Standardized Runoff Index (SRI) Evaluation

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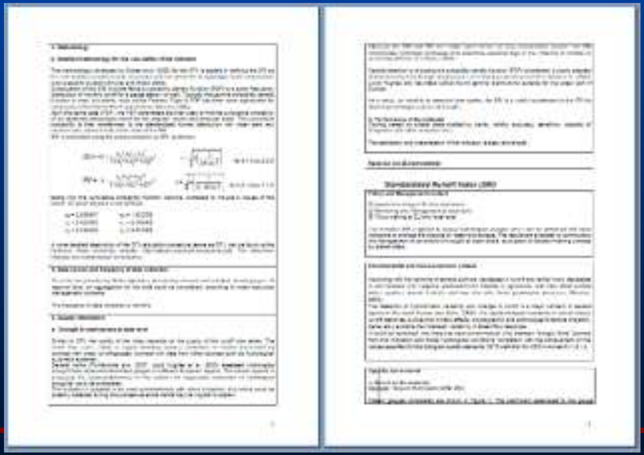
Contents

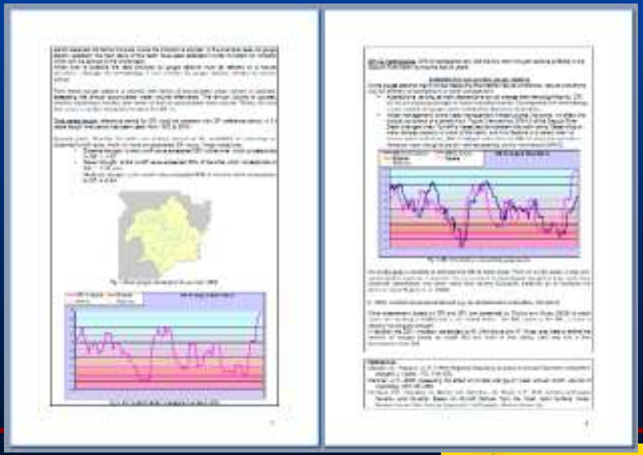
Background

- During the meeting in Brussels, in May 2012, the WS&D Expert Group asked Spain to conduct a further development of the SRI indicator.
- Before that, in 2011, Spain submitted a draft SRI factsheet. A preliminary evaluation of the indicator was carried out by some MS. The results of this assessment were presented to the WS&D Expert Group before October 2011 using the test spreadsheets.
- During the meeting in Venice, in October 2011, Spain presented the final version of the SRI factsheet in which three updates were incorporated.
- To carry out this final assessment of the SRI, Spain developed an Excel Template which was distributed to all members of the WS&D Expert Group.
- These results, sent by the MS, have been analyzed and are presented below.

Final SRI Factsheet

- **SRI factsheet was updated in October 2011 and the result was presented in Venice meeting.**
- **There were three changes that we want to remark:**
  1. **Further description of the methodology to be used.**
  2. **Recommendation that gauge stations in pristine conditions should be used.**
  3. **Definition of new severity thresholds: based on the probability of exceeding an observed runoff value, which will have an associated SRI value. These values are:**
     - **Extreme drought: runoff value exceeded 95% of the time, corresponds to SRI = -1.65**
     - **Severe drought: runoff value exceeded 90% of the time corresponds to SRI = -1.28**
     - **Mild drought: runoff value exceeded 80% of the time corresponds to SRI = -0.84**





Main Goals

- **To check whether the indicator could be applied in Europe with the current available data without new investment,**
- **To verify if the indicator works properly and identifies the existence of drought in the different basins,**
- **To evaluate how well the indicator fits other indexes and historical data.**

Description of the Participants

➢ **Nine countries and 11 basins have participated on this evaluation.**

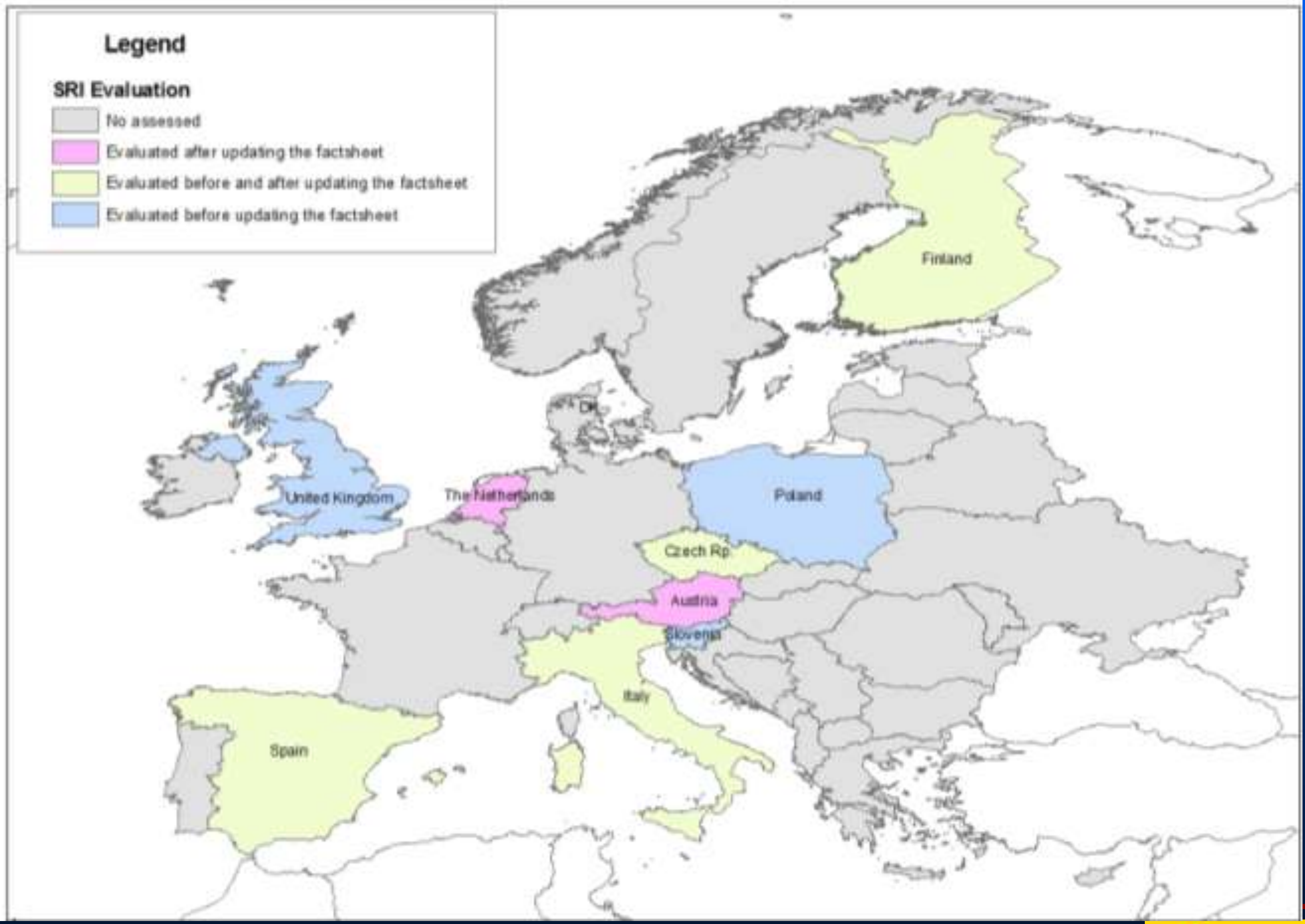
Country (Basin)	Type of data	Nº of Gauge st.	Gauge st. location	River basin Map	degree of affectation	Gauge st. representativeness	Length of the series	Quality of the series	Probability Density Function	Comparison with other indexes	Evaluation phases	Source of data
POLAND (Odra RB)	Gauge st.	NC	high and intermediate basin	No	NC	NC	1980/2010 and 1966/2008	NC	Gamma	No	Before factsheet updating	Test sheet
SLOVENIA	Gauge st.	NC	NC	No	No affected	NC	1980/2010	NC	Gamma	No	Before factsheet updating	Test sheet
UNITED KINGDOM (Thames RB)	Gauge st.	1	NC	No	NC	NC	1980/2010	NC	Gamma	SPI	Before factsheet updating	Comments to factsheet and other documents
ITALY (Arno RB)	Gauge st.	2	low and high basin	Yes	Restored to natural regime	Good	1952/2012 and 1993/2012	Good	NC	SPI_365	After factsheet updating	Evaluation sheet
ITALY (Po RB)	Hydrological model	5	All along the river	No	Restored to natural regime	Good	1980/2010	Good	Gamma, exp normal and log normal	SRI_observed and SPI	Before and after factsheet updating	Test and evaluation sheets
AUSTRIA (Leitha/Raab/Rabnitz RB)	Gauge st.	NC	NC	Yes	NC	Good	1970/2009	Good	NC	SPI_RB	After factsheet updating	Evaluation sheet
THE NETHERLANDS (Meuse RB)	Gauge st.	NC	NC	No	Restored to natural regime	Good	1970/2010	Good	NC	Local drought index	After factsheet updating	Evaluation sheet
FINLAND (Paimionjoki/Kokemaenjodi RB)	Hydrological model based on Gauge st.	2	low basin	yes	Restored to natural regime	Good	1969/2010	Good	Gamma	No	Before and after factsheet updating	Test and evaluation sheet
CZECH REP. (Morava RB)	Gauge st.	1	low basin	Yes	Restored to natural regime	Good	1979/2009	Good	Gamma	SDVI and SPI	Before and after factsheet updating	Evaluation sheet
SPAIN (Segura RB)	Gauge st.	7	All over the basin	Yes	Restored to natural regime	Good	1980/2010	Good	Gamma	SPI, Local drought index	Before and after factsheet updating	Evaluation sheet

