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EUROPEAN COMMISSION
Executive Agency for Small and Medium-sized Enterprises (EASME)

H2020 Environment & Resources

HORIZON 2020

ANNEX 1 (part A)

Research and Innovation action

NUMBER — 641811 — IMPREX

Table of Contents

1.1. The project summary

Project Number [1]	641811	Project Acronym [2]	IMPREX

One form per project	
General information	
Project title [3]	IMproving PRedictions and management of hydrological EXtremes
Starting date [4]	01/10/2015
Duration in months [5]	48
Call (part) identifier [6]	H2020-WATER-2014-two-stage
Topic	WATER-2a-2014 Water cycle under future climate
Fixed EC Keywords	Flood forecasting, Integrated management of water, Water resources, Hydrology, Catchment scale water management, Water policy
Free keywords	Climate Change impacts, risk outlooks, risk management, adaptation strategy

Abstract [7]

IMproving PRedictions and management of hydrological EXtremes
For a better anticipation on future high impact hydrological extremes disrupting safety of citizens, agricultural production, transportation, energy production and urban water supply, and overall economic productivity, prediction and foresighting capabilities and their intake in these strategic sectors need to be improved. IMPREX will improve forecast skill of meteorological and hydrological extremes in Europe and their impacts, by applying dynamic model ensembles, process studies, new data assimilation techniques and high resolution modeling. Novel climate change impact assessment concepts will focus at increasing the realism of relevant events by specific high resolution regional downscaling, explore compounding trans-sectoral and trans-regional risks, and design new risk management paradigms. These developments are demonstrated in impact surveys for strategic economic sectors in a set of case studies in which local stakeholders, public organizations and SMEs are involved. A pan-European assessment of risk management and adaptation strategies is applied, minimizing risk transfer from one sector or region to another. As a key outreach product, a periodic hydrological risk outlook for Europe is produced, incorporating the dynamic evolution of hydro-climatic and socio-economic processes. The project outreach maximizes the legacy impact of the surveys, aimed at European public stakeholder and business networks, including user-friendly assessment summaries, and training material.
The project responds to the call by targeting the quality of short-to-medium hydro-meteorological predictions, enhancing the reliability of future climate projections, apply this information to strategic sectoral and pan-European surveys at different scales, and evaluate and adapt current risk management strategies. With its integrative approach, IMPREX will link current management decisions and actions with an emergent future.

1.2. List of Beneficiaries

Project Number [1]	641811	Project Acronym [2]	IMPREX

List of Beneficiaries

No	Name	Short name	Country	Project entry date[8]	Project exit date
1	KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT-KNMI	KNMI	Netherlands		
2	EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	ECMWF	United Kingdom		
3	SVERIGES METEOROLOGISKA OCH HYDROLOGISKA INSTITUT	SMHI	Sweden		
4	INSTITUT NATIONAL DE RECHERCHE EN SCIENCES ET TECHNOLOGIES POUR L'ENVIRONNEMENT ET L'AGRICULTURE	IRSTEA	France		
5	POTSDAM INSTITUT FUER KLIMAFOLGENFORSCHUNG	PIK	Germany		
6	ARCTIK SPRL	ARCTIK	Belgium		
7	BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION	BSC	Spain		
8	MET OFFICE	METOFFICE	United Kingdom		
9	THE RESEARCH COMMITTEE OF THE TECHNICAL UNIVERSITY OF CRETE	TUC	Greece		
10	THE UNIVERSITY OF READING	UREAD	United Kingdom		
11	HELMHOLTZ-ZENTRUM GEESTHACHT ZENTRUM FUR MATERIAL- UND KUSTENFORSCHUNG GMBH	HZG	Germany		
12	STICHTING DELTARES	DELTARES	Netherlands		
13	STICHTING VU	IVM	Netherlands		
14	ADELPHI RESEARCH GGMBH	ADELPHI	Germany		
15	HKV LIJN IN WATER BV	HKV	Netherlands		
16	FUTUREWATER SL	FW	Spain		
17	CETAQUA, CENTRO TECNOLOGICO DEL AGUA, FUNDACION PRIVADA	CETAQUA	Spain		
18	UNIVERSITAT POLITECNICA DE VALENCIA	UPV	Spain		
19	POLITECNICO DI MILANO	POLMIL	Italy		
20	Centro Internazionale in Monitoraggio Ambientale - Fondazione CIMA	CIMA	Italy		

1.2. List of Beneficiaries

No	Name	Short name	Country	Project entry date[8]	Project exit date
21	HELMHOLTZ ZENTRUM POTSDAM DEUTSCHESGEOFORSCHUNGSZENTRUM GFZ	GFZ	Germany		
22	Bundesanstalt fuer Gewaesserkunde	BfG	Germany		
23	STICHTING WATER FOOTPRINT NETWORK	WFN	Netherlands		

1.3. Workplan Tables - Detailed implementation

1.3.1. WT1 List of work packages

WP Number[9]	WP Title	Lead beneficiary[10]	Person-months[11]	Start month[12]	End month[13]
WP1	Project Management	1 - KNMI	38.00	1	48
WP2	Stakeholder involvement and case-studies definition	8 - METOFFICE	22.00	1	48
WP3	Improved Meteorological predictability and climate scenarios	3 - SMHI	195.00	1	48
WP4	Improved predictability of hydrological extremes	2 - ECMWF	150.00	1	48
WP5	Novel concepts for improved impact and risk assessment	13 - IVM	82.00	1	48
WP6	Coordination of Sectoral surveys	1 - KNMI	6.00	1	48
WP7	Sectoral survey: Flood inundation prediction and risk assessments	12 - DELTARES	83.00	1	48
WP8	Sectoral survey: Hydropower	4 - IRSTEA	51.00	1	48
WP9	Sectoral survey: Transport	22 - BfG	37.00	1	48
WP10	Sectoral survey: Urban Water	17 - CETAQUA	39.00	1	48
WP11	Sectoral survey: Agriculture and droughts	16 - FW	74.00	1	48
WP12	Sectoral survey: Water Economy	23 - WFN	48.00	1	48
WP13	Sectoral integration and climate services	11 - HZG	77.00	1	48
WP14	Communication and dissemination	8 - METOFFICE	63.00	1	48
WP15	Ethics requirements	1 - KNMI	N/A	1	48
		Total	965.00		

1.3.2. WT2 list of deliverables

Deliverable Number[14]	Deliverable Title	WP number[9]	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D1.1	Advisory report	WP1	1 - KNMI	Report	Public	21
D1.2	Advisory report 2	WP1	1 - KNMI	Report	Public	39
D1.4	Minutes of 1st GA	WP1	1 - KNMI	Report	Public	12
D1.5	Minutes of 2nd GA	WP1	1 - KNMI	Report	Public	24
D1.6	Minutes of 3rd GA	WP1	1 - KNMI	Report	Public	36
D1.7	Minutes of 4th GA	WP1	1 - KNMI	Report	Public	48
D2.1	Sectoral summary of climate vulnerability and risk practice	WP2	8 - METOFFICE	Report	Public	12
D2.2	Stakeholder interaction protocol	WP2	8 - METOFFICE	Report	Public	6
D3.1	Meteorological re-forecasts	WP3	2 - ECMWF	Other	Public	12
D3.2	Improved short-term prediction of extremes	WP3	3 - SMHI	Other	Public	30
D3.3	Enhanced skill of seasonal predictions	WP3	7 - BSC	Other	Public	30
D3.4	Hydro-meteor. indices	WP3	7 - BSC	Other	Public	30
D3.5	Impact of increased GCM resolution	WP3	3 - SMHI	Report	Public	26
D3.6	Improved extremes in regional climate	WP3	3 - SMHI	Other	Public	32
D4.1	Verification score card	WP4	4 - IRSTEA	Report	Public	12
D4.2	Hydrological model sensitivity	WP4	10 - UREAD	Report	Public	18
D4.3	Forecast skill developments	WP4	12 - DELTARES	Report	Public	44
D4.4	Improved climate projections of hydrological extremes	WP4	8 - METOFFICE	Report	Public	42
D4.5	Lessons learnt for research and operational exploitation	WP4	2 - ECMWF	Report	Public	48
D5.1	White paper on novel concepts	WP5	13 - IVM	Report	Public	6
D5.2	Intermediate report on novel concepts	WP5	13 - IVM	Report	Public	24
D5.3	Final report on novel concepts, chapter 1	WP5	13 - IVM	Report	Public	48

Deliverable Number[14]	Deliverable Title	WP number[9]	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D5.4	Final report on novel concepts, chapter 2	WP5	1 - KNMI	Report	Public	48
D5.5	Final report on novel concepts, chapter 3	WP5	15 - HKV	Report	Public	48
D5.6	Final report on novel concepts, chapter 4	WP5	21 - GFZ	Report	Public	48
D6.1	Sector Survey Report	WP6	1 - KNMI	Report	Public	48
D6.2	Data Management Plan	WP6	2 - ECMWF	ORDP: Open Research Data Pilot	Public	6
D7.1	Correlated flood risk and finance	WP7	13 - IVM	Report	Public	30
D7.2	Compound flood risk events	WP7	15 - HKV	Report	Public	36
D7.3	Flood damage risk assessment	WP7	12 - DELTARES	Report	Public	48
D8.1	Improved hydropower risk assessment	WP8	4 - IRSTEA	Report	Public	48
D8.2	Hydropower policy brief	WP8	4 - IRSTEA	Websites, patents filling, etc.	Public	48
D8.3	Report on needs in hydropower sector	WP8	19 - POLMIL	Report	Public	12
D9.1	Report on vulnerability of water transport	WP9	22 - BfG	Report	Public	12
D9.2	Navigation quality assessment	WP9	22 - BfG	Report	Public	18
D9.3	Potential economic benefit of better forecasts for water transport	WP9	22 - BfG	Report	Public	38
D9.4	Improved transport cost planning	WP9	22 - BfG	Demonstrator	Public	42
D9.5	Impact on adaptive mgmt of transport sector	WP9	11 - HZG	Report	Public	46
D10.1	Fresh water forecasting in urban water system	WP10	17 - CETAQUA	Report	Public	24
D10.2	Impact in Segura and Llobregat basins	WP10	17 - CETAQUA	Report	Public	36
D11.1	Prototype design of drought DSS	WP11	16 - FW	Report	Public	18

Deliverable Number[14]	Deliverable Title	WP number[9]	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D11.2	Index-based drought risk assessment	WP11	16 - FW	Report	Public	36
D11.3	Multihazard drought management tool	WP11	15 - HKV	Report	Public	36
D11.4	Prototype Drought Decision Support system	WP11	16 - FW	Demonstrator	Public	48
D11.5	Climate change in agricultural water accounting system	WP11	16 - FW	Demonstrator	Public	48
D12.1	Dependence of European economy on water issues elsewhere	WP12	23 - WFN	Report	Public	12
D12.2	European economy risks under climate change	WP12	23 - WFN	Report	Public	48
D12.3	Supply and demand strategies affecting future economic damage	WP12	5 - PIK	Report	Public	48
D13.1	Generic integrative modelling approach	WP13	11 - HZG	Demonstrator	Public	20
D13.2	Integrated risk maps	WP13	11 - HZG	Report	Public	32
D13.3	Prototype hydrological module	WP13	18 - UPV	Demonstrator	Public	34
D13.4	Guide on modelling for decision making in the water sector	WP13	11 - HZG	Report	Public	40
D13.5	White paper about adaptation options	WP13	11 - HZG	Report	Public	44
D13.6	Evaluation of EU water-related frameworks	WP13	14 - ADELPHI	Report	Public	48
D14.1	Communication strategy plan	WP14	6 - ARCTIK	Report	Public	6
D14.2	Dissemination and exploitation plan	WP14	6 - ARCTIK	Report	Public	6
D14.3	First summary of outreach activities	WP14	6 - ARCTIK	Report	Public	6
D14.4	IMPREX logo & website	WP14	6 - ARCTIK	Websites, patents filling, etc.	Public	6

Deliverable Number[14]	Deliverable Title	WP number[9]	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D14.5	Protoype hydrometeorological risk outlook	WP14	8 - METOFFICE	Demonstrator	Public	36
D14.6	Policy briefs of EU Water-related actions	WP14	14 - ADELPHI	Report	Public	48
D14.7	Synthesis brochure on risk mgmt	WP14	14 - ADELPHI	Report	Public	48
D14.8	Brochure, videos and press briefing on climate risk mgmt	WP14	6 - ARCTIK	Websites, patents filling, etc.	Public	48
D14.9	Fact sheets on lessons learnt	WP14	14 - ADELPHI	Report	Public	48
D14.10	Workshp agenda and participant lists	WP14	8 - METOFFICE	Report	Public	46
D15.1	H - Requirement No. 1	WP15	1 - KNMI	Ethics	Confidential, only for members of the consortium (including the Commission Services)	6
D15.2	H - Requirement No. 2	WP15	1 - KNMI	Ethics	Confidential, only for members of the consortium (including the Commission Services)	6

1.3.3. WT3 Work package descriptions

Work package number [9]	WP1	**Lead beneficiary** [10]	1 - KNMI
Work package title	Project Management		
Start month	1	**End month**	48

Objectives

This WP ensures the efficient and timely implementation of project activities, resource allocation and measures maximizing the benefits of the project. It does so by managing the project at 3 levels:
• Strategic management
o Stakeholder involvement and coordination of Sectoral user groups
o Organization of the Science and Service Advisory Board
o Strategic decision making about the evolution and exposure of the project
o Maintain and utilize links with (inter)national programs and projects
• Operational management
o Legal affairs
o Internal communication and meetings, and facilitating partner collaboration
o Reporting to and communication with the EU
o Data management
o Quality assurance
• Risk management
o Guarding progress and budget
o Organize and process an external review
o Implement a Risk contingency plan.

Description of work and role of partners

WP1 - Project Management [Months: 1-48]
KNMI, ARCTIK
The project is designed following a 3-level project management structure, consisting of a Coordination level, Decision taking level, and an external advisory level. The management structure is described in more detail in section 3.2. The entities that are related to the project are (see also Figure 3.4):
Coordination level
• Coordination unit: Project Leader, Administration manager, Data manager, Communication manager, WP-leaders from main WPs
• Sectoral groups: IMPREX partners and stakeholders involved in the case studies addressed in WP6*.
Decision taking level
• Management Board: leaders of all WPs
• General Assembly: delegates of all project partners
Advisory level
• Science and Services Advisory Board: scientific specialists in forecasting, scenarios, stakeholder interaction, risk assessment, and representatives of key sectoral organisations.

Task 1.1: Administrative, legal, and financial coordination (KNMI)
Administrative coordination involves the execution of the overall administrative, legal, and financial responsibilities of the Coordinator. More specifically, this coordination will include the following tasks:
• Coordinate the formation of a Consortium agreement on data exchange, Intellectual Property Rights and the decision taking structure of the consortium;
• To collect appropriate legal, administrative, and financial documentation from the partners;
• To chair formal meetings of the project bodies;
• To operate the financial management of the project;
• To take on the role of intermediary for all communication between the contractors and the EC.

Task 1.2: Consortium coordination, reporting, deliverable production and quality management (KNMI, Arctik, ECMWF, SMHI, HZG-CSC, Deltares, METOFFICE)

On a day-to-day basis the general animation and coordination of the consortium will be assured through implementation of the following tasks:
• Partner communication and coordination
o organizing the kick-off meeting securing partner consensus on the vision, mission, and operational plan for IMPREX.
o all partner consortium meetings are planned to take place approximately every 12-18 months in line with the different stages of development of the project.
o In between all partner consortium meetings, individual WP leaders will organise regular meetings and conference calls between partners involved in the different work packages of the project.
• Reporting
o The Coordination Unit will coordinate the preparation of all required periodic activity and management reports and project reviews for the EC, summarising progress on project tasks, deliverables, and budget usage and reporting any deviations and corrective actions put in place. Three reporting periods are implemented at M18, M30 and M48.
• Deliverable production and quality assurance
o The Coordinator will take overall responsibility to ensure that the deliverables of the project are produced on time and to the required quality level.
o The first production of deliverables will be managed at WP level.
o Before submission to the EC, the quality of all deliverables will be checked at 3 levels by: the partner responsible for producing the deliverable; the WP leader; and the Coordinator. Any issues with quality will be resolved before final approval and submission to the EC.
o Two independent external reviews of the project will be commissioned to the Science and Services Advisory board: a midterm review (M30) and an end review (M48).

