the model will be run initially with relief costs only. Data for integrating relief and livelihood losses into the model will be reviewed at project inception.

As the analysis can only be undertaken for agricultural areas, livestock losses will not be considered.

LEAP Current

This scenario will consider the costs and benefits of the current LEAP system, with predictions of number of people in need of assistance at the end of the crop season. It is noted that predictions at this stage are based on observed and highly reliable data, unlike the seasonal forecasts considered in the following scenario that can be much more uncertain. At this stage, both for the LEAP Current and the LEAP Plus models forecasts from the May season only will be used.

It is assumed that the LEAP prediction is used to scale up a safety net response under the PSNP to those people requiring assistance.

Number of beneficiaries: Historical data will be used to construct the number of beneficiaries predicted to require response using LEAP for the period 1990-2005. The number of beneficiaries is predicted to remain the same across all three scenarios, because the full suite of people who would ultimately require aid will still need a response. The advantage of earlier response rather is that different interventions can be used, and the total magnitude of the food deficit is likely to be less as people have not entered a cycle of asset depletion.

Cost of humanitarian response: The cost of response will be estimated based on the cost of the PSNP per beneficiary (as with the original LEAP CBA, the cost of the transfer as well as the costs of administering the PSNP will be used to represent the full cost), with an additional mark up for non-food items to be consistent with the previous scenario. It should be noted however (a) that the PSNP has only existed since 2005, whereas our analysis would start in the 1990s, and therefore costs will need to be adjusted for inflation; and (b) we would need to find out if PSNP costs in pastoral areas is similar to cropping areas so as to isolate the cost relevant for pastoral areas (if yes, then we can use national average PSNP cost, as in the original LEAP CBA). Further, the PSNP is food/cash only and therefore will need to be adjusted to also include the cost of responding with non-food items to be comparable with the counterfactual.

The costs of LEAP will be added to this to include both up front capital investment as well as annual running costs. These costs are presented in full in the 2012 Cost Benefit Analysis of LEAP and will be updated as necessary.

Losses: Further research will be required to determine whether losses can be included in the analysis, as discussed in the previous section. Information will be required on the decrease in losses as a result of an earlier response if they are to be included in the model.

Additional benefits: Further to this, the impact evaluations of the PSNP document the benefits that arise as a result of early response through a decreasing food deficit, improved livestock holdings, and other indicators of impact. Given that LEAP effectively extends the

PSNP transfer to additional beneficiaries outside of the PSNP, this impact data can be used as a proxy for the type of impact that the LEAP might have on beneficiaries.

Applying the methodology: LEAP with Seasonal Forecast

Currently, LEAP uses monitoring rainfall data to calculate humanitarian needs. The aim of the LEAP EUPORIAS prototype is to integrate quantitative seasonal rainfall forecasts into the calculations, to enable earlier projections of humanitarian needs. The process is described in Figure 12 by using the example of a May seasonal forecast. At the beginning of May, normally a few decades after planting, climate projections are available and can be used to produce a number of drought maps. Starting from such drought maps, LEAP can compute the humanitarian needs and it is possible to establish the probability that the forecasted needs exceed any pre-determined threshold[1].

Seasonal forecasting should facilitate earlier response, provide more accurate predictions, and also allow for greater investment in early action and resilience building measures that can further reduce long-term humanitarian needs.