NC: No Commented

Evaluations Phases

The evaluation of the SRI was carried out in two phases:

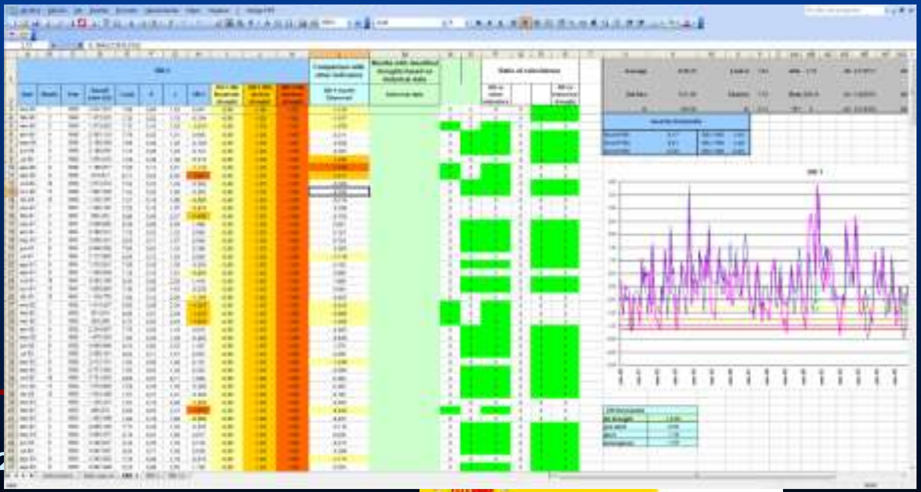
- **Before the Venice meeting, in October of 2011, and**
- **After the Brussels meeting, in May 2012.**



Source of Information

The information comes from three sources:

1. **Test Sheet: in which the MS answered a questionnaire on some issues of the indicator.**
   - **Poland (Odra RB)**
   - **Finland (Paimionjoki/Kokemaenjodi RB)**
   - **Slovenia**
   - **Italy (Po RB)**
1. **Comments to the SRI factsheet and other documents (SRI work for Thames catchment).**
   - **United Kingdom (Thames RB)**
2. **Evaluation Sheet: the Excel Template provided to carry out an homogeneous evaluation of the SRI.**
   - **Czech Republic (Morava RB)**
   - **Italy (Po and Arno RB)**
   - **Austria (Leitha/Raab/Rabnitz RB)**
   - **The Netherlands (Meuse RB)**
   - **Finland (Paimionjoki/Kokemaenjodi RB)**
   - **Spain (Segura RB)**



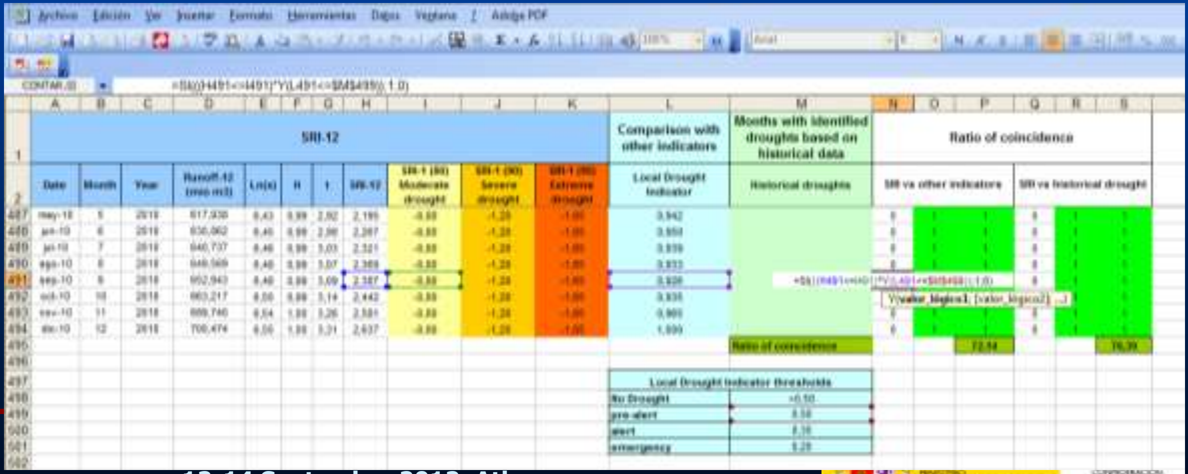
Evaluation Methodology

1. **Acquire data of the watershed runoff from gauge station or hydrological model,**

2. **Calculate SRI in different temporal scales, using Gamma distribution as explained in the factsheet,**

3. **Compare SRI with other indicators and with historical data:**

   - **RATIO OF COINCIDENCE: In order to have a numerical comparison between the SRI and the other indicators and historical data we have developed this ratio which compares the number of months in which both indexes give drought or no drought, divided by the total number of months of the series.**



Results

DATA AVAILABILITY

- **Most of the MS could apply the indicator on their basins with the existing data.**
- **The data series used have good quality and are long enough.**
- **In most cases the MS use data from gauge stations. Some countries believe that they could easily use data from other sources, like hydrological models, without a great investment of money and time.**
- **Some MS remark the importance of the representativeness of the gauge stations in the basins.**

APPLICABILITY

- **The calculation procedure is good and easy to carry out. Also it is sufficiently contrasted since it is the SPI methodology.**
- **The SRI methodology in general delivers feasible results and can be easily used with the available data.**

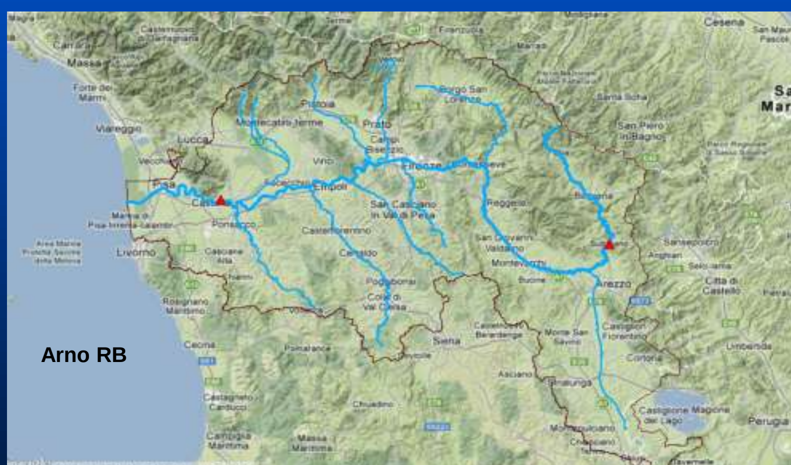
PERFORMANCE

- **The MS also consider that the indicator has a good representativeness of the results. Comparing SRI with other indicators and with historical data it can be seen that SRI can identify past droughts, and therefore future droughts.**
- **Most of the countries commented that the most adequate temporal scale is SRI_12, since it reflects the regulation capacity of the basin (artificial reservoirs, snow, aquifers, etc). However temporal scale would depend on the type of basin.**

Some Examples

Italy: Arno RB

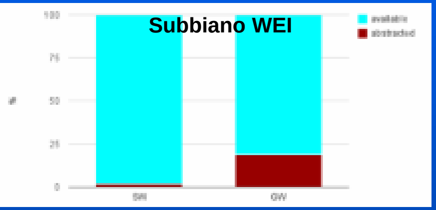
- They have used runoff data from two gauge stations.
- SRI is compared with SPI_365 and with historical data.
- Subbiano GS: small basin (738 sqkm) and non affected gauge station. Data series goes from 1952/2012.
- San Giovanni GS: large basin (8186 sqkm), heavily affected GS. Data series have been restored to natural conditions. Data series goes from 1993/2012.
- Both series of data identifies a strong dry period that is occurring at the present moment.