Task 1.3: Strategic, operational, and risk management (KNMI)
• Strategic Management
o Periodic validation of the consortium targets (at least twice over the project duration)
o Communication of these orientations to all the project stakeholders using the dissemination actions, in particular with regards the plans for exploitation of results during the project and after project conclusion.
o Adjustments of the development trajectory in case of unforeseen events detected by a continuous surveillance of the project environment (technical, technological, economical, social, etc.).
The members of the Science and Services Advisory Board will play a crucial role in providing direction and advice to the Management Board and will assist in dissemination and exploitation of project results at a strategic level.
• Operational Management
o Each of the WP leaders will be responsible for ensuring the efficient and timely organisation of key tasks and deliverables for the specific WPs that they are leading. This requires coordination of the work of each of the partners involved in the WP. The Coordinator will provide support to all WP leaders in the execution of their responsibilities.
• Risk Management process and contingency plans
o WP leaders will present an assessment of progress, and risks to progress, at the Management Board meeting every six months and propose practical contingency plans where necessary to address any specific identified risks. The type of risks that will be covered in the risk management process include: operational risks; personnel allocations; and time/ budget allocation rules (see section 3.2).

Participation per Partner

Partner number and short name	WP1 effort
1 - KNMI	35.00
6 - ARCTIK	3.00
Total	38.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D1.1	Advisory report	1 - KNMI	Report	Public	21
D1.2	Advisory report 2	1 - KNMI	Report	Public	39
D1.4	Minutes of 1st GA	1 - KNMI	Report	Public	12
D1.5	Minutes of 2nd GA	1 - KNMI	Report	Public	24
D1.6	Minutes of 3rd GA	1 - KNMI	Report	Public	36
D1.7	Minutes of 4th GA	1 - KNMI	Report	Public	48

Description of deliverables

• D1.1: Advisory report 1 (review of project progress) covering M1-M18 (KNMI + all partners) (M21).
• D1.2: Advisory report 2 covering M19-M36 (KNMI + all partners) (M39)
• D1.3: Final advisory report covering M37-M48 (KNMI + all partners) (M48)
• D1.4: Minutes of General Assembly and Science and Service Advisory board meetings (KNMI, Arctik) (M48)

D1.1 : Advisory report [21]

• D1.1: Advisory report 1 (review of project progress) covering M1-M18

D1.2 : Advisory report 2 [39]

• D1.2: Advisory report 2 covering M19-M36

D1.4 : Minutes of 1st GA [12]

Minutes of 1st General Assembly

D1.5 : Minutes of 2nd GA [24]

Minutes of 2nd General Assemby

D1.6 : Minutes of 3rd GA [36]

Minutes of 3rd General Assembly

D1.7 : Minutes of 4th GA [48]

Minutes of the 4th General Assembly

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	GA meeting 1	1 - KNMI	12	General Assembly meetings
MS2	GA meeting 2	1 - KNMI	24	GA meeting 2
MS3	GA meeting 3	1 - KNMI	36	GA meeting 3
MS4	GA meeting 4	1 - KNMI	48	GA meeting 4
MS5	Midterm review	1 - KNMI	21	Midterm review
MS6	Final review	1 - KNMI	39	Final review

Work package number [9]	WP2	Lead beneficiary [10]	8 - METOFFICE
Work package title	Stakeholder involvement and case-studies definition		
Start month	1	**End month**	48

Objectives

Coordinate stakeholder interaction

Description of work and role of partners

WP2 - Stakeholder involvement and case-studies definition [Months: 1-48]
METOFFICE, KNMI, ARCTIK, BSC, HZG, DELTARES
One of the first activities of WP2 is to identify a small set of heavily involved users for each of the key sectors, which will largely be based on the stakeholders involved in WP7-12. This core-group of users will form the nucleus of the IMPREX user groups. These groups will be organised on a sectoral base and meet two to four times a year for a few hours at a time. they will provide the key feedbacks and requirements for the specific sector. A combination of teleconference and physical meeting will ensure dynamic interaction. In line with the activities of WP7-12 the groups will work on: agriculture, insurance, infrastructure, water-borne transport, hydroelectric power generation, and drinking water quality. interested parties that are not yet involved in IMPREX are invited to participate in these sectoral user groups. JRC has already expressed its Interest to participate in flood, drought and hydropower planning . Moreover, stakeholders responsible for the implementation of relevant EU directives (WFD/FD) will be invited especially for the two case study regions included in WP7 to ensure the integration of IMPREX climate services into decision making.
In order to ensure the consistency of the project a clear protocol for the interaction with the users will be defined and shared among all project partners. On the one hand, this protocol will ensure that any pre-existing relationship between partners and stakeholders are preserved in the project. On the other hand, the protocol will minimise the stakeholder fatigue by detailing roles, responsibilities and the outcomes that are expected at any given time during the project. For example, the level of commitment expected from each stakeholder and a preliminary calendar of the interactions will be defined at this stage.

Task 2.1: Development of the project dissemination and exploitation plan (METOFFICE, all partners)
This task will identify end users and indirect beneficiaries of the project and design an exploitation plan which will maximise the benefit of the project for both project users involved in the WP6 case-studies and the European community at large. This task is a joint effort with WP14 which focuses on communication and outreach activities beyond the project boundaries. The deliverable corresponding to this task is included in D14.1.

Task 2.2 definition of a protocol for project-user interaction. (METOFFICE, all partners)
This task is devoted to the development of a clear protocol for the interaction between the project and its users. Given the commercial sensitivities of some of the services that may derive from IMPREX it is important that the rules of engagement are made clear to all people involved in the project from the very start. Among other things the protocol will clarify what role (and which level of involvement) each stakeholder is expected to play in each case-study.

Task 2.3: Targeted interview and small interactive workshop with the member of the user groups. (Arctik, BSC)
A series of targeted interviews and interactive workshops will be used to acquire knowledge about the specific needs of the project users. This, once put in the context of the already existing literature on this topic, will provide the whole consortium with a good understanding of the users’ needs that are still unmet by the existing technologies. These workshops are organized in close collaboration with WP6*.

Task 2.4: Presentation of main of users’ needs to project partners. (METOFFICE, all partners)
This last task will ensure that all knowledge on users’ needs that has been acquired during the initial phase of the project is effectively transferred to all project partners to influence the relevant scientific and technical developments within IMPREX.

Participation per Partner

Partner number and short name	WP2 effort
1 - KNMI	2.00

Partner number and short name	WP2 effort
6 - ARCTIK	6.00
7 - BSC	5.00
8 - METOFFICE	6.00
11 - HZG	2.00
12 - DELTARES	1.00
Total	22.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D2.1	Sectoral summary of climate vulnerability and risk practice	8 - METOFFICE	Report	Public	12
D2.2	Stakeholder interaction protocol	8 - METOFFICE	Report	Public	6

Description of deliverables

• D2.1: Summary report highlighting the specific climate vulnerability, sensitivity and exposure and the risk management practice for each stakeholder involved in the WP7-12, as identified in Task 2.4 (METOFFICE, Arctic, HZG, BSC, KNMI, Deltares) (M12)
• D2.2: Rules of engagement for project –users interaction developed and distributed to partners, including interview template and text of the informed consent (METOFFICE, BSC) (M6)

D2.1 : Sectoral summary of climate vulnerability and risk practice [12]

Summary report highlighting the specific climate vulnerability, sensitivity and exposure and the risk management practice for each stakeholder involved in the WP6*

D2.2 : Stakeholder interaction protocol [6]

Rules of engagement for project –users interaction developed and distributed to partners, including interview template and text of the informed consent

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS7	Internal workshops to summarise the main users' requirements	6 - ARCTIK	12	Internal workshops to summarise the main users' requirements

Work package number [9]	WP3	**Lead beneficiary** [10]	3 - SMHI
Work package title	Improved Meteorological predictability and climate scenarios		
Start month	1	**End month**	48

Objectives

The goal of this WP is to improve the skill of hydro-meteorological forecasts and the reliability of climate projections, in order to provide better predictions of precipitation and extreme events. Based on state-of-the-art systems knowledge, methods and important processes will be explored and added in order to improve forecast on time scales from hours to seasons. Results will enhance the value of climate projections te better assess future precipitation statistics, extremes and its variability. This goal is condensed to two major objectives:
• Improve the predictability of the water cycle and precipitation on short-to-seasonal time scales
• Explore variability and extremes in recent and future climate, and improve the ability to simulate those.
The objectives will be met by upgrading and evaluating short-term to sub-seasonal forecasting systems (task 1), seasonal hydro-meteorological prediction (task 2) and long-term precipitation climate projection (task 3). In addition to model improvement, the usability of resulting precipitation will be amplified by downscaling and postprocessing enhancing the signal. Progress in WP3 will further benefit from utilizing existing collaborations with multi-model initiatives in the field of sub-seasonal and seasonal prediction (S2S, NMME and EUROSIP)
The work in WP3 is linked to WP4 where skill-improved prediction systems provided by WP3 are evaluated from a hydrological perspective and are further processed. The models developed in WP3 provide improved methods and are a precondition for better forecast and projection that feed into sectorial impact assessment applications (WP6) on regional and local scale). Detailed needs that arise during the sectorial studies are channelled through WP2, which coordinates the various impact studies.
The improved predictability feeds into more reliable climate services and better quantification of uncertainties. Scientific results on e.g. the amplitude of improvement of seasonal forecast or climate projection, will be transformed into risk reduction and adaptation strategies in WP13, and communicated via the outreach activities in WP8. Improved skills in short term and seasonal prediction and outcomes from international collaborations such as S2S, NMME and EUROSIP will contribute to the semi-operational hydrological risk outlook for Europe (WP14).

Description of work and role of partners

WP3 - Improved Meteorological predictability and climate scenarios [Months: 1-48]
SMHI, KNMI, ECMWF, BSC, METOFFICE, TUC, UREAD
Task 3.1: Improved forecast of short term and sub-seasonal precipitation (ECMWF, SMHI, BSC)
Forecast of precipitation and hydrological variables relies on numerical weather prediction (NWP) systems, that define the scene on which statistical correction methods and hydrological models can act. Task 1 invests in targeted improvement of NWP systems and re-forecasts of meteo-hydrological weather. All development activities focus on key meteorological variables that are of importance to hydrological impact.
In this task, IMPREX will estimate the current skill of the existing, state-of-the-art, operational NWP systems with focus on precipitation extremes for short and medium range weather forecasts. Improvement of short-term (days) prediction of extreme precipitation events is planned by assimilating surface remote sensing data regarding snow and soil moisture (Harmonie NWP model by SMHI). Land surface data inclusion is crucial for a skilful weather forecast at short and medium range . The assimilation procedure will be further improved by including new horizontal background error variation to better derive small scale variations in surface conditions and thereby improve the prediction of detailed precipitation . This work regarding the update of the meteorological model's capability and state, based on remote sensing data, feeds into Task 4.3. The resulting system will immediately provide improved short-term forecast capabilities, especially concerning local moisture conditions and hydrological impact. The development domain covers Northern Europe and the work links directly to case studies in WP8. Effect of the newly introduced assimilation will then even be assessed over an Iberian Peninsula domain (by means of implementation in a reforecast in WP4.1), which links to the IMPREX case studies on Spanish river basins.
On a global scale, ECMWF's prediction system will release an improved meteorological (retrospective) ensemble re-forecast with lead times of 1-15 days. The re-forecast allows for model errors to be diagnosed and corrected, thereby systematically increasing the forecast skill. Output links to case studies in WP6 (hydropower, transport and agriculture). IMPREX will utilize international collaborations to study the sub-seasonal scale forecast quality of hydrometeorological variables in the new operational Sub-seasonal-to-Seasonal project (S2S), around 10 operational

systems are contributing. Those studies cover the whole of Europe and parts of Northern Africa, which links to IMPREX case studies for hydropower and agriculture on a central-European scale. The analysis is focussed on the first month of forecast as part of the S2S multi-model quasi-operational predictions.

Task 3.2: Improved skill of seasonal prediction of water cycle and precipitation (BSC, METOFFICE ECMWF, TUC, UREAD)

Skilful seasonal forecast requires representation of decisive processes and teleconnection patterns such as the North Atlantic Oscillation (NAO)3. State-of-the-art sub-seasonal to seasonal prediction systems will be applied retroactive for development and testing, and for actual forecasts. Skills are estimated and post-processing extracts usable signals of meteorological and hydrological quantities.

In this task, IMPREX will estimate the current skill of the existing, state-of-the-art, operational seasonal forecast systems for hydro-meteorological variables, with a focus on the prediction of intra-seasonal extremes. The forecast quality of hydro-meteorological variables in the current operational seasonal forecast systems NMME (6 quasi-operational systems) and EUROSIP (4 operational systems), will be scrutinized. The study will cover the whole of continental Europe and parts of North Africa. With that evaluation as a base, seasonal prediction of precipitation-related variables will be improved.

Precipitation forecasts are afflicted by spatially and temporarily varying errors. Advanced post-processing and bias correction needs to take different weather situations into account and the correction schemes aim to shift displaced anomalies to their correct location. Post-processing routines will be enhanced to improve the signal to noise ratios of key processes such as the NAO. Further emphasis will be given to the optimal extraction of the frequency of daily localized extremes through a combination of statistical post-processing such as deconvolution, statistical downscaling and weather type analysis, addressing both flooding and water scarcity.

An additional effort makes use of variability modes and correct simulated precipitation for selected modes of variability for which the forecast model has proven skill. The method does not rely on a one-to-one direct correspondence between the observational and model modes, a restriction of previous methods. Following the same principles, forecasts from sub-seasonal and seasonal scale will be merged in an optimized way. Statistical downscaling of seasonal predictions will also be carried out in WP6.

Further improvement of skill is expected from more suitable ways of initialization of an increased number of model sub-components ("coupled initialization") and from enhancing assimilation methods. In addition to initialization of ocean and sea ice, initialization of land surface promises further improvement . Studies will be carried out covering effects by initialisation of land parameters such as soil moisture and snow and other land variables (BSC). Initial fields for land initialisation will be generated by nudging techniques applied to atmosphere, ocean and sea ice components (BSC). The comparison of the different initialization strategies (with or without inclusion of land-surface fields) allows the benefit of land-surface initialization to be assessed, along with the impact on prediction uncertainty on different variables and time-horizons.

IMPREX links the seasonal forecasting systems of METOFFICE, ECMWF and BSC, evaluated as described above, with their various improvements to case studies in WP6 (as indicated in Figure 3.2) by providing ensemble re-forecasts (temperature and precipitation, standardized Precipitation Index SPI, Evapotranspiration Index SPEI and Standardised Runoff Index SRI) to study the impact on exemplary sectors and regions. This includes assessing agricultural drought risk , impacts on hydropower and economy.

As a sensitive area, a special consideration is given here to the Eastern Mediterranean area, where seasonal prediction skill is promising already based on today's results . TUC will evaluate the different retrospective seasonal forecasts over that area and provide results to WP7 (flood damage) and WP10 (urban water).

Task 3.3: Enhanced value in climate projections of precipitation extreme conditions and variability (SMHI, KNMI, METOFFICE, UREAD)

To advance assessment of future risk potential due to climate change, global climate projections will be analysed for variability of extreme precipitation and connected meteorological processes. Existing CMIP5 simulations will be complemented by new CMIP-style IMPREX climate scenario simulations with updated high-resolution global climate models (GCMs) (EC-Earth with T511 for the atmosphere and 0.25 deg for the ocean or higher and HadGEM3 with n512 in the atmosphere). Both climate models are among the highest resolution GCMs in current use. Increasing the resolution is expected to improve the representation of cyclones and blocking statistics . Thus, evaluation and analysis will concentrate on cyclone tracking (TUC), blocking (UREAD) and circulation indexes (SMHI), and explore how related improvements in IMPREX GCM simulations lead to better representation of precipitation and hydrological extremes by improved large scale circulation.