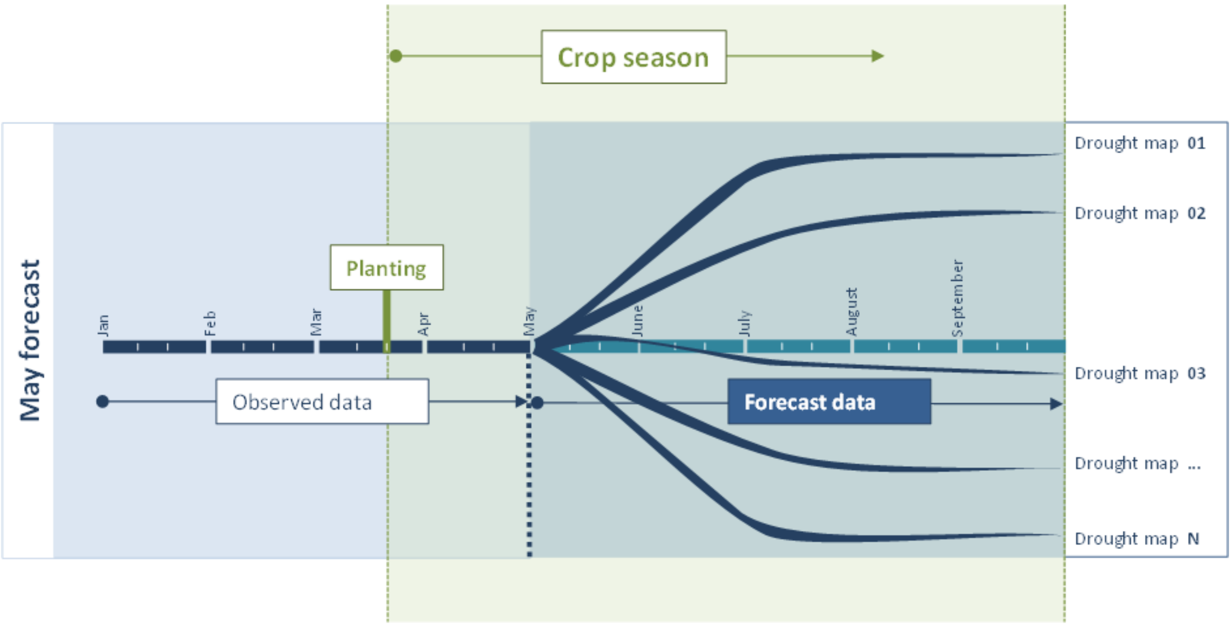


Figure 12: Use of observed and forecast data as input for the LEAP computations.

Earlier response

[1] The probability that forecasted needs exceed a given threshold does not automatically imply the same statement for actual needs. Forecasts are produced in so-called statistical ensembles, i.e. similar replicas of possible future realizations of the same phenomenon starting from similar – but not strictly identical – initial conditions. Each realization is called a member of the ensemble. The type of information that can be extracted from such ensemble forecasts is the number of realizations that produce a certain class of output. For example: how many members of the ensemble correspond to an estimated cost which is larger than the average cost occurred in a given area over the past year? How many members correspond to doubling (or more) the cost occurred over the same area? The underlying assumption is that if the fraction of members that correspond to a certain outcome is large – e.g. a lot of members corresponding to doubling the average historical cost - this corresponds also to a higher probability that actual needs will also fall into that class. This is not strictly true everywhere in the country. Studies have been already conducted to determine in which area the forecasts are more skilful. Typically, in the north/north-east of the country (Tigray, Amahara) seasonal forecasts are expected to be more reliable.

The benefits of earlier response are captured in the 'LEAP Current' model described above, namely:

- Lower cost of response through early procurement and pre-positioning (as with LEAP Current); and
- Reduced food deficit by responding before households enter into asset depletion and negative coping strategies as documented in the PSNP.

It is assumed that these benefits will continue and hence the additional benefits of a LEAP Plus model are combined with the LEAP Current model. The LEAP Plus model is designed to deliver even earlier response than the LEAP Current model; however the additional benefits associated with this are unknown and therefore not quantified. Having said this, the earlier forecasting would provide enough lead-time to invest in earlier action/resilience building measures, and these are addressed in the model below.

Quantitative forecasting

It is assumed that quantitative climate forecasting will result in more accurate predictions for early response. Under a scenario with qualitative forecasting, we do not have precise indications on how to react to a predicted drought. Those funds will most likely be put to productive uses and therefore will not be wasted. However, we assume that humanitarian funding is resource constrained and therefore by spending those funds 'incorrectly' on a disaster that never happened, we are preventing response to another crisis. As a result, the benefit of more accurate response is the opportunity cost of a (late) post disaster humanitarian response to another event.

Hindcast data will be used to estimate the accuracy of seasonal forecasting. Data from 1990-2005 will be evaluated to estimate the number of times that we would respond accurately based on a seasonal forecast (response triggered, drought occurred), as compared with the number of times that we would have delayed response due to not having a seasonal forecast, to estimate the avoided losses from a late humanitarian response. The data will also be evaluated to assess the number of times that we would have got it wrong had we responded early and the drought did not materialize, and therefore we would have unnecessarily used scarce humanitarian resources.

It is also possible that quantitative seasonal forecasting could be used to modulate transfer amounts under the PSNP. Currently, transfer amounts are fixed, but quantitative forecasting could provide information on the magnitude of the crisis, and therefore allow different amounts to be given to affected people depending on the severity of the situation. Again, the assumption would be that the benefit of this is the avoided loss of not being able to allocate those sums to other crises/areas. This will require further exploration as part of implementation of this research, and could be included if adequate data is available.