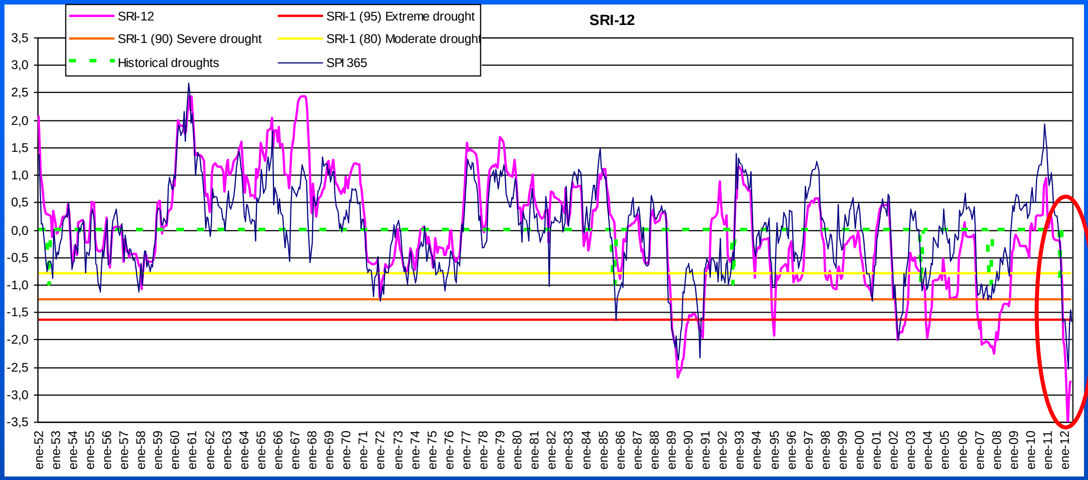


Some examples

Subianno

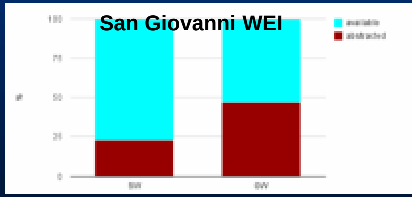
Ratio of coincidence	SRI vs SPI_365	SRI vs historical drought
SRI_1	68.32	73.69
SRI_3	73.28	77.00
SRI_12	86.64	81.54

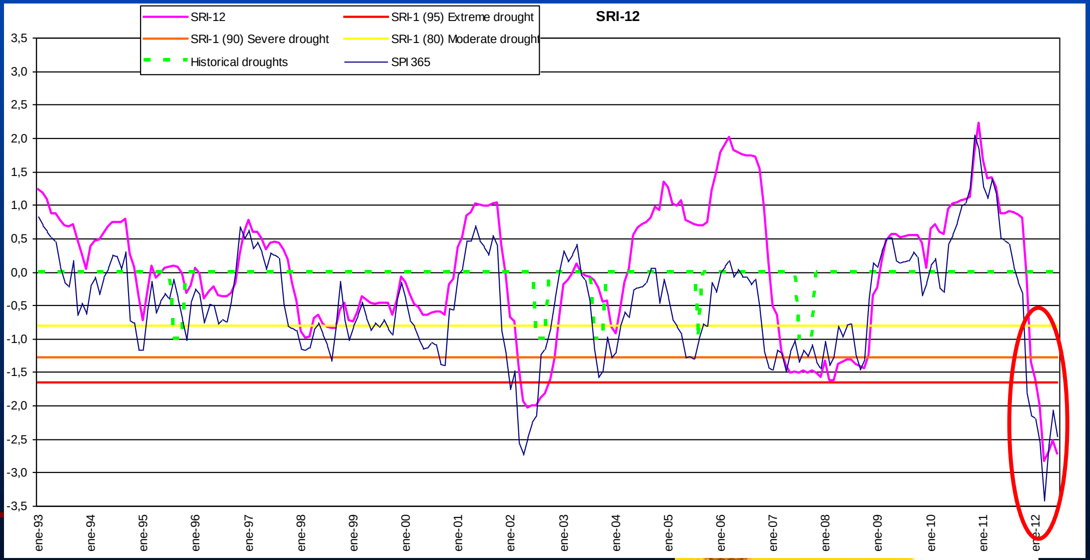




San Giovanni alla Vena

Ratio of coincidence	SRI vs SPI_365	SRI vs historical drought
SRI_1	64.96	80.34
SRI_3	64.96	77.78
SRI_12	79.91	80.77





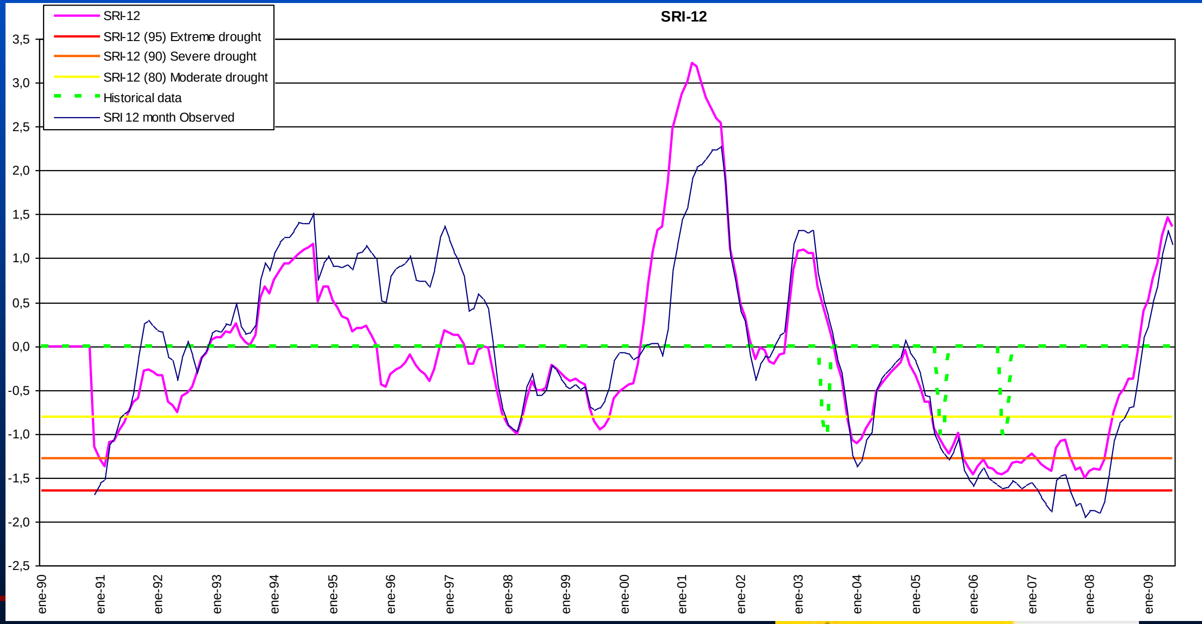
Some examples

Station ID	Station Name	Latitude (ETRS89)	Longitude (ETRS89)	Drainage area [km2]	Municipality name
1	Spessa Po	45,102	9,346	37,372	Pavia
2	Piacenza	45,061	9,703	42,030	Piacenza
3	Cremona	45,123	9,991	50,726	Cremona
4	Boretto	44,906	10,560	55,183	Reggio Emilie
5	Pontelagoscuro	44,889	11,608	700,091	Ferrara