In this task, IMPREX will estimate the current skill of the existing, state-of-the-art, regional climate models at a wide range of horisontal resolutions including convective-permitting scales with focus on precipitation extremes. To add extra value to the assessment of future extreme conditions, dynamical regional downscaling by non-hydrostatic climate models will be utilized in unprecedented very high resolution (from 8 km Central-European and 2 km for regional

areas to 100 m for selected local study areas) for climate time slices based on reanalysis, pre-existing and up-to-date IMPREX-generated global climate scenario simulations. Recent results point out the critical importance of convection-permitting resolution to reflect the growing importance of convective precipitation rather than stratiform precipitation in a warming climate (Kendon et al. 2012). Results will allow for more reliable risk assessment for future climates, that goes far beyond of what can be achieved from existing CORDEX simulations, which had been carried out largely with hydrostatic models in much coarser resolutions.
Additional downscaling will be carried out for selected weather types and cases by developing high resolution future analogues of large flooding in summer for central European catchment areas, with the help of the regional climate model RACMO (KNMI) at 5 km resolution, as downscaling of IMPREX GCM runs. Furthermore, a very high resolution downscaling (2.5 km) for ~50 selected weather cases over the Benelux region in recent climate and in future climate projections will be carried out. Weather cases will be selected with the highest potential for convective precipitation in local domains and are coordinated with the transport case study in WP9. The downscaling activities benefit from the participants experience in the COST action “VALUE”.
The climate model output will be analysed and enhanced by different ways of post processing. Bias correction will be carried out in the case studies (WP6) according to the respective sector's needs. In this WP3, an exemplary novel correction of precipitation fields will be pursued, using novel multi-segment statistical bias correction of daily GCM and RCM precipitation, targeting the eastern Mediterranean case study WP11.
For better applicability of downscaling results, SPI, SPEI, SRI and related indices from future climate projections will be provided for a central-European domain, the Iberian peninsula, an Eastern Mediterranean domain and Northern Europe. In addition to downscaling of IMPREX-generated climate projections, further downscaling of existing simulations will be performed. METOFFICE provides a test case for extremely high resolution and analyses downscaling for the UK, building on earlier work for the Southern UK with a nation-wide resolution of 1.5 km (for present-day and future timeslices), and down to ~100m for three selected UK catchments (Lancashire Eden, Hampshire Avon, Wensum), for specific short-run events. Resulting knowledge on events will be explored for more general application, and will be applied in WP11 focusing for example on long dry spells followed by heavy rain, which trigger soil and nutrient loss. Extreme rainfall statistics will also be explored for future time periods over the areas of the WP6 case study areas Northern Europe, Iberian peninsula and Eastern Mediterranean (TUC and SMHI), with a focus on short sub-daily extremes, which are so far under-explored and are expected to increase more rapidly and stronger than those on longer timescales. As reference, high temporal resolution gauging met networks will be used.

Participation per Partner

Partner number and short name	WP3 effort
1 - KNMI	30.00
2 - ECMWF	20.00
3 - SMHI	44.00
7 - BSC	36.00
8 - METOFFICE	31.00
9 - TUC	12.00
10 - UREAD	22.00
Total	195.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D3.1	Meteorological re-forecasts	2 - ECMWF	Other	Public	12

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D3.2	Improved short-term prediction of extremes	3 - SMHI	Other	Public	30
D3.3	Enhanced skill of seasonal predictions	7 - BSC	Other	Public	30
D3.4	Hydro-meteor. indices	7 - BSC	Other	Public	30
D3.5	Impact of increased GCM resolution	3 - SMHI	Report	Public	26
D3.6	Improved extremes in regional climate	3 - SMHI	Other	Public	32

Description of deliverables

• D3.1: A retrospective meteorological ensemble 1-15 day re-forecast (ECMWF) (M12)
• D3.2: An improved system for short-term prediction of extreme precipitation events (SMHI) (M30)
• D3.3: New methods to enhance the skill of seasonal prediction system compared to current skills for hydro-meteorological variables in operational systems (BSC, ECMWF, METOFFICE, TUC) (M30)
• D3.4: Hydro-meteorological indices from successively improving seasonal prediction systems, for sectoral impact assessment in WP6 (BSC) (M30)
• D3.5: Report of the impact of increased GCM resolution on representation of quantities relevant for precipitation over Europe (e.g. cyclones, blocking statistics and NAO) (SMHI, UREAD, TUC) (M26)
• D3.6: Improved representation of hydro-meteorological extremes in climate scenarios by weather analogues (SMHI, KNMI, METOFFICE, TUC) (M36)

D3.1 : Meteorological re-forecasts [12]

A retrospective meteorological ensemble 1-15 day re-forecast

D3.2 : Improved short-term prediction of extremes [30]

An improved system for short-term prediction of extreme precipitation events

D3.3 : Enhanced skill of seasonal predictions [30]

New methods to enhance the skill of seasonal prediction system compared to current skills for hydro-meteorological variables in operational systems

D3.4 : Hydro-meteor. indices [30]

Hydro-meteorological indices from successively improving seasonal prediction systems, for sectoral impact assessment in WP6

D3.5 : Impact of increased GCM resolution [26]

Report of the impact of increased GCM resolution on representation of quantities relevant for precipitation over Europe (e.g. cyclones, blocking statistics and NAO)

D3.6 : Improved extremes in regional climate [32]

Improved representation of hydro-meteorological extremes in climate scenarios by weather analogues

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS8	Reference seasonal forecast data sets	7 - BSC	12	Reference data sets collected and disseminated (retrospective forecasts (ECMWF), seasonal forecasts
MS9	Regional domains prepared	3 - SMHI	24	Regional domains prepared for dynamical downscaling with non-hydrostatic regional climate models in very high resolution
MS10	Updated data sets of short term and seasonal predictions	3 - SMHI	24	Updated version of data sets available (short term predictions (SMHI), seasonal predictions (BSC), downscaled weather events (KNMI)
MS11	New developments tested for high resolution climate scenarios	3 - SMHI	32	New developments tested (Climate scenarios (SMHI))

Work package number [9]	WP4	**Lead beneficiary** [10]	2 - ECMWF
Work package title	Improved predictability of hydrological extremes		
Start month	1	**End month**	48

Objectives

Hydrological and water resource applications, including forecasting and risk management for shipping, hydropower, agriculture and civil protection are extremely sensitive to the amount, distribution, frequency and intensity of precipitation attributes . Precipitation frequency influences flood and drought related agricultural risks and precipitation intensity strongly influences water quality . The impact of changes to these precipitation attributes on water resource applications is highly complex to calculate, with different sensitivities found across different time scales and between different applications . A better scientific understanding of the natural water cycle variability and extremes is required , yielding an integrated vision of the atmospheric and hydrologic processes to support water management. The current generation of numerical weather prediction systems issue precipitation forecasts that suffer from some severe limitations in quality when it comes to their effective use in hydrological applications, including their accuracy in localizing extreme events in space and time and their reliability in quantifying uncertainties . Improving these forecasts is the key to improving the forecasting of water related natural hazards and the risk they pose to sectoral applications over various time scales, from medium-range to sub-seasonal and climate scales. This is one of the mains topics of the HEPEX initiative concerning present climate . In addition, improved assessments of future climate conditions can likewise benefit from making today’s predictions better. Putting current day extremes and their forecasts in the context of future climate conditions is a new challenge for both hydrometeorological forecasters and water managers.
The main objective of this work package is to improve the hydro-meteorological forecasting chain in terms of hydrological hazards, such as floods and droughts at various lead times. New improved hydrological processes schemes and data assimilation methods will be combined with improved NWP models as well as climate models (from WP3) to produce improved hydrological predictions and outlooks that have an impact on the quality of water and risk management decisions. This work package will lead to:

1. A first release of a reforecast dataset of regional and European-wide risks of exceeding critical hydrologic thresholds for various strategic highly vulnerable water resources applications and considering hydrologic hazards at various lead times. This reforecast will represent a reference where new applications can collect essential information on past situations;
2. The assessment of the degree to which available hydro-meteorological data sources can improve the modelling of hydrological processes and enhance the quality of hydrologic forecasts through data assimilation techniques;
3. The improvement of the representation of the hydrological processes in land surface schemes which are essential to capture the hydrological extremes from short- to medium-range and climatic scales;
4. The assessment of the improved performance of a multi-model hydrological forecasting system through advanced model combination techniques;
5. The validation of improvements through the development of score cards that are specifically designed to bring information on the performance of a forecasting system to targeted users’ applications. A new perspective will be introduced: the definition of metrics to evaluate the quality of a forecast based on its usefulness in water risk decision-making. This is essential to assess the effects of the different system’s improvements and efficiently convey the right information about the quality of the reforecast at different space-time scales to stakeholders and their decision-making problem;
6. Provide input for the seamless ensemble-based advanced hydrological risk outlook (WP14) from the short- through the medium-range scale with associated uncertainty estimates based on the quality analysis of the reforecast dataset;
7. Hydrological ensemble outputs for monthly to seasonal time scales in near-real-time to provide input to the risk outlook tool developed in WP14;
8. Assessment of the potential future changes in flood hazards along with its associated uncertainties (by driving a robust multi-model hydrological system with the WP3 climate scenarios);
9. A comprehensive reporting of products with a clear end-user focus.

The objectives will be achieved through 4 tasks, detailed below. In Task 4.1, a reforecast of hydrological extremes in Europe will be created for the time period from 1980 to 2015. In Task 4.2, the role of precipitation forcing from short- to medium-range and up to climate scales will be analysed, using also the improved precipitation forecasts of extremes from WP3. Data assimilation to improve the hydrological assessment of initial catchment conditions and uncertainty analyses to quantify the sensitivity of hydrological extreme predictability to improved forcing will be the main activities in Task 4.3. This work will lead to improved unified short- to medium-range forecasts of hydrological extremes, which will be further used in the sectoral applications in WP6. They will also contribute to a near-real-time forecast tool for monthly to seasonal timescales that will be set up in the risk outlook of WP14. In Task 4.4, the multi-model hydrological models will be used to produce future projections of the changes to hydrological extreme events.

Description of work and role of partners

WP4 - Improved predictability of hydrological extremes [Months: 1-48]
ECMWF, SMHI, IRSTEA , METOFFICE, TUC, UREAD, DELTARES, FW, UPV, CIMA, BfG
WP4 links to WP3 as it integrates current and improved precipitation (and other hydrological hazard related variables) datasets and products generated in WP3 for short, medium and climate scales, and evaluates these products from a hydrological perspective. Case studies from WP6 will use the products provided here in several sectoral applications and provide feedback on how these products improve the value of forecasts and predictions in concrete applications. WP4 will provide assessments of the key hydrological hazards at the European scale that will be used in the risk assessment of each sectorial application in WP6. WP14 will use hydrological outputs to create a risk outlook for monthly-seasonal timescales.
This work package will benefit from a large range of specialized hydrological models and their optimization towards the sectorial applications

Task 4.1: Development of the regional and European scale reforecast dataset of hydrological extremes (ECMWF, IRSTEA, Deltares, CIMA, BfG, UoR, SMHI, TUC, METOFFICE)
To understand current climate and the quality of current forecasts we will use the various hydrological models to generate a single unified current state-of-the-art reforecast dataset of hydrological extremes . This will build on the work done in the other FP7 projects (see Table 1.1). The reforecast dataset will allow the sectoral applications to understand current skill and strengths of individual hydrological models for their specific needs. It will further serve as guidance for the hydrological model improvements in this work package (Tasks 4.3 and 4.4). The reforecast generated here will also be used in the multi-model combination in Task 4.5. This hydrological reforecast dataset will be based on short- to medium-range and sub-seasonal to seasonal meteorological reforecasts from the UK METOFFICE and ECMWF, including post-processing enhancements from WP3.2. We will verify the hydrological reforecasts on the regional and European scales. Verification will be based on hydrologic threshold exceedances for various hydrologic variables (e.g. peak discharges, flow volumes) and with a particular focus on hydrological extremes (towards high and low flows). It will use new and existing datasets (e.g., streamflow used in the UN-ISDR's 2013 Global Assessment Report on Disaster Risk Reduction (GAR 2013). The verification will stretch from the short, to medium and climatic ranges.

Task 4.2: Analysis of the impact of changes in precipitation attributes from short to medium and climatic ranges (UREAD, ECMWF, Deltares, BfG, FW, IRSTEA)
Building on the uncertainty analyses performed in the FP7 project EUPORIAS, we will perform a full formal sensitivity analysis (e.g. SOBOL or OAT) to establish the sensitivity of hydrological models' responses to precipitation attributes and its uncertainties across various time scales. In particular, this task will test sensitivities of precipitation from different meteorological forecast systems employed in WP3, investigating the impacts of different ways of initializing and producing predictions on the hydrological responses for extremes. This task will produce a 'hydrological sensitivity chart' informing Task 4.3 where targeted improvements should focus. It will also provide evidence of the hydrological impacts of the improvements achieved in WP3. In order to canalize the impact analysis towards helpful and informative scores for stakeholders, this task will also develop score cards where the effect of improvements in hydrological model response is easily visualized, communicated to and understood by users). The verification will be performed against hydrologic gauging stations across Europe using appropriate statistical scores. These score cards will also be used to quantify the effects of the improvements described in Task 4.3.

Task 4.3: Improving forecast skill of extreme events through data assimilation and multi-model combination across time scales (Deltares, BfG, CIMA, ECMWF, SMHI)
Data assimilation is a key system component in improving forecast skill and reducing uncertainties in hydrology4, differentiating the act of forecasting for real-time decision-making from the process of continuous simulation of hydrological response for processes understanding. In this task, we will use state-of-the-art data assimilation schemes to assimilate gauge data (precipitation, snow depth, lake levels, discharge) and remote sensing data (soil moisture, snow cover, precipitation - e.g. from EUMETSAT and HSAF) into hydrological forecasting systems. Data assimilation will be investigated considering also the interactions with the post-processing of the predictions from WP3 that will be used as input forcing to the models. This provides a new perspective for improving forecast quality, with a useful guidance towards where efforts on forecast improvements can be more efficient for water managers . In addition, new and unconventional data (e.g., evapotranspiration from remote sensing, ground water extraction, irrigation, river levels) will be used to initialise and nudge hydrological models. This task will apply state-of-the-art model combination techniques, such as Ensemble Copula Coupling (ECC), Bayesian model averaging (BMA) and Non-homogenous

Gaussian regression (NGR) in order to increase the performance of modelling of hydrological extremes by weighting models according to their previous performance (using the score cards developed in Task 4.2). Finally, we will establish a framework for the provision of near-real-time monthly-seasonal integrated multi-model hydrological forecasts to WP14, where a hydrological risk assessment tool will be developed.

Task 4.4 Improving predictions on the climate scale (METOFFICE, HKV, UPV, FW, BfG)
This task will provide improved hydrological hazard assessments to be used as input to produce improved risk management strategies in water-related decisions for the future . The hydrological modelling results from Task 4.3 will be used together with the newly developed ERACLIM ensemble reanalysis to estimate historical water hazards. High resolution climate model outputs from WP3 (Task 3.3, EC-Earth, HadGEM3, and km-scale local downscaling) will be used to estimate the future risks of hydrological variables of interest to the sectoral impact applications in WP6. This includes activities focusing on: impacts of sea level increase on urban areas, impacts of increase/decrease of inflows on hydropower dam operations, impacts of decreasing river levels on shipping and commercial navigation, etc. A particular focus will be placed on drought evolution on the climate time scale and its possible impacts on agriculture, water supply and other sectors.

Participation per Partner

Partner number and short name	WP4 effort
2 - ECMWF	23.00
3 - SMHI	26.00
4 - IRSTEA	12.00
8 - METOFFICE	16.00
9 - TUC	6.00
10 - UREAD	18.00
12 - DELTARES	23.00
16 - FW	6.00
18 - UPV	6.00
20 - CIMA	6.00
22 - BfG	8.00
Total	150.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D4.1	Verification score card	4 - IRSTEA	Report	Public	12
D4.2	Hydrological model sensitivity	10 - UREAD	Report	Public	18
D4.3	Forecast skill developments	12 - DELTARES	Report	Public	44
D4.4	Improved climate projections of hydrological extremes	8 - METOFFICE	Report	Public	42

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D4.5	Lessons learnt for research and operational exploitation	2 - ECMWF	Report	Public	48

Description of deliverables

• D4.1: Verification score card for hydrological reforecasts (and initial testing on re-forecast data) by reviewing the most appropriate verification scores for the sectoral applications with particular focus on highly vulnerable water resources of strategic importance (IRSTEA, CIMA, BfG, UREAD, SMHI, TUC, Met Office) (M12)
• D4.2: Report on sensitivity of hydrological model outputs relevant for sectoral applications towards the role and attributes of precipitation forcing, focusing on water cycle variability at local/regional scales in Europe, over various timescales (UREAD, Deltares, BfG, FW, METOFFICE, UPV) (M18)
• D4.3: End-user-focused report on the advances in the forecast skill of hydrological extremes through data assimilation, seamless predictions and multi-modelling (DELTARES, ECMWF, SMHI, CIMA, BfG, UREAD, SMHI, TUC) (M24)
• D4.4: Estimation of hazards based on improved representation of highly vulnerable water resources of strategic importance on the climate scale (METOFFICE, UREAD, HKV, SMHI, UPV, FW) (M42)
• D4.5: White paper on lessons learnt and future opportunities for research and operational exploitation (ECMWF + other WP4 partners) (M48)

D4.1 : Verification score card [12]

Verification score card for hydrological reforecasts (and initial testing on re-forecast data) by reviewing the most appropriate verification scores for the sectoral applications with particular focus on highly vulnerable water resources of strategic importance

D4.2 : Hydrological model sensitivity [18]

Report on sensitivity of hydrological model outputs relevant for sectoral applications towards the role and attributes of precipitation forcing, focusing on water cycle variability at local/regional scales in Europe, over various timescales

D4.3 : Forecast skill developments [44]

End-user-focused report on the advances in the forecast skill of hydrological extremes through data assimilation, seamless predictions and multi-modelling

D4.4 : Improved climate projections of hydrological extremes [42]

Estimation of hazards based on improved representation of highly vulnerable water resources of strategic importance on the climate scale

D4.5 : Lessons learnt for research and operational exploitation [48]

White paper on lessons learnt and future opportunities for research and operational exploitation

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS12	Hydrological input data for sectoral surveys available	2 - ECMWF	6	Input data for sectoral case studies for current modelling and forecasting of hydrological extremes
MS13	Retrospective runs with hydrological models completed	2 - ECMWF	12	Output of the first run of the models for sectoral applications to produce state-

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
				of-the-art reforecasts of hydrological extremes
MS14	Forecasts for hydrological risk outlook available	8 - METOFFICE	30	Provision of near-real-time monthy-seasonal hydrological forecast data from the improved hydrological models to allow the creation of a hydrological hazard outlook tool (WP8)

Work package number [9]	WP5	Lead beneficiary [10]	13 - IVM
Work package title	Novel concepts for improved impact and risk assessment		
Start month	1	End month	48

Objectives

Next to the further development of meteorological and hydrological forecasting tools in WP3 and 4, advances are needed to harness and develop novel concepts that can use the hydrometeorological information to support impact and risk assessments, and in order to benefit the decision-making process. Current scenario or impact assessment techniques have their limitations. They can be expensive in terms of multi-model and multi-scale scenario generation, they are often difficult to interpret for non-scientists, there are gaps between available and required information, and they may not fully harness all of the available and rapidly developing information and data.
In WP5, we will therefore develop and test a number of novel concepts for representing and/or assessing the impacts and risks of hydrological extremes. Each concept builds on an existing gap in current impact assessment procedures. Each concept will then be implemented or tested in (at least) one of the case studies in WP6, in order to gain experience on how these concepts can contribute to improved impact or risk assessments. The actual concepts are described in the specific tasks below.
For each novel concept, we first carry out a review of past scientific and non-scientific literature relating to the current state of the knowledge on which our concepts will develop. Then, the concepts are developed and tested in (at least) one of the case studies. Furthermore, the task identifies possible applications of the concepts in other case studies and/ or sectoral assessments, and requirements for further improvements.