Greater investment in early action and resilience building measures

Seasonal forecasting should also promote greater investment in early action and resilience building measures. These can be wide ranging, and might include activities such as changing cropping patterns, investing in soil and water conservation measures, or installing water infrastructure. Importantly, in terms of the analysis, the measures included are those that would only occur with a quantitative seasonal forecast as these are the types of measures that are triggered by LEAP Plus – as such they are dependent on a seasonal forecast and hence this is the added value of LEAP (as opposed to a wide range of disaster risk reduction measures that are likely to be invested in regardless of whether there is a quantitative seasonal forecast or not).

The specific activities that would be invested in will be determined through workshops with DRMFSS and other stakeholders as part of a process to determine standard operating procedures in response to forecasts. Costs and benefits for these measures will be investigated and incorporated to the extent that data is available.

Cost of LEAP+PSNP

The costs of LEAP+PSNP used in the previous scenario are used here as the cost of LEAP and LEAP Plus are the same. The only difference might be the development costs of the forecasting capabilities which will be reviewed.

3.7.3. Implementation, results and next steps

The following key steps will underpin the development of the analysis:

1. **Finalize methodology**: A draft methodology will be submitted in December and finalized with Euporias, WFP and the consultant by end January.
2. **Conduct consultation and data gathering:** Initial consultation and data gathering will take place with relevant stakeholders in Ethiopia in January/February. Stakeholders will include WFP, LEAP implementers, relevant PSNP staff, and others as relevant. The objective of this consultation will be to brief relevant stakeholders on the proposed methodology and to begin to gather relevant data for the study.
3. **Analyze hindcasts:** Hindcast data will be obtained from U. Cantabria and assessed by the WFP team to build a profile as per the above methodology of drought characteristics from 1990-2005, as well as those that would have been accurately predicted by seasonal forecasting. This analysis will be done in conjunction with the consultant running the overall study to make sure that it fits with the study design. This activity will occur in parallel with Step 2.
4. **Develop analysis:** Data gathered will be combined to build a model using the three scenarios (counterfactual, LEAP Current and LEAP Plus) that will be run over the 15 years 1990-2005. The model will compare the relative net present costs and benefits of the three scenarios. March.
5. **Draft report:** A draft report that summarizes the assumptions and findings of the study will be submitted for comment from EUPORIAS and WFP. It may also be sensible to identify several key experts as peer reviewers. This report will be submitted in April.
6. **Final report:** A final report will be developed based on feedback on the draft report, and submitted in May to close the research project.

3.8. NEXT BEST ALTERNATIVE (Met Office)

3.8.1. **The value of the predictions in the eyes of the users**

Met Office worked on the intrinsic value a prediction has in the eyes of the users. More than an analysis of a specific skill metrics that can be more or less relevant to the users, the approach that has been followed is the one of that look at the incremental difference in both value (whatever defined) and costs of a specific prediction with respect to the next best alternative available to the users. The question we propose to answer is: “should the users don’t have access to our impact forecast how worse off they would be?” This is basically the answer most verification metrics have tried to answer. The problem is that in most cases the only alternatives considered as benchmarks are far less skilful that the real alternatives available to the users.

3.8.2. **Methodology**

Name of the methodology/study: **Next best alternative**

Background

For example whilst looking at ROC skill scores with respect to climatology appears to be a sensible way forward to compare different modelling systems, a real user may prefer to use a system based on conditional re-sampling of past observations, multiple linear regression (Eden et al, 2015) neural network or other statistical techniques. It is difficult to estimate the cost of a global forecasting system (back of the envelope calculation suggest costs of several hundred millions to develop a global model and several million per year to run it), and at the moment of writing it is not yet clear when and what sort of information will become freely available through initiatives such a Copernicus. What is certain is that on top of the large cost associated to the generation of this sort of forecasts, it is necessary to include also the cost to deal with information that is intrinsically more difficult to process post-process and analyse. In that sense looking at the incremental value a prediction system based on a dynamical model has with respect to one based on statistical tool appears to be a sensible approach. By definition a climate service is designed to serve the community of users it is targeting. Because of that no assumption should be made on the specific technique to use to produce such a forecast.