- **Italy: Po RB:**
  - **They have used runoff data hydrological model to evaluate the entire basin.**
  - **The data series goes from 1990/2012.**
  - **SRI is compared with SRI_observed calculated for 5 gauge stations located all along the river and with historical data.**

Pontelagoscuro

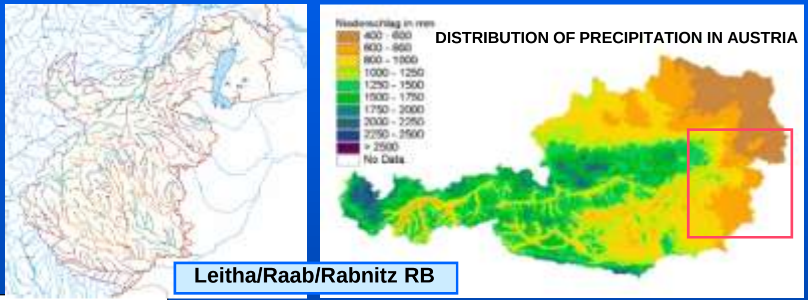
Ratio of coincidence	SRI vs SRI_observed	SRI vs historical drought
SRI_1	76,98	73,81
SRI_3	77,60	72,40
SRI_12	95,85	76,76

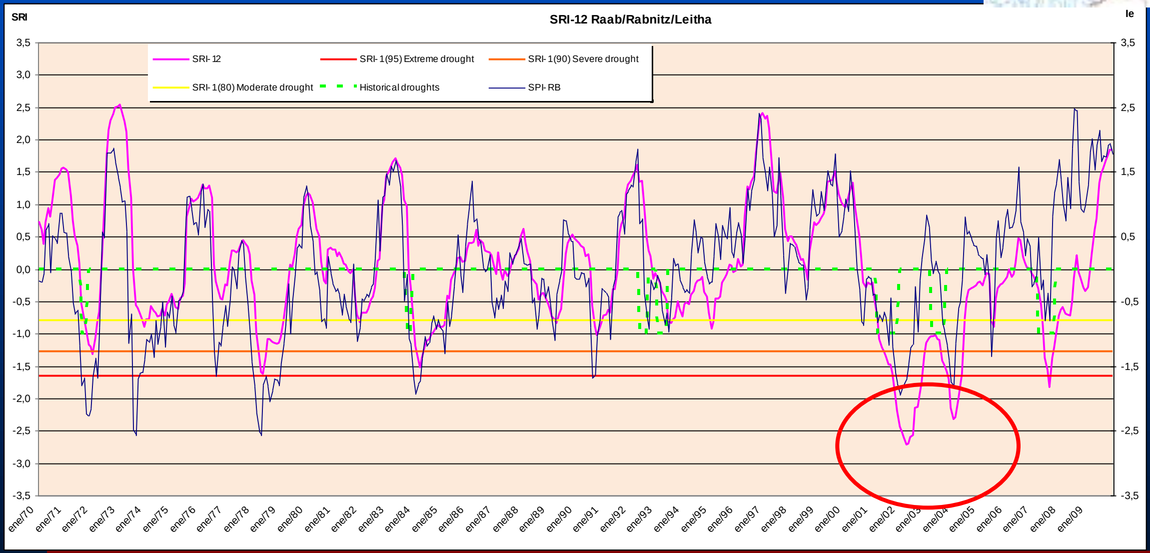


Some examples

Austria: Leitha/Raab/Rabnitz RB

- The area evaluated is the national part of three basins located on the driest part of the country.
- Runoff data comes from gauge stations with long data rows: 1970/2009.
- SRI is compared with SPI_RB
- SRI identifies a very dry period occurred in 2003.



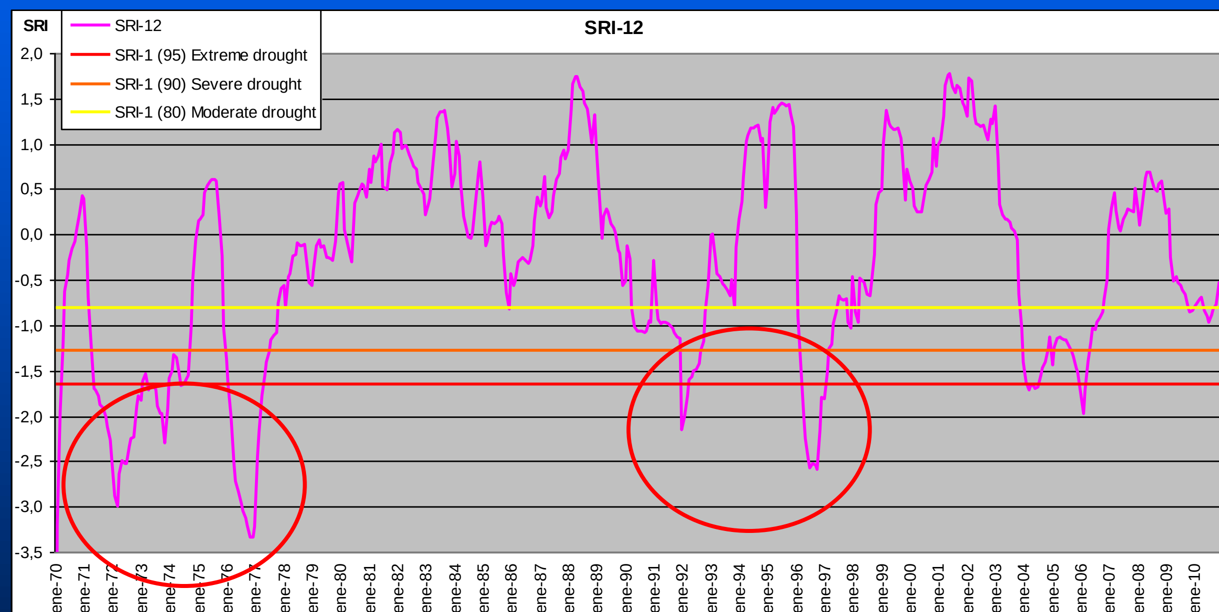


Ratio of coincidence	SRI vs SPI_RB	SRI vs historical drought
SRI_1	70,6	80,21
SRI_3	74,6	80,63
SRI_12	84,6	81,72
SRI_seasonal	78,8	79,38

Some examples

The Netherlands: Mouse RB

- They have used runoff data from gauge stations.
- The data series goes from 1970/2010.