Description of work and role of partners

WP5 - Novel concepts for improved impact and risk assessment [Months: 1-48]
IVM, KNMI, HKV, FW, UPV, GFZ
Task 5.1: Large scale climate variability and impacts (IVM, Future Water)
Whilst modelling chains are often used to assess the impacts of hydrometeorological extremes, there is also potential to harness information on future impacts by examining statistical relationships between indices of large scale climate variability and those impacts. For example, it has been shown that there are strong relationships between peak river flows in Europe and indices of large scale climate variability such as Grosswetterlagen and the North Atlantic Oscillation (NAO). Also, several have shown statistically significant correlations between El Niño Southern Oscillation and low flows. However, only little work has been carried out to examine statistical relationships between indices of climate variability and risk. Ward show that flood risk is strongly related to El Niño Southern Oscillation (ENSO) in large parts of the world, and Cane have shown that crop yields in Zimbabwe are strongly related to ENSO. However, very little is known on such relationships in Europe. The method holds large potential for risk management. In regions where strong statistical relationships exist between large scale climate variability, projections of potential impacts could be provided with different lead times, from months to seasons, by harnessing existing predictions of modes of interannual climate variability on those timescales. Here, we propose to develop methods to examine statistical correlations between large scale modes of climate variability and societal impacts of hydroclimatic extremes in a broad sense. We will then use these methods to examine statistical correlations between large scale climate variability and: drought-related agricultural impacts in WP11; and pan-European flood risk in WP7. In both cases, we will also focus on how the information can be used in the decision-making process. We will also work together with WP14 to include the impact results in the risk outlook. IVM will lead task 5.1, carry out a literature review on the concepts, and develop the statistical methods.
Future Water will contribute to developing the methods for assessing agricultural impacts through large scale climate variability.

Task 5.2: Multi-risks (sea-coast) (KNMI, IVM, HKV)
Most studies of hydrometeorological risks and hazards focus on one particular hazard at a time. However, the impacts of extreme hydrometeorological events may be worsened by the coincidence of different hazards. For example, Kew have shown that flood risk assessments that only examine either river floods or coastal floods may result in an underestimation of the actual flood risk in coastal zones. New research is being carried out within the EU RISES-AM project to assess the joint probability of river and coastal flooding at the global scale. At the regional scale, the analysis of compounding events, their joint impact, and the statistical and physical relationship between them implies a focus on (realistic) weather phenomena rather than single-variate climate statistics. Als for future risk assessments, analysis of “future weather” rather than “future climate” implies a paradigm shift in climate research. High resolution simulations, a different

statistical perspective, and a high degree of tailoring output from meteorological projections to make them relevant for the local risk assessment are required.
In IMPREX, we propose to strengthen this novel research, by examining the effects of joint hazard events on risk, based on case studies in the Netherlands. The resulting flood risk maps will provided to WP13, providing an example of integrated risk maps. We will not only consider the joint occurrence of flood related hazard events, but also focus on combinations of events that are important in drought-related issues and in times of water scarcity. For instance, shortages of fresh water supply during summer periods often result from the joint occurrence of low river discharges in combination with salt water intrusion (depending on conditions at the sea side, i.e. expected sea level rise). The short-term history – for instance the water storage in open surface water and in soil water - prior to the occurrence of low river discharges should also be jointly considered when studying drought-related issues. The concepts related to low flows will be applied in the case study of the River Rhine in WP11 (Rhine and Meuse Estuaria). KNMI will lead the task and focus on multiple flood risks from coasts and river/pluvial floods, together with IVM. HKV will develop the methods related to low flows.

Task 5.3: Water allocation schemes (HKV, UPV)
Traditionally, the decision-making process in fresh water management is based on a deterministic approach . However, fresh water supply in summer periods exhibits a large range of uncertainty resulting from inherent uncertain conditions, such as uncertain low river discharges (consecutive period of low discharges), uncertain salt water intrusion (depending on uncertain conditions at the sea), and uncertain water storages in soil and in the surface water system. Additionally, the consequences of insufficient fresh water supply depend on the uncertain needs of the end user/sector (and in some cases also on the duration and seasonal period in which water shortage occurs). This asks for an approach for fresh water allocation that deals with uncertainty in fresh water supply and demand, and its consequences.
We therefore propose to develop a risk-based approach for fresh water allocation in which the probability of drought-related hazard events are jointly considered with the consequences of these hazard events. This information about drought-related risks enables us to prioritise and predicate decisions, and can also be used in the assessment of feasible options and adaptation strategies to manage risks in WP 13. It can help to assess the cost-efficiency of measures to cope with droughts and define cost-efficient solutions through a cost benefit analysis.
The novel approach for a risk assessment of fresh water allocation consists of three major steps:
1. Definition criteria for fresh water allocation (i.e. evaluation of criteria for fresh water allocation in present situation and definition of set water allocation criteria).
2. Set-up of a framework for risk-based fresh water allocation containing the following input: (a) describing the probability of drought-related hazard events, (b) impact of these events on water supply/availability (~ time, space), (c) water demand of end users (~ time), (d) computing water shortage (water demand minus water supply/availability) (~ time, space), (e) impact and consequences of water shortage (damage functions, often depending on the frequency, duration and season in which shortage occurs)
3. Decision support framework for water allocation (evaluation of risk adaptation and mitigation strategies).
Various alternatives and measures (at river basin scale, regional water system, or end user) could be assessed using this risk-based approach and indicate the consequences in terms of costs and risk reduction.
The risk based approach will be demonstrated in a number of case studies, amongst which a case study in the Netherlands, but also a case study in another river catchments in Europe suffering from drought related issues.
HKV and UPV will develop the risk based management instrument (1) to evaluate the impact of climate variability on drought related risks, (2) to support decision making and assess the cost-efficiency of measures to better cope with water scarcity.
HKV will use the case study River Rhine Basin (in the Netherlands) (WP11) to demonstrate the potential of this instrument for fresh water allocation in times of water scarcity. Within the case study HKV will focus on a number of characteristic regions in the Netherlands, amongst which the Rhine-Meuse Estuary. Since the characteristics of droughts in northern European basins are very different from the Mediterranean basins, UPV will focus mainly on the adaptation of the approach to Spanish Mediterranean rivers, based on the experience of methodologies and applications developed by UPV38. UPV will apply the instrument to the Júcar River Basin (Spain) (WP11).

Task 5.4: Probabilistic impact assessment (GFZ, UPV)
Impact assessments in the framework of hydrometeorological risk analyses have in common that complex damaging processes are described by relatively simple, deterministic approaches (Meyer et al. 2013). For instance, for flood damage estimation depth-damage curves are set up for certain objects or land use units using bivariate statistical analysis of empirical or synthetic flood damage data. Just recently some multi-factorial models have been developed for example for Japan and for Germany . Studies have shown that the application of multi-factorial models that take several damage influencing factors into account improve the reliability of flood damage modelling . However, uncertainty remains relatively high, so that the development of probabilistic damage models is an innovative enhancement, since they inherently provide quantitative information about the model prediction uncertainty. Probabilistic modelling approaches

may use Bayesian Networks. An advantage of utilising a Bayesian approach is that it enables a structured region specific updating on basis of local data. This will significantly help to overcome problems associated with spatial transfer of damage models. We propose to test this concept in focussing on flood damage modelling for the flood risk (WP7). Moreover, based on results from WP3 and WP4, UPV will improve a methodology currently used for probabilistic impact assessment of drought, by using Montecarlo simulation and/or optimisation, generating multiple hydrological scenarios conditioned by the hydrological situation at the moment of the assessment, as well as by meteorological forecasts, by means of multivariate ARMAX modelling and/or neural network modelling. The results of the simulation/ optimizations can then be used to derive probability functions for the impacts, in terms of deficits of water supply to the demands (agriculture, urban, hydroelectric), or in economic terms. Also environmental impacts can be assessed in similar manner. The concepts will be tested in relation to droughts in WP11, for the case study of the Jucar River Basin. GFZ will lead the task, and develop the novel concepts on probabilistic impact assessment for the flood damage modelling for the insurance case (WP7).
To support this task sub-contracting will be applied. See section 4.2.

Participation per Partner

Partner number and short name	WP5 effort
1 - KNMI	19.00
13 - IVM	34.00
15 - HKV	10.00
16 - FW	4.00
18 - UPV	6.00
21 - GFZ	9.00
Total	82.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D5.1	White paper on novel concepts	13 - IVM	Report	Public	6
D5.2	Intermediate report on novel concepts	13 - IVM	Report	Public	24
D5.3	Final report on novel concepts, chapter 1	13 - IVM	Report	Public	48
D5.4	Final report on novel concepts, chapter 2	1 - KNMI	Report	Public	48
D5.5	Final report on novel concepts, chapter 3	15 - HKV	Report	Public	48
D5.6	Final report on novel concepts, chapter 4	21 - GFZ	Report	Public	48

Description of deliverables

D5.1: White paper on novel concepts and state of the knowledge (IVM; M6)
D5.2: Intermediate report on development of novel concepts and potential applications (IVM; M24)

D5.3: Chapter 1 of the final report on novel concepts and state of the knowledge, focused on "Large scale climate variability and impacts " (IVM; M48)
D5.4 Chapter 2 of the final report on novel concepts and state of the knowledge, focused on Multi-risks (sea-coast) (KNMI; M48)
D5.5 Chapter 3 of the final report on novel concepts and state of the knowledge, focused on Water allocation schemes (HKV; M48)
D5.6 Chapter 4 of the final report on novel concepts and state of the knowledge, focused on Probabilistic impact assessment (GFZ; M48)

D5.1 : White paper on novel concepts [6]

White paper on novel concepts and state of the knowledge

D5.2 : Intermediate report on novel concepts [24]

Intermediate report on development of novel concepts and potential applications

D5.3 : Final report on novel concepts, chapter 1 [48]

Chapter 1 of the final report on novel concepts and state of the knowledge, focused on "Large scale climate variability and impacts"

D5.4 : Final report on novel concepts, chapter 2 [48]

Chapter 2 of the final report on novel concepts and state of the knowledge, focused on Multi-risks (sea-coast)

D5.5 : Final report on novel concepts, chapter 3 [48]

Chapter 3 of the final report on novel concepts and state of the knowledge, focused on Water allocation schemes

D5.6 : Final report on novel concepts, chapter 4 [48]

Chapter 4 of the final report on novel concepts and state of the knowledge, focused on Probabilistic impact assessment

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS15	White Paper on novel concepts	13 - IVM	6	WP meeting for discussing White paper concepts
MS16	Draft results new conceptual models	13 - IVM	36	WP meeting draft model results

Work package number [9]	WP6	Lead beneficiary [10]	1 - KNMI
Work package title	Coordination of Sectoral surveys		
Start month	1	End month	48

Objectives

WP7-12 consists of several sub-WPs for sectoral analysis and case studies. To avoid stand-alone operation of these sub-WPs and the forecast tool development WPs, coordination between WP3/4/5/6 and within the WP7-12 is needed. WP6.0 manages the interface between the tool development versus tool application. It coordinated data exchange and other internal communication to allow coupling of tools and input/output data, by organizing regular meetings, and development of a common reporting/outreach structure.

Description of work and role of partners

WP6 - Coordination of Sectoral surveys [Months: 1-48]
KNMI, ECMWF, HZG
In IMPREX a strong link between new, enhanced or tailored methods (models, datasets, concepts), and testing of these developments is created. The developments in WP3 and WP4 cover different time scales and episodes, and different areal domains. The sectoral surveys in WP7-12 generally focus on regional areas, and evaluate a mixture of meteorological and hydrological products for different time horizons. Figure 3.2 shows an overview of the range of products and datasets that is exchanged between the WPs. The data manager will monitor this data exchange and is responsible for resolving issues. More detailed experimental designs were compiled during the preparation of this proposal but not shown here.
The following activities are carried out:
• Monitoring and organisation of interaction between tool development WPs and surveys in WP7-12
• Coordinating case studies and (inter-sectoral) links between WP7-12
• Resolving data exchange issues
• Management and initiation of new case studies when appropriate
• Coordination of the reporting of the WP7-12
The monitoring of the progress over the various sectoral surveys is applied by imposing a “heart beat” milestone rhythm, in which all WPs are synchronised with respect to their benchmark analysis, preparedness to ingest new data, pilot tests of updated versions of input data, and full evaluations of sectoral applications of the data.

Participation per Partner

Partner number and short name	WP6 effort
1 - KNMI	2.00
2 - ECMWF	1.00
11 - HZG	3.00
Total	6.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D6.1	Sector Survey Report	1 - KNMI	Report	Public	48
D6.2	Data Management Plan	2 - ECMWF	ORDP: Open Research Data Pilot	Public	6

Description of deliverables

• D6.1 Sector Survey report (including activities, results and management) (KNMI + all partners) (M48)
• D6.2 Data Management Plan (ECMWF) (M6)

D6.1 : Sector Survey Report [48]

Sector Survey report (including activities, results and management)

D6.2 : Data Management Plan [6]

Data Management Plan

Schedule of relevant Milestones

Milestone number[18]	**Milestone title**	**Lead beneficiary**	**Due Date (in months)**	**Means of verification**

Work package number [9]	WP7	Lead beneficiary [10]	12 - DELTARES
Work package title	Sectoral survey: Flood inundation prediction and risk assessments		
Start month	1	**End month**	48

Objectives

This work package aims to develop improved short to medium, seasonal and long-term improved flood risk assessments for fluvial flooding. This risk-based information produced in this work package is required by decision makers in public and private arenas, in order to assess strategic decision making on risk reduction and climate adaptation in the short term (efficient warning and decision making, evacuation planning, financial liquidity to cover losses), as well as long term. In particular, results are relevant for civil protection and the (private) insurance sector for household and business policies. Also, new approaches are needed for assessing correlated risks related to flood occurrence and impacts at the local and European scale and application for insurance and the European Solidarity Fund (EUSF). The improved reanalysis, forecasts and hydrologic models from WP3 and WP4 will be used to derive meaningful flood maps offline and in forecast mode at various scales (Bisagnio, Rhine, Europe). Additionally, WP7 will test probabilistic flood damage forecasting.
The case studies for this work package are located in the lowland stretches of the Rhine river (in the Netherlands and Germany, downstream from Bonn), the Elbe river (Germany), Somerset (UK), and also include an EU-wide analysis. The Bisagno Catchment case study whose outlet passes through the City of Genoa (Italy) is included to test potential use in case of flash floods. Further, the Somerset region that experienced extensive flooding in 2013/2014 is chosen as case study area, as well as several water board areas in The Netherlands.
The WP will involve various consultation with stakeholders (as part of WP2), that require flood risk and damage information in the areas of a) civil protection, b) water managers involved with strategic planning against flooding, c) insurance organisations. These stakeholders are listed above.
The objectives of WP7 are:
• To consult with organisations with strategic responsibility for reducing flood risks (water ministries, regional governments), and those organisations covering residual losses (insurance companies, finance ministries, European Commission -EUSF) on their requirements for long-term flood damage assessments, in support of the EU Flood Directive goals and in compliance with the EU risk assessment Guidelines. (in WP2)
• To develop Europe-wide flood inundation maps for the short-medium and seasonal scales, and climate risk assessments. For several case study sites, inundation will be modelled (Rhine, Bisagno). The climate risk assessment will help to develop adaptation strategies, and links to the work in WP13.
• To develop Europe-wide and case study site specific (Rhine and Bisagno rivers) flood damage assessments, and to test the proposed improvements in assessing damages from low-probability flood events, using probabilistic damage models and analysis of correlated risks between river basins within the European region under future climate conditions
• To analyse compound meteorological events that lead to flooding in several highly managed water board areas in The Netherlands, and for Somerset in the UK.
• Collect experiences in using the newly developed approaches and disseminate results to a wide range of stakeholders.