3.8.3. **Implementation, results and next steps**

To test the value of the climate predictions for Europe we design and run a benchmark model based on a simple Markov Chain process. This is a class of memory-less processes designed over a set of arbitrarily defined state. The basic assumption for a process to be Markovian is that the probability of transition from one state to another only depends on the state itself rather than on how it got to that state. Higher order Markov processes (which consider step 1, 2… history) are also possible but we have not considered them in current study. We defined the process using the monthly mean value of a meteorological parameter categorised into monthly terciles (above, below, neutral). Then we looked at the probability of transition from each tercile to all the other on a monthly basis. For some parameter, as for example the NAO index, the approach described doesn’t seem to add much over the climatological value. In this case, in facts, the probability of transition from each tercile to each other is, for most months, close to the 33% value that would have been provided by a climatological approach. On the other hand looking at meteorological variables such as precipitation or temperature at grid point location the situation changes significantly and probability of transition well in excess (on in defect for what it matters) of 33% can be seen in a number of months. Figure 13 shows an example for the temperature in Rome but similar results can be obtained for rainfall. This is not entirely surprising as it is widely known that

persistence can be difficult to beat. What is, at least partially, more surprising is that the difference from the climatological base rate can occur also for probability of transition different from the persistence. This means that, for example, having had a, let's say, wet April can increase the probability of having a dry May and vice versa. The ability to capture this anti-persistence behaviour represents a clear improvement with respect to both climatology and persistence approaches. The other intrinsic advantage of the Markov chain approach is its ability to provide probabilistic forecast (as in the case of climatological forecasts) and change forecast depending on the specific initial conditions (as in the persistence forecast).

The system that was developed for this study was implemented with a few lines of R and it takes few minutes to run on a normal laptop computer. Given how inexpensive these predictions are we think they could represent a very solid alternative to the benchmark conventionally used to assess climate predictions skill.

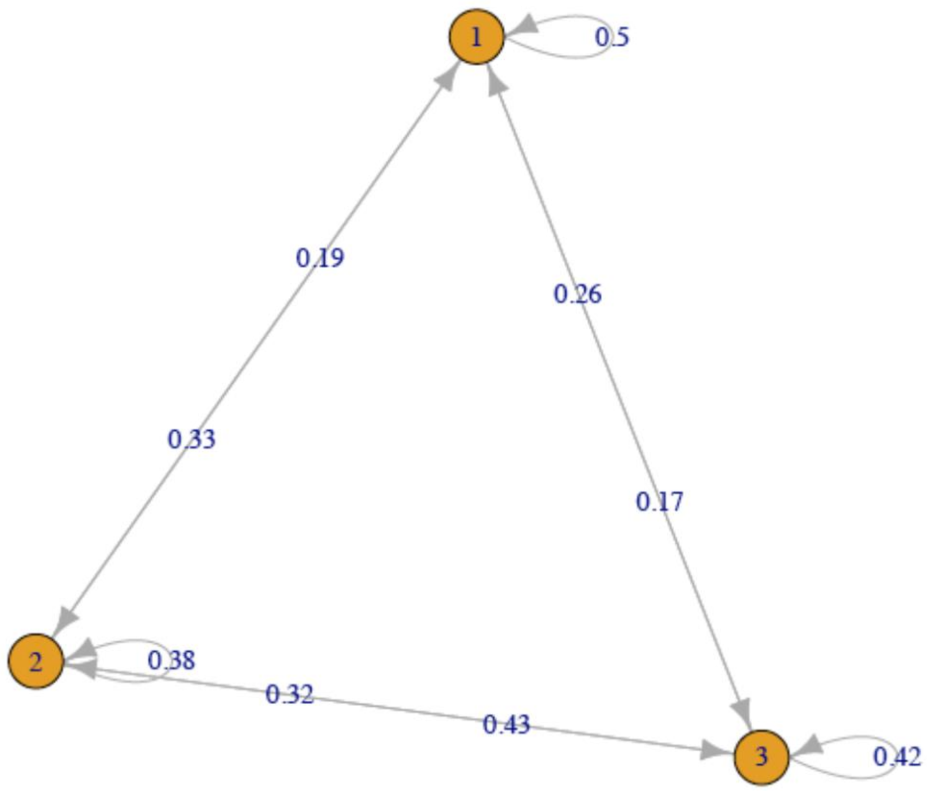


Figure 13: Probability of transition between the different terciles for temperature in Rome the month of September to October.