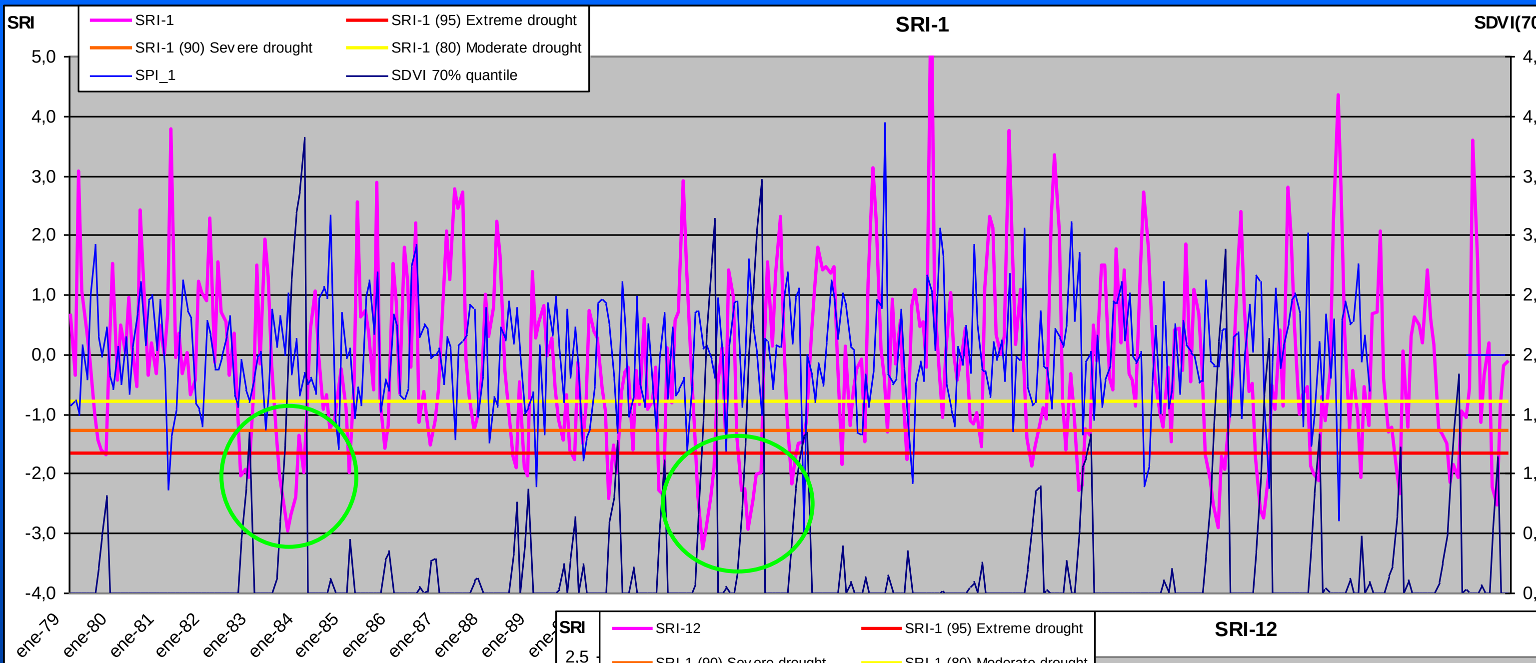
Some examples

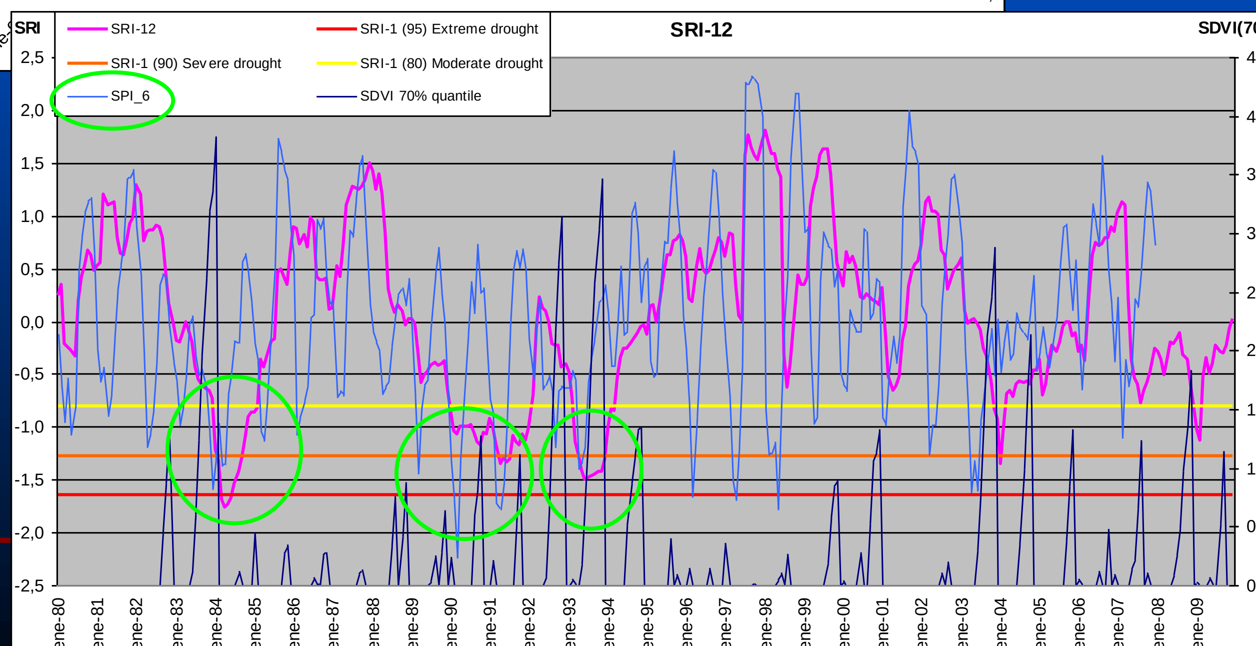
➢ **Czech Republic: Morava RB:**

- They have used runoff data from a gauge station located at the mouth of the river to evaluate the entire basin.
- The data series goes from 1979 to 2009.
- The data set refers to re-naturalized streamflow values.
- SRI has been compared with SDVI and SPI_1, SPI_3 and SPI_6
- The Standardized Deficit Volume Index (SDVI) is based on the threshold level method. It is an indicator that it's being used in the Czech republic to assess hydrological drought.

$$SDVI_t = \begin{cases} if\ Q_{obs} < Q_{\lim} & SDVI_{t-1} + \left(\dfrac{Q_{\lim} - Q_{obs}}{Q_{\lim}} \right) \Delta t \\ else & 0 \end{cases}$$

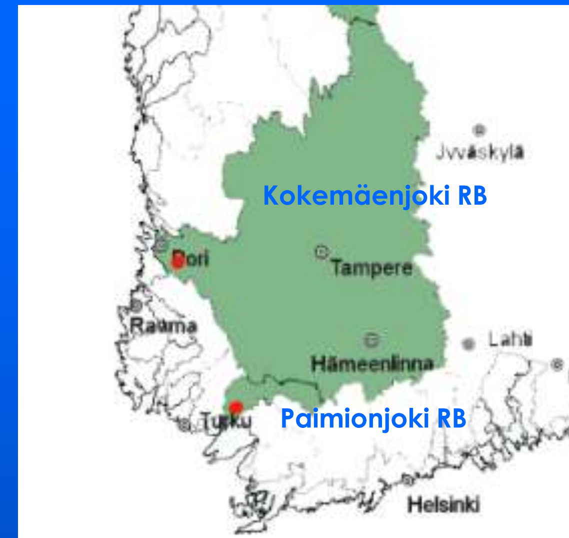
Some examples



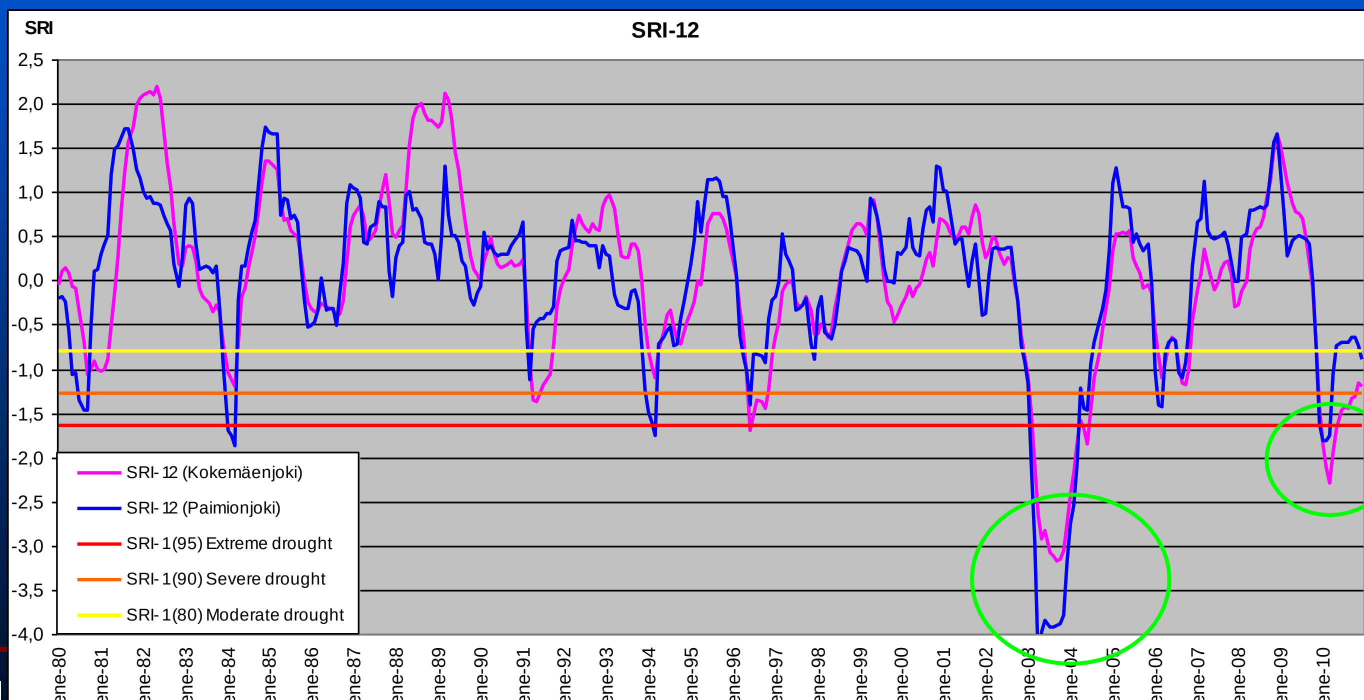


Ratio of coincidence	SRI vs SDVI(70)	SRI vs SPI
SRI_1	92,7	61,2
SRI_3	83,6	68,7
SRI_12	62,9	85,9