Description of work and role of partners

WP7 - Sectoral survey: Flood inundation prediction and risk assessments [Months: 1-48]
DELTARES, KNMI, UREAD, IVM, HKV, CIMA, GFZ
Task 7.1: Flood inundation extents for Europe, Rhine, Bisagno (Deltares, CIMA):
Currently, only flood levels and/or extreme discharges are provided by the forecasting agencies. However, there is a strong need before and during a flood to have the information available on expected flood extent (for example Germany in 2013 and Great Britain and Serbia in 2014) to allow efficient decision making, evacuation planning and warning. Additionally, this would also allow rapid assessment of the flood damage immediately after the flood occurred.
In this task, the hydrological estimates of WP4 will be translated into inundation extents for Europe, the Rhine (Germany and The Netherlands) and Bisagno basins. Information from WP4 from hydrological and hydraulic models will be used to assess damages at high and low return periods. For Europe, the EFAS forecasts will be used to derive flood extent maps using the Delft 3D Flexible Mesh model, which will feed into the Hydrological Risk Outlook of WP14. For The Netherlands, we will apply newly developed methods to assess correlation effects of failure of dikes along different protected areas for The Netherlands and Germany . For the Bisagno river, Genoa Area official risk assessment studies will be complemented with modelled hydraulic forcing necessary to damage evaluation.

Task 7.2: Flood damage modelling (GFZ, Deltares and CIMA):

Deterministic damage functions suffer from overly simplistic representations of flood damage occurrence. First promising applications of probabilistic approaches for the small scale have been made56, and in IMPREX this application will be extended to the regional and river basin scale. In this approach, multiple flood parameters and vulnerability characteristics of exposed objects are used for estimating damages. The advantage is that more effects can be taken into account which improves the estimation of damaging processes significantly56. The development of probabilistic damage models has the further advantage that it inherently provides quantitative information about the model prediction uncertainty.
This task consists of the development of probabilistic, multi-parameter flood damage models for direct economic damages to companies and households, applicable at the regional/river basin (meso) scale. These approaches will be applied in the Rhine and Bisagno basins, and tested for the European scale. Probabilistic modelling approaches will use Bayesian Networks or bagging decision trees. This approach could be compared to Monte-Carlo simulations of depth-damage functions. These concepts will be developed in WP5, Task 5.4. This work would result in long-term estimates of changes in low-probability damaging flood events, associated economic losses, including the analysis of changes in vulnerability related to socio-economic drivers, based on e.g. SSP pathways.

Task 7.3: Compound flood events (HKV, Deltares, UREAD, KNMI)
The processes that can lead to the occurrence of high water levels are often assumed to be independent; e.g. high runoff, high discharge, high rainfall and wind-driven events. However, the coincidence of these events can lead to compound flood events, and these processes must therefore be studied together, in order to arrive at the correct flood probabilities. When the relevant processes are physically not independent, this must be taken into account in deriving the statistics of the resulting high water levels and floods.
For several locations (specifically: water board areas) in The Netherlands, we will study in close cooperation with the local water authorities if and how large these compound flood events are. This will be done for present and future climates. Key stakeholders for this information are the operational managers of the water boards in The Netherlands that are actively cooperating with the IMPREX project. We will quantify the size of the coincidence of different mechanisms for current and future climates, indicate what is the added value of the IMPREX approach for dealing with this issue, estimate the uncertainty of the estimates using different model approaches and output available in the IMPREX project, and analyse the communalities and differences between the different location and water board areas. This work is done in close cooperation with WP4 and WP5.

Task 7.4: Correlation analysis of EU-wide flood damage (IVM, Deltares):
Previous work has found strong correlations between large scale climate variability and high-flows at both the European46 and global50 scales. Such correlations are, however, not included in current national or EU-wide flood risk assessment, or climate change impact assessments, leading to substantial underestimations of overall risk on the basis of relationships between observed economic losses and hazard probabilities.
Based on concept developments in WP5, this task will focus on the analysis of correlations in flood damages with large scale climate oscillations and forcings, such as the North Atlantic Oscillation (NAO). This task extends previous studies to assess correlations between climate variability and damages directly. Potentially, this information could be combined with information on the predictability of large scale climate variability, to provide seasonal predictions of (anomalies in) risk, and this line of work will be explored. The work will make extensive use of economic loss data (e.g. from the EM-DAT and/or Munich Re NatCatSERVICE databases), next to geophysical data.

Participation per Partner

Partner number and short name	WP7 effort
1 - KNMI	5.00
10 - UREAD	4.00
12 - DELTARES	28.00
13 - IVM	5.00
15 - HKV	6.00
20 - CIMA	18.00
21 - GFZ	17.00
Total	83.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D7.1	Correlated flood risk and finance	13 - IVM	Report	Public	30
D7.2	Compound flood risk events	15 - HKV	Report	Public	36
D7.3	Flood damage risk assessment	12 - DELTARES	Report	Public	48

Description of deliverables

• D7.1: Report on correlated flood risks in Europe and implications for risk finance (IVM) (M30)
• D7.2: Report on compound flood events in the Netherlands and UK (HKV) (M36)
• D7.3: Report on flood damage risk Europe wide and Rhine and Bisagno Catchments (Deltares) (M48)

D7.1 : Correlated flood risk and finance [30]

Report on correlated flood risks in Europe and implications for risk finance

D7.2 : Compound flood risk events [36]

Report on compound flood events in the Netherlands and UK

D7.3 : Flood damage risk assessment [48]

Report on flood damage risk Europe wide and Rhine and Bisagno Catchments

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/ projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP8	**Lead beneficiary** [10]	4 - IRSTEA
Work package title	Sectoral survey: Hydropower		
Start month	1	**End month**	48

Objectives

Hydrometeorological predictions in hydroelectricity systems are useful to guarantee people safety and dam security, and to optimize energy production and the economic value of water resources. For this, hydropower users need accurate and reliable forecasts over a range of space and time scales: short-term streamflow forecasts (2-3 days ahead) for flood protection and the security of installations, medium-range forecasts (7-15 days ahead) for the optimisation of production, and long-term predictions for water resources management and environment protection. Hydrological trends and outlooks under future climate conditions help anticipating the effect of changes in runoff volume, extremes and seasonality, directly affecting the potential for hydropower generation . The role of hydropower storage capacity increases with the expansion of intermittent solar and wind energy productions in a society moving towards a low-carbon economy. Storage allows handling the natural variability of hydrometeorological hazards and extremes, and can increase power transmission capabilities between northern and southern Europe. Hydropower reservoirs are often operated for multiple purposes (e.g., domestic/agriculture water supply, environment protection, tourism, flood protection) and conflicts may arise . In several places in Europe, the usefulness of optimization tools and adaptive strategies to define optimal management rules was demonstrated and led to better informed decisions using available forecast information . These tools allow consideration of climatic constraints and variability of water resources, other users, legal/policy requirements, and socio-economic aspects.
Based on the forecasts and products produced in WP3 and WP4, WP8 will evaluate the impacts of improved predictability of hydrometeorological events (considering reservoir inflows and extremes) on the hydropower sector at different temporal scales.

Description of work and role of partners

WP8 - Sectoral survey: Hydropower [Months: 1-48]
IRSTEA , SMHI, UPV, POLMIL
The activities in WP8 will comprise two main impact assessment applications:
1. the implementation of improved predictability of inflows and extreme events on hydropower decision models and the assessment of the operational value of forecasts, at short to medium up to seasonal time scales;
2. the evaluation of the impacts of climate projections on the adaptability of reservoir operation rules in a multi-sector perspective, with focus on 10- to 20-year periods between 2030 and 2100.
Input data for hydropower models will come from WP3 and WP4 (precipitation, temperature and streamflow). Additional post-processing or statistical downscaling (bias-correction and spatial disaggregation), using local data, will be carried out to match hydrological needs at the catchment scale. We will focus on impacts on operational decisions taken at different time scales in single- and multi-purposes energy production/demand systems. Four sites in Europe, covering different hydroclimatic and socio-economic contexts, are included to capture the diversity of conditions encountered in hydropower management. Work will be developed in close collaboration with operational centres of EU weather-sensitive energy production companies.
WP8 provides insights to WP2 on current status of knowledge and needs on the hydropower sector. In multi-purposes reservoir cases, it interacts with other sectoral applications (WP11, Agriculture & Droughts). It also contributes to WP7 for its inter-sectoral assessment and to WP14 for dissemination among stakeholders.
The associated tasks to achieve the objectives for the hydropower sectoral survey are:

Task 8.1: Review of existing knowledge and needs on the hydropower sector (POLMIL , IRSTEA, SMHI, UPV)
A concise and practical overview of existing knowledge and needs will be carried out for a better understanding of the hydrometeorological impacts on both production (operation systems) and consumption in the hydropower sector. This task will highlight open opportunities that may further strengthen the usefulness of climate inputs in the EU hydroelectricity business. It will be based on interviews and contacts with operational users of hydrometeorological products in the hydropower sector, including those involved in the WP8 applications (EDF, Vattenfall AB, A2A trading) and other potentially interested users in or outside Europe. This review will serve as knowledge input to WP2. (M1 to M12)

Task 8.2:Evaluation of hydrological forecasts of the Pan-European HYPE model (SMHI , IRSTEA, POLMIL, UPV)

Hydrological forecasts from the pan-European application of the HYPE model (E-HYPE) produced in WP4 will be applied to the specific case study catchments (Task 8.3 below). This task will measure the added value of E-HYPE improved hydrologic predictions to the hydropower sector in Europe. E-HYPE predictions analysed concern predicted river discharges on daily basis and monthly snowmelt volumes. By using the same input to the different case studies, which use different management models, the assessment can focus on the sensitivity to the choice of hydropower modelling tools. This task will also serve as a benchmark to which improvements and alternative simulations (see Task 8.3) can be compared. (M1 to M36)

Task 8.3: Case study analyses of new data, improved hydrometeorological forecasts and risk assessment methods (IRSTEA, POLMIL, UPV, SMHI)

Applications will be carried out to provide robust conclusions about the impacts of new data, improved hydrometeorological forecasts and risk assessment methods on the hydropower sector in Europe. They concern four sites:

• South-eastern French catchments (IRSTEA): It comprises a set of 10 catchments where the French energy company EDF operates hydropower reservoirs. At EDF, an expert-based semi-automatic hydrologic ensemble prediction system has been running operationally since December 2010 43. It is based on post-processed ECMWF EPS forecasts and a conceptual hydrological model . In a recent IRSTEA-EDF collaboration, a decision model based on a heuristic optimisation of energy production was developed and tested over a short reforecast dataset. Results showed that 7-day probabilistic forecasts of improved quality result in economic gains of energy production of up to 1.5% (over hundreds of M€). The model was applied over a short time series, with few extreme events. In IMPREX we will apply it to a longer reforecast dataset, with higher resolution. The impact of improved forecasts from WP3 and WP4 on the economic gains of energy production will be evaluated using the GR5 semi-distributed hydrological model . The links between quality and value of forecasts will be analysed. Hourly or daily time steps, according to the catchments' dynamics and response times, will be considered in the short to medium-range prediction horizon (lead time up to 7 to 10 days).

• A typical snow-dominated Alpine basin (Lake Como Basin, Italy), heavily exploited for hydropower production in the upper catchment and with a multi-sectoral use in the lower part (POLMIL): This water system comprises one large regulated lake and 16 hydropower reservoirs. It is a large socio-economic system and a paradigmatic example of many Alpine watersheds: large storage capacity distributed in small reservoirs, mainly operated for hydropower production and located in the upper watershed region; regulated lakes in the middle region; and multiple water consumption users, mainly agricultural areas, in the lower region62. Stakeholders include 4 hydropower companies (A2A, Enel, Edipower, Edison), the lake operator (Consorzio dell'Adda), and irrigation districts. Currently, an uncoordinated management prevails, where each operator takes its release decision independently, with no or little information sharing, and a focus on its operating objective only. The case-study area is representative of EU snow-dominated regions vulnerable to extreme hydrologic events, particularly droughts, and with potential to acquire significant benefits from cooperation with an efficient trans-sectoral risk management. In this case-study, a decision model based on stochastic optimization and optimal control tools will be set up. Optimization tools will be applied to cope with increasingly high and frequent droughts that are enhancing the conflict between energy and food production, and threatening the main ecosystem services and flood buffering capacity (inter-sectoral links are addressed in WP13). Models will run at daily time steps, on the short to medium-range prediction horizon (lead time up to 7 to 10 days), and for seasonal forecasts to the long-term planning of release strategies based on snowmelt runoff.

• A typical south Mediterranean basin (Jucar basin, Spain) suffering from significant drought issues, with an important share of water for irrigated agriculture (80%), and conflicts on water allocation in its multi-reservoir system (UPV): The Jucar basin has Europe's largest pumped-storage hydropower project (Cortes-La Muela) and, with its 3 main reservoirs, is an ideal case-study for water use optimization and impact assessment. Water scarcity, irregular hydrology and groundwater overdraft cause droughts to have significant economic, social and environmental consequences38. The situation is expected to be exacerbated by the impacts of climate and socio-economic (global) changes, and the increasing institutional impediments from political disputes among the two main riparian regions. A range of innovative solutions have been implemented, but coordination is still needed, which makes this case a real lab for analyzing risk management strategies to cope with drought events. Legally, hydropower has a lower priority on reservoir releases than agriculture, but significant benefits of cooperation between these uses can be expected. With the help of hydroeconomic optimization models , optimal coordination mechanisms at the basin scale can be designed and evaluated. This case study will use a stochastic optimization hydro-economic model (including the economic value of water use) to investigate potential strategies of coordinated reservoir operation for future scenarios, including improved climate projections from WP3. Gains from improved coordinated reservoir operating rules, considering water values and the spatial-temporal dependence of the hydrological time series in the basin will be analysed. Models will run at daily time steps and focus on impacts of future climate conditions.

• The upper part of river Umeälven, a typical north European catchment highly influenced by snowmelt runoff and volumes in hydropower production, with a multi-reservoir system (SMHI):There are several hydropower companies operating in the river Umeälven, and the main actor in the upper part (Vattenfall AB) will be involved in this case study. The upper part of the river basin includes 4 major reservoirs and 4 hydropower stations, and is partly dominated by high mountain basins and forest areas. In the area, seasonal forecasts of snow melt runoff volumes, together with ground based and remote sensing snow cover monitoring, are key inputs to the decision models of the hydropower companies when planning the production for the current and next winter seasons. Currently, the operational seasonal forecasts are based on hydrological model simulations using an ensemble of historical years of observations of precipitation and temperature as input (Olsson et al., 2011). Forecasts for the April-July accumulated runoff are issued once a month from January until the start of the melt season in April. This case study will focus on comparing the usefulness of the hydrometeorological predictions developed in WP3 and WP4 in comparison to the current operational methods. Spring melt runoff predictions will be made using both the HYPE model applied to the case study area, as well as using the traditional method with ensembles of historical years. (M1 to M48)

Participation per Partner

Partner number and short name	WP8 effort
3 - SMHI	8.00
4 - IRSTEA	24.00
18 - UPV	7.00
19 - POLMIL	12.00
Total	51.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D8.1	Improved hydropower risk assessment	4 - IRSTEA	Report	Public	48
D8.2	Hydropower policy brief	4 - IRSTEA	Websites, patents filling, etc.	Public	48
D8.3	Report on needs in hydropower sector	19 - POLMIL	Report	Public	12

Description of deliverables

• D8.1: Summary report on the review of existing knowledge and needs on the hydropower sector (POLMIL) (Task 8.1) (M12)
• D8.2: Report on the assessment of the impacts of improved hydrometeorological predictions and risk assessment methods on the hydropower sector (Tasks 8.2 & 8.3) (IRSTEA) (M48)
• D8.3: Policy Brief aiming stakeholders and policy makers summarizing key impacts of improved predictability on the hydropower sector (IRSTEA) (M48)

D8.1 : Improved hydropower risk assessment [48]

Report on the assessment of the impacts of improved hydrometeorological predictions and risk assessment methods on the hydropower sector ((Tasks 8.2 & 8.3))

D8.2 : Hydropower policy brief [48]

Policy Brief aiming stakeholders and policy makers summarizing key impacts of improved predictability on the hydropower sector

D8.3 : Report on needs in hydropower sector [12]

Summary report on the review of existing knowledge and needs on the hydropower sector

Schedule of relevant Milestones

Milestone number[18]	**Milestone title**	**Lead beneficiary**	**Due Date (in months)**	**Means of verification**
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/ projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP9	**Lead beneficiary [10]**	22 - BfG
Work package title	Sectoral survey: Transport		
Start month	1	**End month**	48

Objectives

The aim of WP9 is to evaluate how improved hydro-meteorological and hydrological forecast products produced in WP3 and WP4 increase operating efficiency and strategic management of the European transportation sector with special focus on Inland Waterway Transport (IWT). In light of continuing transport growth within the European Union there is a need to use the free capacity offered by IWT more consequently in order to release road and railway networks. Although the inland waterways offer a congestion-free network, the ease, safety and efficiency of IWT is sensitive to hydrological impacts from the short term up to the climate time scale.