Figure 13 shows a graph highlighting the probability of transition between the different terciles for temperature in Rome the month of September to October. This means that if you had a warm September there is only a 17% chance of seeing a cold October. Given how inexpensive these predictions are we think they could represent a very solid alternative to the benchmark conventionally used to assess climate predictions skill

Building on this toy model we would like to develop a general approach to model prediction based on the complexity of a statistical algorithm able to provide, for a given verification

metric, a value similar of greater to the one provided by the dynamical model. Working on the assumption that a no statistical post-process, at least for the time being, can be as computational expensive as a dynamical model, the complexity of the algorithm that outperform the dynamical model should provide an intrinsic value of the prediction itself. For example if for a given metric, a simple linear extrapolation can outperform my dynamical model output then it means that such a model is inherently less valuable than another model that can only be beaten, using the same metric, by a high order polynomial.

4. LESSONS LEARNT

- **IC3** : The concept of economic value does not necessarily have to be linked to the actual monetary benefits of including climate predictions to decision making processes. For the energy sector the first step to include climate information in decision making processes is to demonstrate that the new method outperforms the current practice.
- **University of Leeds:** In the context of this study, the complexity of the land management decisions including the influence of weather, climate and other socio-economic factors as well as the existence (or not) of options available required an in depth qualitative analysis in order to allow us to understand the mental models of decision-making used by the farmers involved in the Land Management Tool prototype and the potential value/benefit that SCF can have in supporting those decisions.
- **Meteo-France** : The estimation of the CS value into DMP is an essential step for adapting stakeholders practises by taking account CI that relies both on strong DMP knowledge of end users and on listening ability of scientists for tailoring specific products. The decision redo of numerous past situations by stakeholders is essential to correctly evaluate probabilistic forecasts but necessitate to be able to spend significant time to do it. The RIFF evaluation by Placebo concept (2 scenarios plus current practise) with 29 years replayed and two different dates of SF initialisation has necessitated several end users work days for the simulation of only one dam.
- **CetAqua**: The value of the predictions for water management depends on the status of the system. The value increases in drought conditions or high flood risk as an action is necessary. Conversely, the value decreases if actions based on the prediction do not lead to critical decisions.
- **WFP:** In order to assess fully the benefits of the LEAP “plus” tool (with Seasonal forecast) versus the LEAP “normal” scenario (with no seasonal forecast), besides the estimation on cost savings which could be done by pre-positioning or better positioning food assistance, there is a clear need to carry out a more in-depth research on the specific activities that the Government of Ethiopia and partners could enact as part of early action and resilience building measures, such as changing cropping patterns, investing in soil and water conservation measures, or installing water infrastructure. The type of measures are those that would only occur with LEAP Plus – as such they are dependent on a seasonal forecast and hence this is the added value of LEAP (as opposed to a wide range of disaster risk reduction measures that are likely to be invested in regardless of whether there is a quantitative seasonal forecast or not). As a result, more research needs to be done in this regard.
- **Met Office** : Using climatology as a benchmark is a natural choice when comparing model simulation but doesn’t necessarily provide the next best alternative for users. In that sense to account for the value seasonal predictions

have in the eyes of a decision makers we should look at the incremental value (however defined) these provide on top of the next best alternative available to them.

5. LINKS BUILT

- Close interaction with all deliverables of **WP41** by using a common structure for describing evaluation methods and results of each partners and with the outputs of D42.2 (**WP42**) for common user feedback on prototype performance assessments
- Close interaction with **WP2x** (CetAqua and MF in particular) aiming to develop a modelling framework for seasonal prediction (calibration and downscaling) as input of water management model. Finally, in **WP45** the potential business opportunity of the new service propose will be analysed
- Interest to compare two CS experiments led in the same water sector of dam management in Spain (**S-CLIMWARE case study**) and France (**RIFF prototype**) and analyse common impacts of CI on DMP and differences in CS implementation.
- **Météo-France** was also involved during the last years in a French national program called **PREMHYCE** aiming to benchmark hydrological models for low-flow simulation and forecasting on French catchments (Nicolle et al, 2014). Five hydrological models (four lumped storage type models – Gardenia, GR6J, Mordor and Presages – and one distributed physically oriented model – SIM, used in EUPORIAS) were applied within a common evaluation framework and assessed using a common set of criteria in simulation and in forecasting modes.
- For **Met-Office**a fruitful collaboration with Matteo DeFelice at **ENEA** has been developed as part of this WP.

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