Some examples



- **Finland: Kokemäenjoki & Paimionjoki RB:**
  - They have used data from a hydrological model.
  - The data set refers to natural conditions.
  - The data series goes from 1969/2010.
  - In the graph below you can see the comparison between the SRI_12 of both basins.

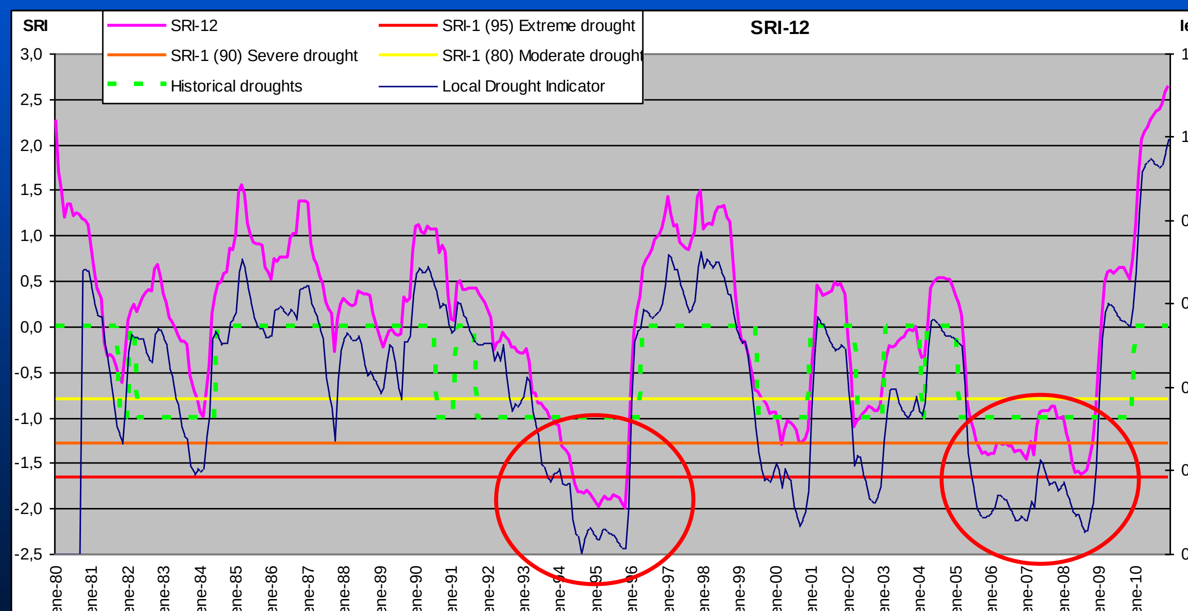


Some examples

➢ Spain: Segura RB:

- We have used aggregated runoff data from 7 gauge stations to evaluate the entire basin.
- The data set refers to natural conditions.
- The data series goes from 1980/2010.
- SRI is compared with a local drought indicator and with historical data.

Ratio of coincidence	SRI vs Local Drought Indicator	SRI vs historical drought
SRI_1	58,6	64,3
SRI_3	61,7	66,9
SRI_12	72,1	78,4
SRI_seasonal	46,3	53,7



Conclusions

At this moment, there are available data in Europe to apply this index

The calculation procedure is good and easy to carry out

The SRI works well in all the basins in where it has been applied

SEGURA PRB

DEVELOPMENT OF A METHODOLOGY TO MAKE

RISK MAPS

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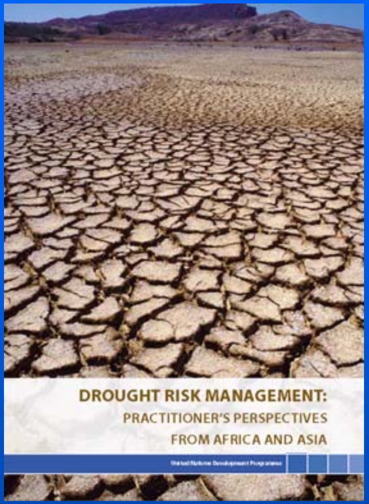
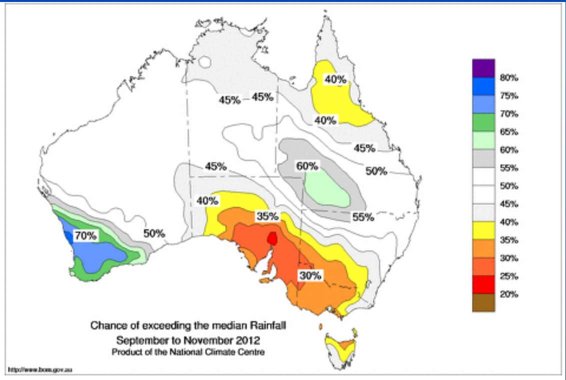
Concept of Risk

- **UNDP (United Nations Development Program)- *Drought Risk Management: Practitioner's Perspectives from Africa and Asia*[1] (Published on 31 January 2012): *It deals with the problem of how a good Drought Risk Management and a good early warning system can reduce drought impacts.***



- ***Australian Government. Boureau of Meteorology*[2]*: "The Bureau's seasonal outlooks are general statements about the probability or risk of wetter or drier than average weather over a three-month period."***



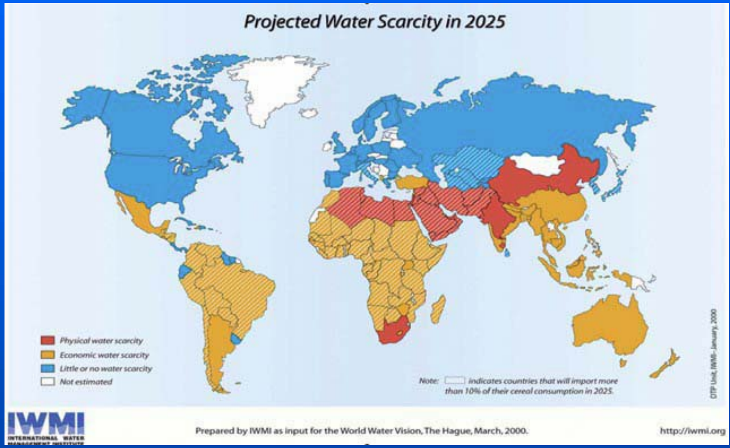
1) http://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_land_management/drought-risk-management-from-africa-and-asia/

2) http://www.bom.gov.au/climate/ahead/rain_ahead.shtml

Concept of Risk

- ***Spain, Water and Climate Change in COP 15 and Beyond: Aligning Mitigation and Adaptation through Innovation (WP) (Elena Lopez-Gunn; Elcano Royal Institute)[3]:***

  It is a document mainly focused on Water Scarcity, where the concept of Water Scarcity Risk map is proposed.