Short- to medium term forecasts of discharges / water-levels are essential to optimize the load capacity of the vessels as well as to timely take into account that waterways might be blocked due to floods. Navigation related water level forecasts with lead times ranging from 2 days – 8 days are operationally available for the large navigable Central European Rivers Rhine , Elbe, and Danube and are accessible for the IWT via river information systems RIS . These water level forecasts are currently deterministic based on a single meteorological forecast with no additional information about the forecast uncertainty for the users. One of the barriers to publish probabilistic forecasts is finding an adequate way of communicating the calculated (un)certainties to the end-users . The provision of probabilistic forecasts is one of the IMPREX objectives.

Monthly to seasonal forecasts are required for the medium- to long-term planning and enhancement of the water bound logistic chain (stock management, adjustment of the industrial production chain, modal split planning). Despite the great demand and interest of the IWT, no operational forecasts with lead times exceeding 8 days are available for the Rivers Rhine (max. lead time 4 days), Elbe (max. published lead time 2- 8 days depending on the gauge) and Upper Danube (max. published lead time 2-4 days depending on the gauge) due to the large uncertainties and the limited skill on monthly and seasonal scales . Another objective of IMPREX is to find adequate ways to communicate these large uncertainties in collaboration with the users involved.

Climate projections are essential for the optimal future fleet planning of shipping companies as well as for infrastructural waterway management. Potential consequences of climate change for navigation have been analysed for the navigable rivers in Central Europe in the research program KLIWAS “Impacts of climate change on waterways and navigation - Searching for options of adaptation” and with focus on the Rhine-Main-Danube corridor in the EU FP7 project “ECCONET-Effects of climate change on the inland waterway networks” 76 . Regional climate projections from the EU-Ensembles project and regional climate model runs conducted in German research initiatives have been used as input to hydrological models to assess the potential impact of climate change on the water balance and navigation conditions with focus on low and medium flow situations.

The non-waterbound transportation network (roads, railways) is also vulnerable to hydrological extremes, primarily to floods (link to WP7). Reliable information on their vulnerability is essential to reveal hot-spots in the intermodal transportation infrastructure. Hence short- to medium term hydrological forecasts are required to optimize emergency planning, preparedness programs as well as to guide transport via alternative routes / transport modes. For the long-term planning of flood protection measures climate projections about the possible future evolution of extremes are needful. Adaptive management approaches offer here an important step in the strategical planning with the aim to reducing uncertainty over time via system monitoring.

The objectives of WP9 are to

• couple different transport related forecasting chains to IMPREX-products and verify the resulting runoff and water-level forecasts at different lead times (short- to medium-term, monthly, seasonal, climate projection) with special focus on extreme low flow and flood conditions which are harmful for transportation networks (Task 1 – 4),

• develop a pre-operational system for probabilistic short- to medium-term forecasting for IWT based on the current operational system for the River Rhine72 and to apply a cost structure model to demonstrate the economic benefit of probabilistic forecasts to the end-users (Task 3a),

• evaluate the potential skill of meteorological monthly to seasonal forecasting products as input for navigation related forecasting for the Rivers Rhine, Elbe and Danube (up to the gauge Nagymaros in Hungary). A monthly forecast prototype for IWT will be developed in collaboration with the potential end-users based on existing operational and pre-operational forecasting systems. Based on the skill evaluation of the seasonal forecasts possible Seasonal Outlook prototypes for IWT are discussed with the end-users (Task 3b),

• apply climate projections and meteorological extreme scenarios to derive extreme runoff scenarios for the design of waterway infrastructure and for the identification of critical points in the non-waterbound transportation network with

respect to floods (inundation areas from WP7) for Central European Rivers. This aspect was not considered in the previous navigation related impact of climate change projects KLIWAS and ECCONET (Task 3b).
Three main elements will ensure that progress achieved by IMPREX with respect to transportation is applicable for the main axes of the European waterway network and that the findings of IMPREX are beneficial for strategical transport management as well as day-to-day business:
• The data feed from WP3 and WP4 will be directly linked to operational or semi-operational forecasting systems feeding River Information Services (RIS) for the main waterways. BfG is developing and operating those forecasting systems for German stretches of the international waterways.
• The target areas chosen as case studies (Rhine, Danube, Elbe) are part of the backbone of Europe's waterway and non-waterbound network. Therefore improvements demonstrated have a direct economic relevance for the transportation sector. Furthermore these river basins represent different runoff regimes and climate characteristics (Rhine: mixed runoff regime, temperate oceanic climate, Elbe: rainfall-dominated runoff regime, humid continental climate, Danube up to Nagymaros: snowfall dominated runoff regime, humid continental climate) facilitating the transfer of results
• The users involved in WP9 represent the different parties involved in the transport chain with different requirements: shipping / logistic companies (Imperial Shipping group, Royal Dutch Barge Association – Koninklijke Schuttevaer), industrial enterprises relying bulk shipment (BASF), intergovernmental organisations providing free navigation for commercial vessels (Central Commission for the Navigation of the Rhine, Danube Commission) as well as public authorities maintaining and managing the waterways (Federal Ministry of Transport and Digital Infrastructure, Federal Waterway and Shipping Administration). The users will be involved from the very beginning of WP9 giving already input to task 1 (sensitivity and vulnerability of transport due to hydrological extremes) and task 2 (quality assessment framework).
Two case-studies are conducted within WP9 (task 3):
• River Rhine Basin: evaluation of short- to medium-range IMPREX-products with special focus on the quantification of monetary benefits by coupling a cost structure model with BfG's operational hydrological forecast system. Users involved in this case study are: Imperial Shipping group, Royal Dutch Barge Association, BASF, Central Commission for the Navigation of the Rhine, Federal Ministry of Transport and Digital Infrastructure, Federal Waterway and Shipping Administration
• Central European basins of Rhine, Elbe and Danube: applying monthly- to seasonal forecasts as well as predictions on the climate scale. Special attention will be paid to relevant low flow and flood parameters and the added value compared to climatology. Users involved in this case study are the same as in case study River Rhine Basin and additionally the Danube Commission.

Description of work and role of partners

WP9 - Sectoral survey: Transport [Months: 1-48]
BfG, HZG
Task 9.1: Review of existing knowledge (BfG, HZG)
This review addresses the vulnerability and sensitivity of waterway management and the waterbound transportation chain on hydrological extremes and climate change and the needs of the intermodal transportation sector related to improved forecasts and projections. This review will serve as knowledge input to the developments that will be further conducted within WP9 itself, and be executed in close collaboration with WP2.

Task 9.2: Development of an objective quality assessment framework (BfG)
This concerns a framework of hydrological forecasts and projections with special focus on the needs of the transportation sector. Relevant deterministic and probabilistic verification measures for navigation-related forecasts depending on the time scale are identified and integrated in the framework. This framework will be used in Task 9.3 to objectively evaluate the potential improvement of the forecasts by using improved methods from WP3 and WP4.

Task 9.3: Case studies (BfG)
Case studies will be executed that analyse adaptive management approaches, including the impacts of new data, improved hydro-meteorological forecasts and predictions, improved hydrological tools covering a wide range of space and time scales. As meteorological ensembles tend to be biased and underdispersed, the resulting ensemble forecasts for river runoff typically are biased and underdispersed too. Hence standard post-processing methods like Bayesian Model Averaging (BMA) or Ensemble Model Output Statistics (EMOS) are applied to estimate skillfull and reliable probabilistic forecasts from the raw runoff / waterlevel ensemble . These probabilistic runoff and water level forecasts on all time scales are evaluated with special focus on extreme low flow and flood conditions using the objective evaluation framework of Task 9.2.

• Case Study River Rhine Basin: The hydrological model HBV working on an hourly/daily timestep is applied to calculate runoff forecasts from short-to-medium term hydro-meteorological forecasts (lead times up to 14 days). These runoff forecasts are used as boundary condition for the hydrodynamic model SOBEK-River to calculate water level forecasts along the River Rhine. To quantify the impact of the potential improvement of the water level forecast on transportation costs monetarily a cost structure model is applied to the water level forecasts. The results of this model are also used to communicate the potential benefit of probabilistic forecasts to the users. Meteorological products of WP3 provided on a regular raster are regionalized to the subbasins and used as input to the hydrological model, runoff forecasts from WP4 are used as direct input to the hydrodynamic model.
• Case Study Central Europe: The hydrological model LARSIM-ME working on a daily time step which covers the main river basins in Central Europe (River Rhine, River Elbe, River Danube up to the gauge Nagymaros in Hungary) is applied to calculate runoff forecasts / projections / extreme events from monthly to seasonal meteorological forecasts, climate projections and extreme scenarios. Meteorological products of WP3 provided on a regular raster are bias corrected and statistically downscaled to a regular 5 km grid and used as input to LARSIM-ME. Flood inundation maps from WP9 are used to identify flood prone hot spots of the non-waterbound transportation network.

Task 9.4: Formulation of robust qualitative and quantitative conclusions (HZG, BfG):
Conclusions will be drawn about the impacts of new data and improved hydro-meteorological forecasts and predictions on the transportation sector in Central Europe.

Participation per Partner

Partner number and short name	WP9 effort
11 - HZG	6.00
22 - BfG	31.00
Total	37.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D9.1	Report on vulnerability of water transport	22 - BfG	Report	Public	12
D9.2	Navigation quality assessment	22 - BfG	Report	Public	18
D9.3	Potential economic benefit of better forecasts for water transport	22 - BfG	Report	Public	38
D9.4	Improved transport cost planning	22 - BfG	Demonstrator	Public	42
D9.5	Impact on adaptive mgmt of transport sector	11 - HZG	Report	Public	46

Description of deliverables

• D9.1: Report on the vulnerability and sensitivity of waterway management and the waterbound transportation chain on hydrological extremes and climate change (Task 9.1, BfG) (M12)
• D9.2: Report on the objective quality assessment framework for navigation related forecasts (Task 9.2, BfG) (M18)
• D9.3: Report on the potential economic benefit of the improved forecasts for inland waterway transport via cost structure modelling for the River Rhine (BfG) (M38)

• D9.4: Semi-operational forecasting system for the waterway Rhine and Central Europe forced by IMPREX products (BfG) (Task 9.3, initial version in M30, final version in M42)
• D9.5: Report the impacts of new data and improved hydro-meteorological forecasts and predictions on the transportation sector in Central Europe (HZG) (Task 9.4, initial version M34; final version M46)

D9.1 : Report on vulnerability of water transport [12]

Report on the vulnerability and sensitivity of waterway management and the waterbound transportation chain on hydrological extremes and climate change

D9.2 : Navigation quality assessment [18]

Report on the objective quality assessment framework for navigation related forecasts

D9.3 : Potential economic benefit of better forecasts for water transport [38]

Report on the potential economic benefit of the improved forecasts for inland waterway transport via cost structure modelling for the River Rhine

D9.4 : Improved transport cost planning [42]

Semi-operational forecasting system for the waterway Rhine and Central Europe forced by IMPREX products

D9.5 : Impact on adaptive mgmt of transport sector [46]

Report the impacts of new data and improved hydro-meteorological forecasts and predictions on the transportation sector in Central Europe

Schedule of relevant Milestones

Milestone number[18]	**Milestone title**	**Lead beneficiary**	**Due Date (in months)**	**Means of verification**
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/ projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP10	**Lead beneficiary** [10]	17 - CETAQUA
Work package title	Sectoral survey: Urban Water		
Start month	1	**End month**	48

Objectives

Urban water supply in Europe is highly vulnerable to weather extremes and the long term evolution of their occurrence . Weather extremes affect the fresh water quality and quantity, challenging treatment capacity, safety of drinking-water and reliability of supply. For example, droughts induce low river flow and high concentration of pollutants, while intense rainfall events cause high levels of turbidity protecting microorganisms from disinfection treatment, and rising temperatures reduce dissolved oxygen and increase the probability of development of communities of cyanobacteria releasing toxins into the water. To manage the risks raised by those hazards, drinking-water suppliers are responsible for preparing and implementing water safety plans (WSPs), consisting of a system assessment, operational monitoring and the definition of risk management plans .
While climatological and hydrological outlooks could bring significant improvement in the implementation and definition of the WSPs, this is not a common practice in most of the European drinking water utilities. Current limitations include: (1) lack of a robust methodology for downscaling climate projections and linkage to water quality models, (2) the ability to run predictive water quality models generating key parameters used in decision making, (3) the assessment of the risk of high impact extreme weather events in current and future climate, and (4) lack of operational methods and treatment techniques that could be used to limit current and future risks. IMPREX is designed to address these limitations. Based on the products produced in WP3 and WP4 and on the concepts developed in WP5, WP10 will focus on the above mentioned issues.
WP10 will take the following innovative steps to improve risk management for drinking water supply at various timescales:
• Development of a methodology for downscaling weather and climate foresights (WP3 and WP4)
• Utilizing ensemble weather forecasts and seasonal outlooks leading to the design and test of a water quality forecasting system for some relevant parameters (dissolved oxygen, organic matter, ammonia, nitrates, phosphorous, turbidity, toxins)
• Long-term risk assessment of high impact weather events
• Implementation and test of a number of upgrades in the water treatment system
• Update and Upgrade Water Safety Plans based on these new forecasting tools.

Description of work and role of partners

WP10 - Sectoral survey: Urban Water [Months: 1-48]
CETAQUA, UPV
Different methodologies to utilize weather and climate data will be developed in Task 10.1, focusing on the simulation of fresh water quality and the impacts on urban water systems. The strategies to integrate these forecasts in risk management schemes will be developed in Task 10.2. These two tasks will be assessed in depth in Mediterranean regions and some water resources of strategic importance, but will gain insights that can be applied at European scale. In Task 10.3, the methodologies and strategies developed will be applied in two Mediterranean catchments with vulnerable water resources of strategic importance for supplying the regions of Barcelona and Murcia. This last task will be carried out in close collaboration with the stakeholders (including Aguas de Murcia (EMUASA)), to optimize the relevance and uptake of the outcomes and recommendations in practice.

Task 10.1: Simulation of the impacts of climate variables on urban water systems (CETaqua, UPV)
The following sub-tasks will be performed:
• Development of a methodology to downscale and use climate projections into water quality models. Different spatial and temporal horizons (point to basin, sub-daily to monthly) and different lead times (a few hours in advance to several decades) will be considered.
• Utilization of probabilistic weather forecasts for parameters of major interest for drinking water (e.g. conventional parameters such as temperature or turbidity and advanced parameters such as organic matter or eutrophication). Different predictive methods and modelling tools will be studied, such as multiple linear regression (MLR) model, and the GESCAL model .
• An assessment of the consequences of changing water quality on the operation, design and planning for different features of the urban water system (reservoirs, distribution system, drinking water treatment plant).

Task 10.2 Adaptation of the urban water system according to fresh water quality forecasts (CETaqua).
The following sub-tasks will be performed to upgrade water safety plans (WSPs):
• Analysis of the benefits of an early activation of the adaptation measures based on probabilistic water quality forecasts, and comparison with current activation practices based on measurement.
• Analysis of the benefits of improving water treatment operations, such as a better adjustment of the chemicals needed (typically coagulants and disinfection products) and the type of treatments applied.
• Proposition of structural changes such as the creation of water buffer tanks in order to better control influent water quality conditions.