- ***Flood Directive (Directive 2007/60/CE on the assessment and management of flood risks):***

  "'Flood risk' means the combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event"

  Risk = Hazard * Vulnerability

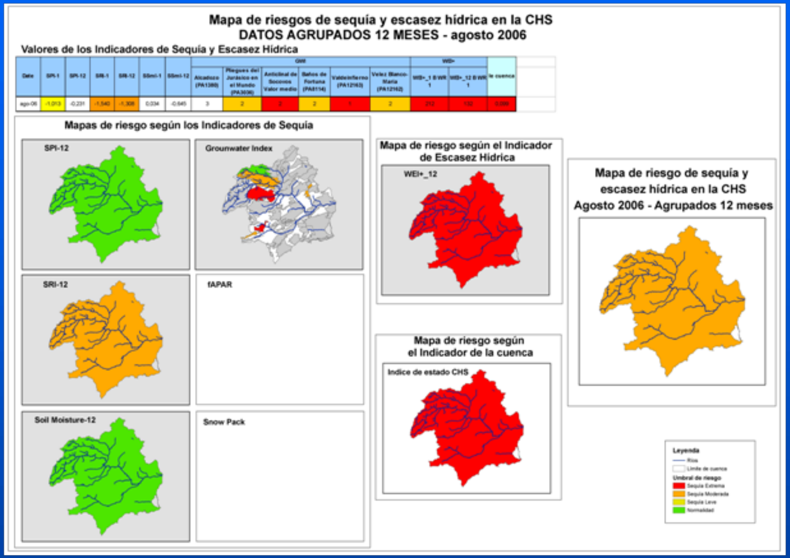
3)_http://www.realinstitutoelcano.org/wps/portal/rielcano_eng/Content?WCM_GLOBAL_CONTEXT=/elcano/elcano_in/zonas_in/international+economy/dt65-2009

First approach to risk maps

1. **Current status maps water of drought:**
   - Using drought indicators like SPI, SRI, GWI, SnowPack, etc, to establish the current state.
   - In this case we'll have a picture of the existing situation in terms of drought.

- **2. Forecasts of main variables are provided:**
  - Short-Medium term: 1-3 months
  - Long term: Climate Change

- **3. Sometimes impacts are taken into account**



Example of the Segura RB current status map (august 2006)

Second approach to risk maps

Food Directive approach- Risk maps:

- **It evaluates the consequences of water scarcity on the population and the environment.**
- **Circumstances only vary in medium or long term. Risk is a stable variable since is set based on the probability of occurrence of a phenomenon from the statistical analysis of a historical data set.**

Risk = Hazard * Vulnerability

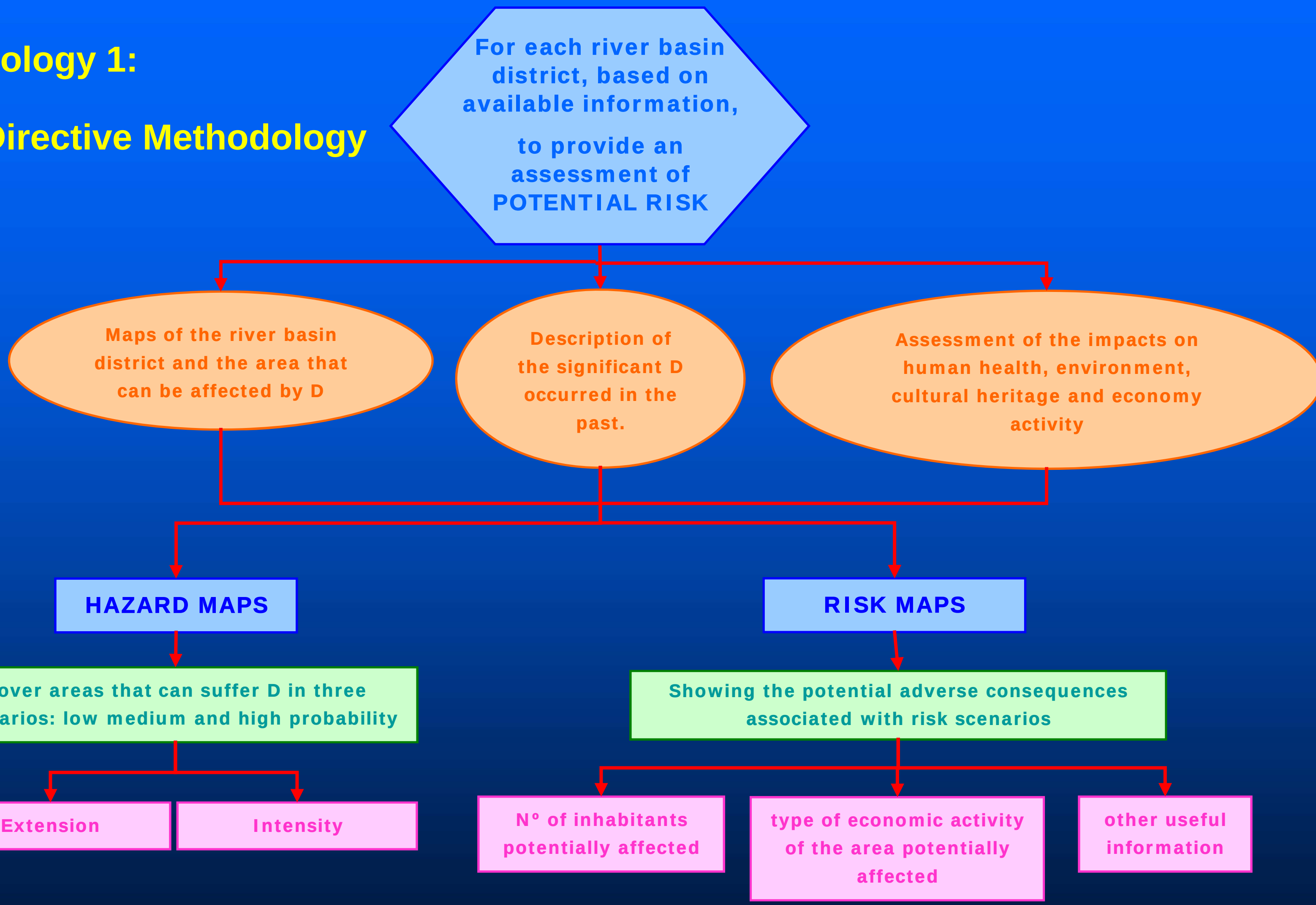
However, Floods and Droughts are different phenomena:

- **Floods only appear in a concrete area of the territory while Droughts can happen anywhere.**
- **Floods are developed in a short period of time (hours) while Droughts can last months or even years.**
- **In Floods events only the flow parameter is involved while Droughts can be depicted using different parameters (precipitation, flow, soil moisture, snow pack, etc.)**

Flood directive approach- Methodologies

Methodology 1:

Flood Directive Methodology



Flood directive approach- Methodologies

Methodology 1:

Flood Directive Methodology

Advantages and weaknesses of using this methodology:

- **It is coherent with the Flood Directive (2007/60/EC)**

But…:

- **There is still no consensus on which indicators should be used.**
- **It s not easy to identify the demand areas since these areas are not located by the river but in the entire basin or sometimes even outside of it.**
- **It is also difficult to assess the impacts produced by a drought period in terms of "*human health, the environment, cultural heritage and economic activity.*"**

Flood directive approach- Methodologies

Methodology 2: suggested alternative based on WEI+

- We use WEI+ to develop *water scarcity risk maps* since this indicator estimates the consequences of water scarcity on the population and the environment.
- Water Demand is more or less a stable variable while Water Resources can vary along the time for many reasons: drought, quality hazards, etc.
- Basins with a high WEI+ and a great rainfall variability are more vulnerable to water scarcity than basins with high WEI+ but a constant amount of annual precipitation.

Flood directive approach- Methodologies

Methodology 2: suggested alternative based on WEI+

Advantages and weaknesses of using this methodology:

- **It is ready to provide ‘risk maps’**

But…:

- **It might be a bit simplistic**
- **It inherits all the uncertainties of WEI+: data availability, thresholds, Water Requirements issue….**
- **adding a new threshold issue.**

Methodological Scheme of Water Scarcity Risk Maps

Calculate WEI+ Time series

$$WEI = \frac{Abstractions - Returns}{Water\ Resources - \Delta Sart}$$

Determine the WEI+ threshold that can not be exceeded (WEI+_Limit)

% of Water Requirements (EWR) compared to Available Resources

Count the number of time steps (months or year) where WEI+ threshold is exceeded, and obtain its percentage.

Based on the probability of exceeding WEI+_Limit a number of years

Calculate Water Scarcity Risk

Draw Water Scarcity Risk Map

Red	Extreme: WEI+ value is exceeded more of the 50% of the years
Dark orange	High: WEI+ value is exceeded between the 30 and the 50% of the years
Light orange	Medium: WEI+ value is exceeded between the 10 and the 30% of the years
Yellow	Low: WEI+ value is exceeded between the 5 and the 10% of the years
Green	Null: WEI+ value is exceeded between the 0 and the 5 % of the years

An example of Water Scarcity Risk Maps

- Using data from the WEI+ evaluation performed by de MS (annual practical exercise_v1.xls) we have calculate the Water Scarcity Risk for some European basins:

Germany – Spree RB
Austria – LeithaRaab RB
Slovakia – Bodva RB
Spain – Segura RB
Finland – Paimionjoki RB
France – Voulziel RB
Italy – Arno RB

1. Calculate WEI+ annual average using the accepted formula, in which Environment Requirements are not take into account.

$$WEI = \frac{Abstractions - Returns}{Water\ Resources - \Delta Sart}$$

$$WR = P - ETa + ExIn - \Delta Snat$$

YEAR	WEI+
1989	62,7
1990	85,3
1991	115,8
1992	114,7
1993	137,3
1994	168,2
1995	184,1
1996	100,5
1997	88,3
1998	112,3
1999	118,9
2000	108,9
2001	102,1
2002	108,7
2003	108,3
2004	83,1
2005	141,3
2006	133,2
2007	145,0
2008	142,0
2009	81,8
2010	56,0
Average (1989/2010)	113,6

WEI+ annual average Segura RB

An example of Water Scarcity Risk Maps

2. **Calculate WEI+ annual average taking Environmental Requirements into account.**

   In the Segura RB Management Plan the environmental requirements are establish as the 10% of the water resources long term average plus the environmental demand for wetlands.

   Therefore Environmental Water Requirements are 102,7 mio m3/year.

Año	SIMPA CHS	Eflow RBMP	Requeriments for wetlands	EWR
Average (1986/2010)	747,0	74,7	28,0	102,7

YEAR	WEI+	WEI+ with EWR	WEI+ - WEI+ with EWR
1989	62,7	68,6	5,9
1990	85,3	92,6	7,3
1991	115,8	125,2	9,4
1992	114,7	125,8	11,1
1993	137,3	152,1	14,8
1994	168,2	186,1	18,0
1995	184,1	205,4	21,4
1996	100,5	108,9	8,5
1997	88,3	95,0	6,7
1998	112,3	120,1	7,8
1999	118,9	127,7	8,8
2000	108,9	117,8	8,9
2001	102,1	109,5	7,4
2002	108,7	117,2	8,5
2003	108,3	116,6	8,3
2004	83,1	89,6	6,5
2005	141,3	154,0	12,7
2006	133,2	148,7	15,5
2007	145,0	161,5	16,5
2008	142,0	159,1	17,1
2009	81,8	90,7	8,9
2010	56,0	61,3	5,4
Average 1989/2010	**113,6**	**124,3**	**10,7**

When calculating the WEI+ taking account EWR, and comparing these values with WEI+ calculated without EWR we can see that the difference is also 10,7%.

An example of Water Scarcity Risk Maps

3. The differences between both WEI+, subtracted from 100, is what we have determined WEI+_Limit for this exercise.
   - Is the value of WEI+ that can not be exceeded.
   - In the Segura RB the WEI+_Limit would be:

WEI+_Limit = 100 – 10,7 = 89,3

4. Define risk thresholds as the maximum number of years that WEI+_Limit is exceeded by the annual WEI+.

YEAR	WEI+
1989	62,7
1990	85,3
1991	115,8
1992	114,7
1993	137,3
1994	168,2
1995	184,1
1996	100,5
1997	88,3
1998	112,3
1999	118,9
2000	108,9
2001	102,1
2002	108,7
2003	108,3
2004	83,1
2005	141,3
2006	133,2
2007	145,0
2008	142,0
2009	81,8
2010	56,0
Average 1989/2010	113,6

In the Segura RB the threshold 89,3 is exceeded 16 years of 22, which gives a probability of 73%.

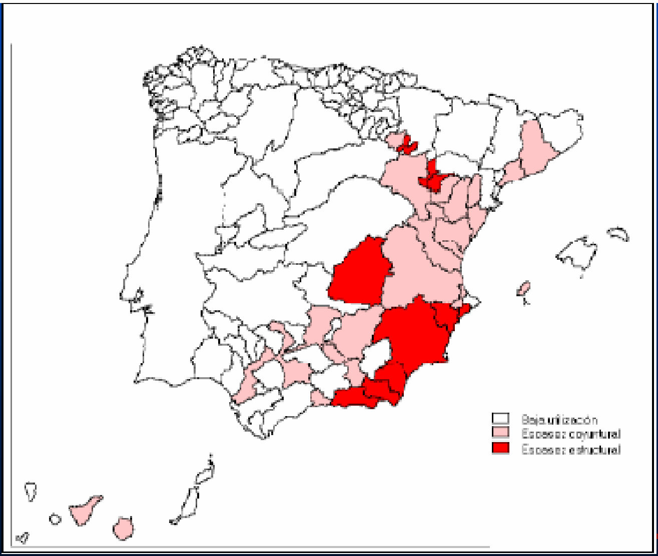
Risk Thresholds are defined as follows:

Red	Extreme: WEI+_Limit is exceeded more of the 50% of the years
Dark orange	High: WEI+_Limit is exceeded between the 30 and the 50% of the years
Light orange	Medium: WEI+_Limit is exceeded between the 10 and the 30% of the years
Yellow	Low: WEI+_Limit is exceeded between the 5 and the 10% of the years
Green	Null: WEI+_Limit is exceeded between the 0 and the 5 % of the years

An example of Water Scarcity Risk Maps

5. Draw the Water Scarcity Risk Map

Country-basin	WATER RESOURCES			Average water deficit	WEI+					Nº of years	WEI+ without Eflow				WEI+_Limit	nº of years that WEI+_Limit is exceeded	Level of risk	
	WR self evaluation	Recursos OPTION 1	Recursos OPTION 2		WEI+ self evaluation = (Abs - Ret)/ WR	WEI+ A WR1	WEI+ A WR2	WEI+ B WR1	WEI+ B WR2		WEI+ A WR1	WEI+ A WR2	WEI+ B WR1	WEI+ B WR2				
Alemania-Spree	2670,6	2863,0	5229,6	908,0	7,42	22,0	5,0	7,1	9,1	30	94,8	21,3	30,4	38,9	76,7	4	13,3	Medium
Austria-LeithaRaab	285,2	1452,2	1013,6	1804,1	-6,0	3,0	2,7	3,0	2,7	59	7,8	6,9	7,8	6,9	95,8	0	0	Null
Eslovaquia-Bodva	118,3	0,0	18,9	99,4	20,1	#	20,0	#	21,5	22	#	43,6	#	46,2	75,3	0	0	Null
España-Segura	1138,8	1138,8	1214,4	37,4		113,1	95,1	113,6	96,8	22	123,7	103,8	124,3	105,7	89,3	16	72,7	Extreme
Finlandia-Paimionjoki	304,8	304,8	309,3	299,8	1,7	1,6	1,9	1,8	1,5	50	12,9	14,5	14,5	12,6	88,9	0	0	Null
Francia-Voulziel	106,5	185,4	75,4	75,0	1,9	1,4	2,9	1,4	2,9	37	45,8	100,0	45,8	100,0	55,6	0	0	Null
Italia-Arno	2802,4	2802,4	2796,2	2450,9	13,1	13,2	13,2	13,2	13,2	14	21,3	21,4	21,3	21,3	91,9	0	0	Null



As an example we have calculated the WEI+_Limit for some countries of which we had data (*Annual practical exercise_v1.xls*), and also the probability of exceeding this value that give us the Level of Risk of Scarcity.

Water Scarcity Risk Map for Spain

Discussion points

- Risk concept
  - Risk based on forecasts approach
  - Risk based on Flood Directive approach
- Selection of a Methodology
  - Flood Directive methodology, step by step
  - Alternative methodology based on WEI+
- Methodology details