Task 10.3 Applications in the Segura Basin and Llobregat Basin (CETaqua, UPV).
The methodologies developed in the previous sub-tasks will be applied in different contexts and for different objectives. The Llobregat Basin, supplying the Barcelona Region, and in the Segura Basin, supplying Murcia Region have been selected to perform the following analyses:
• In the Llobregat River, a water quality model will be developed to represent the main events impeding satisfactory water production in the system . The model uses climate variables as input and will simulate several constituents (such as dissolved oxygen, organic matter, ammonia, nitrates, phosphorous) and indirect variables (such as turbidity events in the raw water at the inlet of the water treatment plant). The water quality model will be developed by CETaqua and UPV, in collaboration with local water operators (Aguas de Barcelona, Aguas de Terrassa). Different lead times will be considered (sub-daily predictions to decadal predictions).
• In the Segura basin, a water quality model will be developed, the impacts of the climate variables on the system will be evaluated, and several adaptation measures will be proposed and tested. The main purpose of the modelling part will be to predict the development of communities of cyanobacteria in a reservoir upstream the water treatment plant to anticipate the release of cyanotoxins. Accordingly, a specific monitoring campaign and water quality analysis will be performed. In addition, the drinking water treatment will be optimized in collaboration with the local water operator EMUASA, stakeholder of the IMPREX project. Experiments in a pilot plant will be carried out to evaluate and compare the efficiency of different treatment techniques (e.g. ozone, chlorine, chlorine dioxide, biocides, and electrocoagulation) to remove the toxins (including microcystins, BMAA and anatoxins). Alternative water sources from inter-basin water transfers will also be included in the study. The final result will be a global and cost-effective strategy to manage risks, initiated by weather and climate forecasts and translated into decision making through the water quality model and the water treatment model. This strategy will be studied in collaboration with WP11 that will study the occurrence of drought in the basin at different time scales and the improvement of the drought monitoring system in the basin.

Participation per Partner

Partner number and short name	WP10 effort
17 - CETAQUA	24.00
AquaTEC	8.00
18 - UPV	7.00
Total	39.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D10.1	Fresh water forecasting in urban water system	17 - CETAQUA	Report	Public	24
D10.2	Impact in Segura and Llobregat basins	17 - CETAQUA	Report	Public	36

Description of deliverables

• D10.1: Report on the adaptation of the urban water system according to fresh water quality forecasts (CETAqua) (M24)
• D10.2: Report on the applications in the Segura Basin and Llobregat Basin (CETAqua) (M36)

D10.1 : Fresh water forecasting in urban water system [24]

Report on the adaptation of the urban water system according to fresh water quality forecasts

D10.2 : Impact in Segura and Llobregat basins [36]

Report on the applications in the Segura Basin and Llobregat Basin

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/ projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP11	**Lead beneficiary [10]**	16 - FW
Work package title	Sectoral survey: Agriculture and droughts		
Start month	1	**End month**	48

Objectives

A major threat to the agricultural sector in Europe is a potential increasing occurrence of droughts, affecting the local and regional food security and economies. Especially in the Mediterranean part of Europe, droughts are relatively frequent, while at the same time, agriculture concerns a major economic sector sustaining a significant part of the food supply for Europe. Also in Northern Europe, below average conditions in water resources availability can have serious consequences for the agricultural sector.
The agricultural sector, water managers and other decision makers can benefit from climatological and hydrological outlooks to anticipate better to drought conditions and take preventive actions to reduce their impacts. However, the use of operational forecasts and projections is still limited due to a number of factors : (1) the importance of downscaling climatic drought indices to find basin-specific relations with local agricultural drought impacts taking into account local management features, (2) lack of management instruments that consider the complex interactions between sectors and joint probability of drought-related hazard events and consequent risks for the agricultural sector, (3) the importance of better understanding relationships between large scale climate variability patterns and indices and regional agricultural impacts, and (4) lack of a generic framework that assesses climate change impacts on the agricultural sector on a pan-European scale, taking into account the different structures of the water resources system and consumptive and competing sectors in each basin. Based on the products from WP3 and WP4 and on the concepts developed in WP5 to represent impacts, WP11 will focus on the above mentioned issues and questions.
This WP will provide an overview of the agricultural sector by means of several case studies focusing on drought forecasting and drought risks in different basins across Europe, and a pan-European assessment of agricultural drought vulnerability under climate change. Through various case studies, new methodologies will be applied to learn from historic drought events and apply these tools and relations to better anticipate future events. The usability of seasonal forecasts of downscaled drought indices to improve predictions of agricultural drought impacts will be studied (task 1 and 2). A new tool will be tested to evaluate the impact of climate variability on drought related risks for the agricultural sector by means of a so-called risk profile (task 3). Relationships will be analysed between large scale teleconnection indices and agricultural impacts for selected basins in Europe (task 4). And a pan-European assessment will be carried out using a new analytical framework called Water Accounting Plus (WA+)7 to study the impact of changing rainfall, evapotranspiration and atmospheric recycling under climate change on water fluxes, flows, stocks, consumption and the agricultural services rendered in river basins (task 5).

Description of work and role of partners

WP11 - Sectoral survey: Agriculture and droughts [Months: 1-48]
FW, TUC, DELTARES, IVM, HKV, UPV, POLMIL
Task 11.1: Exploration of drought indices (FW, UPV, TUC, POLMIL)
Currently, several drought indices (meteorological, hydrological and agricultural) are available online for drought monitoring at the European level. Good examples are the SPI products disseminated by several European institutes, and the more elaborated products by JRC from the European Drought Observatory and the MARS Agricultural Drought Bulletin. However, they are hardly used by water management authorities. Regional water managers often do not have a clear understanding of the relations between these indices and local agricultural drought impacts. Besides, most of these indices can be of use for rainfed agriculture but have a more complex relation with production in irrigated agriculture. For this reason, in several drought-prone Mediterranean basins, water authorities chose to develop their own hydrological drought indices only based on local data and with better-understood relations with the dependent services87.
For each of the case studies this task will explore the relations between (1) drought indices available at the European level and agricultural drought impacts, and (2) the locally used hydrological indices versus agricultural drought impacts. This will be done by establishing relationships, combining statistical and deterministic approaches through (agro-) hydrological modelling. An evaluation will be carried out of the information currently used to monitor drought risks in the case study basins (Segura, Jucar, Como and Messara), serving as a benchmark for each of the case studies. Examples for indicators of agricultural drought that will be used are trends and anomalies in agricultural production based on statistical data and satellite-based anomalies in biomass production . The objective is to better understand which of the

indices are well related with agricultural impacts and under which conditions (drought intensity, severity, magnitude, type of agriculture, seasonality, etc).

Task 11.2: Bringing drought index predictions into local practice (FW, UPV, POLMIL, TUC)
The objective of this task is to incorporate drought index predictions available at the European level in local water management procedures and tools. Currently, in several basins, Drought Management Plans and monitoring systems exist that can be enhanced by using drought index predictions and as such better anticipate to drought. Here, the relations found in Task 11.1 will be used to make this step forward, to reach a TRL (Technology Readiness Level) of 6 ("prototype demonstration in a relevant environment"). Multi-model predictions will be used from WP3 of the Standardized Precipitation Index (SPI) and Evapotranspiration Index (SPEI), delivered by WP3. Bias correction of these ensemble forecasts will be necessary and carried out to make sure that the statistical properties of the prediction data are similar to those in the observations. Based on the relationships found with agricultural drought impacts, a combined drought indicator will be developed tailored to the local agricultural sector and biophysical conditions of the case study. The relations and predictions will also be used for the periodic risk outlook of WP14. The operational value of drought index predictions will be assessed by employing this information in the different management systems of the case studies (Segura, Jucar, Como and Messara). This will lead to enhanced drought management systems for the different basins, developed in close collaboration with the different end-users.

Task 11.3: Application of drought risk management instrument (HKV, UPV)
Already in the present situation, delta regions world-wide encounter problems resulting from fresh water scarcity. Climate change and socio-economic developments make delta societies even more susceptible to consequences arising from drought events. The resulting risks exhibit a wide range of uncertainty, making management decisions even more difficult than they usually already are. As a result, decision making in water resources management and especially making appointments for fresh water assignment rules is becoming increasingly more complex.
This is also the case in the Netherlands, where fresh water availability will be more and more under pressure, due to the predicted effects of climate change. There is a strong wish to make uncertainty in water shortage and drought related risks more explicit. Therefore, we will develop a decision support instrument for water resources management especially related to periods of water scarcity (WP5.3). An integrated risk-based approach will allow us to analyse the effects of climate change but also to assess the effectiveness of management options and interventions. The management instrument will help to identify opportunities and measures and to quantify their subsequent consequences. By combining this with probability of occurrence we can quantify drought-related risks in present and future situation (under the influence of climate change) associated with various measures (which may include controlling water flows in major waterways, local infrastructural solutions to supplement water and local adaptations by the end users). This also allows comparisons of various options to include an assessment of their cost-effectiveness, which helps to prioritise operational and strategic actions and investments.
This task will apply the management instrument to evaluate the impact of climate variability on drought related risks for the agricultural sector, and to assess the cost-efficiency of measures to better cope with water scarcity. This instrument (developed in WP5.3) will consider the joint probability of drought-related hazard events and the consequences of these hazard events for the agricultural sector, yielding a so-called risk profile. The tool will be tested in the Rhine-Meuse Estuary of the Netherlands and Jucar Basin, Spain. It will consider (1) the probabilities of the joint occurrence of low river discharges, salt-water intrusion and limited water storage in the surface and ground water system, (2) the impact on water shortage and the consequences for the agricultural sector (using damage functions, often depending on the frequency, duration and season in which shortage occurs). The resulting risk profile serves as a starting point for new management strategies for risk adaptation and mitigation (explored in WP13).

Task 11.4: Application of large scale indicators (IVM, FW, POLMIL)
This task uses developments in WP5.1 focusing specifically on agricultural impacts in the case studies. Large scale climate oscillations and climate variability (such as North Atlantic Oscillation, El Niño Southern Oscillation, Frequency of Western Circulation and the Mediterranean Oscillation Index) affect the water cycle, and thus the probability of droughts and agricultural productivity. Previous work has found clear correlations between large scale climate variability and river discharge at both the European46 and global scales50. This task extends that work to assess correlations between climate variability and periods of water scarcity, and agricultural drought impacts. The work will be carried out using both observed and simulated data on water availability, satellite-based and local data on vegetation and agricultural production, and ancillary data stored in international database on drought impacts. The operational value of this low frequency information will be tested in a medium long term management model of the Lake Como water system for better anticipation at the river basin scale. These relations will also be used for the periodic risk outlook of WP14.

Task 11.5: Pan-European assessment (FW supported by subcontracted wateraccounting.org, UPV , POLMIL, TUC, HKV)

This task will provide a pan-European assessment of climate change impacts on flows, stocks, consumption and the services rendered in river basins related to agriculture by means of a novel water accounting framework. Water accounting is a new step in water resources management, currently being promoted from the European level, aiming at national and basin-level adoption of this methodology. Current developments are those led by Eurostat having a Task Force on Water Satellite Accounting, the European Environment Agency actively investing and improving the methodology and DG-ENV of the EC, supporting various pilot projects across Europe in this field. In this task, a novel analytical Water Accounting Plus (WA+) framework will be applied, supported by UNESCO-IHE, The International Water Management Institute (IWMI) and FAO.
WA+ examines the exploitable water in a river basin, i.e. the water that is utilized by a certain water use sector (irrigation, industry, domestic, energy, wetlands) or is utilizable for future withdrawals. The input data sets for WA+ are based on state of the art, open-access data from earth observation measurements, hydrological modelling and global GIS datasets of specific water and environmental parameters. Local data sources from the case studies can bring more detail to the water accounting system.
So far, climate change impact assessments using water accounting frameworks have not been carried out, given their relatively recent development. At this point, the methodologies are sufficiently mature to be used also for assessments under future change. IMPREX will make this step forward and study the impact of changing rainfall, evapotranspiration and atmospheric recycling under a changing climate on water resources with an emphasis on agriculture for the case study basins. This task will be carried out in close collaboration with WP12 (Water Economy), and input will be based on climate change scenarios from WP3. For the Jucar case study basin, results will be used in WP13 for strategy and policy development at climatic time scale.

Participation per Partner

Partner number and short name	WP11 effort
9 - TUC	7.00
12 - DELTARES	6.00
13 - IVM	6.00
15 - HKV	7.00
16 - FW	31.00
18 - UPV	6.00
19 - POLMIL	11.00
Total	74.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D11.1	Prototype design of drought DSS	16 - FW	Report	Public	18
D11.2	Index-based drought risk assessment	16 - FW	Report	Public	36
D11.3	Multihazard drought management tool	15 - HKV	Report	Public	36
D11.4	Prototype Drought Decision Support system	16 - FW	Demonstrator	Public	48

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D11.5	Climate change in agricultural water accounting system	16 - FW	Demonstrator	Public	48

Description of deliverables

• D11.1: Prototype design of drought decision support systems including seasonal forecasts (FW) (M18)
• D11.2. Exploration of drought indices and agricultural impacts (FW) (M36)
• D11.3. Test and evaluation of a multi-hazard drought-risk decision support tool (HKV) (M36)
• D11.4. Prototype demonstration and evaluation of IMPREX-enhanced drought decision support systems (FW) (M48)
• D11.5. Implementing climate variability assessments in a basin water accounting system (FW) (M48)

D11.1 : Prototype design of drought DSS [18]

Prototype design of drought decision support systems including seasonal forecasts

D11.2 : Index-based drought risk assessment [36]

Exploration of drought indices and agricultural impacts

D11.3 : Multihazard drought management tool [36]

Test and evaluation of a multi-hazard drought-risk decision support tool

D11.4 : Prototype Drought Decision Support system [48]

Prototype demonstration and evaluation of IMPREX-enhanced drought decision support systems

D11.5 : Climate change in agricultural water accounting system [48]

Implementing climate variability assessments in a basin water accounting system

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/ projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP12	**Lead beneficiary [10]**	23 - WFN
Work package title	Sectoral survey: Water Economy		
Start month	1	**End month**	48

Objectives

The impact of hydrological extremes, especially droughts, will affect economic activities and ecological systems that depend on the availability of water. For example, the lack of water can often result in losses in yields in both crop and livestock production. Production losses combined with change in demand of products and water by different economic sectors may lead local shortages of certain goods, and thus result in need for importing these goods from other regions. However, availability of these imports, particularly those that rely on water, can be at risk considering that production of many commodities are potentially sensitive to climate change on a global scale.
Europe currently meets some of its water needs by importing "virtual" water in the form of goods and services from other countries and regions. This external component accounts for approximately 40% of Europe's water footprint . Reliance on food, energy and goods, which require water in their production from regions outside of Europe that are themselves vulnerable to hydrological extremes and climate change, may impose water related risks to different economic sectors in Europe. For example, IPCC's 1 suggests that the Mediterranean Basin, Southern Africa, western United States and southern and eastern Australia will suffer a decrease in water resources with a consequential reduction in production as a result of increase in droughts. This forecast may suggest that the structure of production within Europe and imports may need to be adjusted to respond to climate changes to the availability of water resources around the world. Changes in the locality of production may have a number of subsequent environmental and social effects both in Europe and around the world.
Especially the linkages between different regions within Europe with respect to the interdependence of their production is a potentially large source of climate-change damages. Furthermore, European productivity depends to a large extent on the import of goods from the outside.
This work package aims at understanding and assessing vulnerability of European economy on global supply and production of goods under hydrological extremes (drought and flood damage) and climate change. Specific objectives of this work package are:
• to understand current dependencies of economic sectors in Europe on water resources of Europe and of other parts of the world;
• to elaborate impacts of climate change and hydrological extremes on water resources of the regions that Europe's economy depend on;
• to elaborate vulnerability of European economy on global supply and production of goods under hydrological extremes and climate change;
• to elaborate how Europe's dependency upon climate-sensitive imported resources;
• to understand environmental and social effects of this susceptibilities in Europe.
Within this WP, the Water Footprint Assessment (WFA) will be applied to study changes in demand for products within Europe and their water footprints under hydrological extremes (drought) and climate change. WFA covers the full range of activities to quantify and locate the water footprint of a process, product, producer or consumer or to quantify in space and time the water footprint in a specified geographic area and assess the environmental, social and economic sustainability of this water footprint. WFA will be used to elaborate the ability of Europe to meet changes in demand taking into account variations in water availability in producing river basins. In addition, the impacts of droughts and climate change on global water resources will be studied to obtain insight in the effects on the supply of goods and economic security of Europe. For this purpose, outputs of climate change scenarios from WP3 will be used as an input for the assessment. The results will be used in hydrological risk assessment (WP14).
Based on the improved meteorological scenarios of WP3, new projections of future extreme floods developed in WP4 will be used to compute the direct economic damages onto different regional sectors in Europe. Using the global damage transfer model "Acclimate" developed by PIK, the linkages and indirect damages within Europe will be computed. A special focus lies on the question of whether and under which circumstances the indirect effects exceed the direct ones. In a second working phase the scope is broadened by studying global impacts and their indirect effect on Europe. To this end, the generalized methods from WP2 and WP3 are applied to derive projections of global impacts of climatic extremes. Their impact onto the European economy are investigated together with potential adaptation measures to reduce these effects. The results are directly relevant for society and will feed into the outreach activity in WP14.

Description of work and role of partners

WP12 - Sectoral survey: Water Economy [Months: 1-48]
WFN, PIK
Task 12.1: Mapping dependencies of economic sectors in Europe on other parts of the world in terms of water resources (WFN)
This task will develop the baseline case for analysis of future susceptibilities of Europe's imports under climate change and hydrological extremes. To establish the baseline conditions, first, current water footprint of production and consumption in Europe and water footprint of different economic sectors (e.g. agriculture) will be analysed. This will help analysing external component of Europe's water footprint - water consumed in other parts of the world to produce goods consumed in Europe - and identifying key imported products and their production regions. Blue water scarcity and water pollution levels and impacts of hydrological extremes in these regions will be elaborated to understand vulnerability of production of key imported products. Hotspot regions and goods will be identified considering environmental vulnerability (e.g. water scarcity, water pollution level and hydrological extremes) and economic importance (based on EU dependence for production in that river basin/region).

Task 12.2: Assessment of water-related risks of European economy due to dependencies on water resources in Europe and other regions of the world under climate change and hydrological extremes (WFN)
This task aims to identify water-related risks that different economic sectors in Europe may face due to Europe's dependence on water resources elsewhere in the world and international dimension of climate change. This task will consist of:
a) Assessment of water demand changes in Europe: Changes in demand of products and their water footprints for individual regions and sectors within Europe will be elaborated by using existing climate change and socio-economic scenarios. This will help understanding how Europe's water demand will vary under different conditions.
b) Analysis of future susceptibilities of Europe's imports under climate change and implications of this to Europe's water resources: Impacts of climate change on importing regions' water resources and effects of this to Europe's imports will be elaborated by using existing climate change scenarios. Hotspot regions (regions experiencing production losses due to reduced water availability) and products (imported products that are economically significant and climate-sensitive) will be identified. This information and changes in product demand by different economic sectors will be used to understand need for increased production within Europe. The ability of Europe to meet changes in demand taking into account variations in water availability under hydrological extremes will be elaborated. Subsequent environmental effects in Europe will be analysed. The pan-European assessment of agricultural drought vulnerability under climate change from WP11 will be used an input to this analysis. This task will identify risks that different economic sectors of Europe may face due to dependencies on imports and water resources of the other regions under climate change and hydrological extremes.

Task 12.3: Projections of direct impacts on European and global economic productivity from future floods (PIK)
As a result of the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP) global projections of runoff from 1971 to 2100 are available from 11 global hydrological models based on climate projections of 5 different global climate models (GCMs) using 4 different GHG concentration scenarios (RCPs). This wealth of consistent data allows a robust quantification of future runoff trends and the associated uncertainties, and thus provides the basis for a probabilistic estimation of future flood hazard. WP3 and WP4 aim for improved representations of future climatic extremes an d their impacts. We will embed these into the existing ISI-MIP projections in an effort to understand their differences and learn about the robustness of current projections. A global river and floodplain model, CaMa-Flood3.4 , will be used to translate the runoff projections into spatially-resolved time-series of flooded area and flood depth , which will then be downscaled to the ~10km scale using high-resolution topographic data. From the resulting daily inundation data, relevant aggregated metrics such as times flooded per year, maximum flood depth, etc. will be calculated for each grid point. The flood depth and frequency obtained will be translated into damages to sector-specific production capacity using spatial distribution of economic output for present day conditions and future projections together with existing relations and historical evidence of damages caused by flooding. Relevant damage indicators include the percentage of economic output affected and the restoration timescale. The resulting damages will be spatially aggregated to eliminate higher-order variability and detect robust climate-change signals. We compute the direct damages onto the European economy, but also assess the direct damages outside of Europe to be fed into Task 12.4.

Task 12.4: Estimation of indirect flood damages for Europe with the model Acclimate for different supply and demand strategies (PIK)
After having computed the direct costs to be expected from future floods, the indirect costs through global supply and production failure will be assessed with the global damage transfer model acclimate. Acclimate is a global numerical damage model that captures the dynamic response of the global supply network to climatic impacts, particularly extreme weather events like floods. It estimates the indirect costs that arise through unanticipated production and supply failures using zeean data as a baseline. Thereby the model depicts the propagation of disaster induced shock waves in a highly

non-linear, time-dependent and spatially explicit way. While the model asymptotically optimizes a global welfare function when perturbed by one climatic impact (cost-benefit-analysis), it does not assume that the actors can anticipate climatic impacts in advance (no perfect foresight). This short-term response is complemented by longer term adaptation strategies within the production network which may reduce the costs of climatic impacts. We will focus on the indirect damages witin Europe and also compute the indirect damages for the European economy that are caused by production loss in other parts of the world. Specifically, this will be done by separating the indirect costs according to different strategies which are price-oriented. The initial starting point is to assign a history weight to different demand distribution strategies. Depending on how much weight is put on the history of the supplier-buyer relationship, the global supply network can find back to its initial structure once the disaster is overcome. One example of a particular strategy that can be applied, once a supplier fails to deliver, is to assign a production site's demand to use the most recent delivery as a major reference, i.e. if a production site has fulfilled the last demand request it is anticipated that it will fulfil the subsequent request as well. In this case, it is assumed that the existing trend continuous. This strategy has the advantage that production sites unimpaired by the disaster can react promptly to a breakdown of one of their suppliers. The indirect damages caused by floods will be estimated for different supply-and-demand strategies.

Participation per Partner

Partner number and short name	WP12 effort
5 - PIK	24.00
23 - WFN	24.00
Total	48.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D12.1	Dependence of European economy on water issues elsewhere	23 - WFN	Report	Public	12
D12.2	European economy risks under climate change	23 - WFN	Report	Public	48
D12.3	Supply and demand strategies affecting future economic damage	5 - PIK	Report	Public	48

Description of deliverables

• D12.1: Report on dependencies of economic sectors in Europe on other parts of the world in terms of water resources (WFN) (M12)
• D12.2: Report on water-related risks of European economy due to dependencies on water resources in other regions under climate change and hydrological extremes (WFN) (M48).
• D12.3: Estimation of indirect future economic damages on Europe from within and outside Europe for different supply and demand strategies through global supply and production failure (PIK) (M48).

D12.1 : Dependence of European economy on water issues elsewhere [12]

Report on dependencies of economic sectors in Europe on other parts of the world in terms of water resources

D12.2 : European economy risks under climate change [48]

Report on water-related risks of European economy due to dependencies on water resources in other regions under climate change and hydrological extremes

D12.3 : Supply and demand strategies affecting future economic damage [48]

Estimation of indirect future economic damages on Europe from within and outside Europe for different supply and demand strategies through global supply and production failure

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP13	**Lead beneficiary [10]**	11 - HZG
Work package title	Sectoral integration and climate services		
Start month	1	**End month**	48

Objectives

An integration of the experience gathered in WP7-12, and a transfer of this experience towards science-based risk-reduction and adaptation strategies is the main objective of WP7. For two of the survey areas addressed by multiple sectors in WP6, the Jucar River Basin and the Rhine river basin, a (modelling) chain is designed that does right to the paradigm of climate services: transformation of climate/hydrological projections into information that is usable as a base for decision making. This modelling approach is well aligned with the modular structure of the JPI Climate8. This modelling chain combines the pieces of information derived from WP3 and 4 at both the short- term and climate time scales, the information on risk and vulnerability assessment of WP5, and the case study information obtained in WP6 with a newly developed integrative participatory modelling approach that allows iterative exchange of information between physical and social scientists and regional stakeholders.
The modelling chain will be used to analyse potential management strategies and policy implications both for current and future conditions. In both test sites, Jucar and Rhine, the impacts of hydrological high-impact events affect different sectors with different intensities and at different time scales. For instance, in the agricultural sector in the Jucar basin short-term decisions reflect crop management options, while longer term decisions concern crop selection and insurance arrangements. Tradeoffs among multiple and conflicting objectives will be differently affected across different temporal scales.
With this modelling chain, future strategic options will be inspired by analysing decisions under historic conditions, giving body to the paradigm that dealing with current extremes forms a solid ground of experience to anticipate future extremes. It does so by structuring and integrating the heterogeneous experience from WP3, 4, 5 and 6 in a comprehensive synthesis that supports the management of extreme hydrological events . The approach allows a thorough evaluation of cross-sectoral and cross-regional impacts of hydrological hazards (e.g. droughts affecting simultaneously reservoir operation, economic sector, energy and urban water supply).
To ensure applicability of the approach applied to the Jucar basin and Rhine basin to other target areas, a guideline for transferability will be compiled, that will explain which region/site/stakeholder specific information needs to be provided in order to make use of the developed approach.

Description of work and role of partners

WP13 - Sectoral integration and climate services [Months: 1-48]
HZG, ADELPHI, HKV, UPV, POLMIL
The tasks will be exemplary implemented in the Júcar and the Rhine River basins. The approach is transferable to other river basins but also to other contexts in which hydrological extremes turn into high-impact events.

Task 13.1: Integrative participatory modeling approach (HZG, UPV)
This task will develop a participatory modeling approach to test and evaluate risk and adaptation management options for hydrological extremes integrating scientific and end-user knowledge. The modeling approach is generic to assure the transferability to other geographic areas, which will be documented in a set of guidelines for transferability. The approach is based on system dynamics modeling and agent-based modeling, incorporating the hydro-economic modeling tools from WP8 and WP11 to analyze climate risk management and adaptation, including innovative economic policy instruments, such as water pricing, markets or insurances and policy analysis. The economic characterization of the competing water uses will allow to assess economic impacts of different climate change scenarios and potential benefits of adaptation measures.

Task 13.2: Risk mapping (HZG, UPV)
The output of WP3 is transferred into precipitation maps for the Júcar River Basin and the Rhine River Basin conditions. This approach is developed in WP13 as a prototype that can be implemented for other river basins and regions. These precipitation maps will facilitate decision making under uncertainty by providing extremes tendencies at the short-term (task 3.1), seasonal term focus on the prediction of intra-seasonal extremes (task 3.2) and long term climate projections (task 3.3). These maps provide updated precipitation knowledge for the regions showing the range of variability of results. Information will come directly from D3.2 and D3.5. They will be made publicly available.

Task 13.3: Integrating the hydrological hazard module (UPV, HZG, POLMIL)

The input of WP4 on improving predictability of hydrological extremes will facilitate the enhancement of future risk management strategies by improving predictions on the climate scale (as described in task4.4). The combination of WP3 and WP4 contribution into the integrative modelling approach will allow end-users to include this information in their decision making process and facilitate the management of hydrological extremes at different times scales.

Task 13.4: Integrating risk assessment concepts (HZG + all)
Making use of the concepts tested and evaluated in WP5 (task 5.3 and task 5.4), WP13 delivers a step-by-step-guide for assessing the impacts and risks of hydrological extremes linking risk assessment concepts into the integrative modeling approach and providing possible management alternatives. In this way we are able to integrate the above described three levels of ex-ante analysis for extreme hydrological events (task 13.1, 13.2 and 13.3) to test and evaluate which the optimal way to transfer knowledge for the development of risk and adaptation management strategies for hydrological extreme events.
For instance, the risks profiles for the Rhine River basin resulting from drought related hazards events (derived in WP6) serve as a starting point for risk management strategies in WP7. A first step is to identify and assess individual measures that could be undertaken at various scales to reduce risks resulting from drought-related hazard events, viz. (1) measures at river basin scale (by optimizing the distribution of fresh water flows over the Rhine branches, or by measures reducing salt water intrusion in the main water systems), (2) measures at regional scale (construction of water storage basins in the regional water system) or (3) measures at local scale by the end users. The risk based approach from WP5 can help to assess the cost-efficiency of measures to cope with droughts and define cost-efficient solutions through a cost benefit analysis.

Task 13.5: Ex-post analysis (HZG + all)
The application of the participatory integrative modeling chain as a decision-support tool or as a regulatory instrument for policy frameworks will be tested:
• For instance, the effect of actual management decisions after the drought period that the Júcar is suffering will be tested. It is tested how a change in the provisions of water uptake for the agricultural sector influence water management and adaptation.
• For the Rhine River basin a number of measures at various scale levels is combined (task 13.4). New risk management and adaptation strategies are compiled. This will allow to prioritise and predicate decisions and support decision making about new risk management strategies. For instance, it will be used to evaluate the application of new alternative water allocation rules in the Netherlands (at river basin scale and at regional level).
The results will be feed into the deliverable 13.5 providing a white paper on adaptation capabilities.

Task 13.6: Policy implications (ADELPHI,HZG, HKV, UPV)
WP13 links IMPREX results to the key European legislation and policy processes related to water and climate such as the Water Framework Directive (WFD), the Blue Print for Safeguarding European Waters, or agricultural policies (e.g. CAP). This is done by evaluating how climate change (projections of extremes) were considered so far in these policies/legislations and by providing guidance for improved management planning within the framework of EU directives and policies.
For instance, it will be assessed in a literature review and document analysis what types of measures were included in the River Basin Management plans, how impacts (risk) are considered and represented; and how early warning was integrated in the (risk) management plans and on what basis; Therefore, Task 13.6 starts with analyzing how hydrological extremes were considered in the three steps of the WFD and FD for our primary test sites (Jucar and Rhine River Basin). The results of this analysis will be mirrored against IMPREX findings such as the novel concepts for representing and/or assessing the impacts and risk of hydrological extremes (WP5) and particular the case study work in WP6, such as a) the evaluation of optimal coordination mechanisms at the Jucar basin scale in terms of water allocation and use (WP8.3), b) the developed drought indicator tailored to the local agricultural sector and risk profile of the Jucár basin(WP11.2), and c) the results from applying the newly developed (WP5.3) drought risk management instrument (risk profile) in the Jucár basin (WP11.3).
Based on the above analysis and additional stakeholder interviews with selected policy makers and decision makers identified in WP2, recommendations for improved management planning within the framework of EU directives and policies will be developed.
For the Rhine river basin we intend to evaluate the application of new water assignment rules as a means in the main water system to deal with drought related hazards. Additionally, we also intend to investigate the measures that could be undertaken in the regional water system and by the end-users (agriculture, industry, navigation, drinking water, etc.). The results of this task will feed into Deliverable D.13.6, D.14.6 (policy briefs), and D.14.7 (Brochure on climate risk management and adaptation strategies).

Participation per Partner

Partner number and short name	WP13 effort
11 - HZG	38.00
14 - ADELPHI	11.00
15 - HKV	10.00
18 - UPV	15.00
19 - POLMIL	3.00
Total	77.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D13.1	Generic integrative modelling approach	11 - HZG	Demonstrator	Public	20
D13.2	Integrated risk maps	11 - HZG	Report	Public	32
D13.3	Prototype hydrological module	18 - UPV	Demonstrator	Public	34
D13.4	Guide on modelling for decision making in the water sector	11 - HZG	Report	Public	40
D13.5	White paper about adaptation options	11 - HZG	Report	Public	44
D13.6	Evaluation of EU water-related frameworks	14 - ADELPHI	Report	Public	48

Description of deliverables

• D13.1: Generic integrative modeling approach (HZG) (M20)
• D13.2: Integrated risk maps for test sites (HZG) (M32)
• D13.3: Prototype hydrological module (UPV) (M34)
• D13.4: Step-by-step guide on standardized modeling approach for climate-sensitive decision making in the water sector (HZG) (M40)
• D13.5: White paper about adaptation options prioritization and performance to future expected hydrological extremes. (HZG, UPV, HKV) (M44)
• D13.6: Policy implications: evaluation of the integration of hydrological extremes and representation of impacts in the different steps of EU water-related frameworks and policies for the test sites (Adelphi) (M48)

D13.1 : Generic integrative modelling approach [20]

Generic integrative modeling approach

D13.2 : Integrated risk maps [32]

Integrated risk maps for test sites

D13.3 : Prototype hydrological module [34]

Prototype hydrological module

D13.4 : Guide on modelling for decision making in the water sector [40]

Step-by-step guide on standardized modeling approach for climate-sensitive decision making in the water sector

D13.5 : White paper about adaptation options [44]

White paper about adaptation options prioritization and performance to future expected hydrological extremes

D13.6 : Evaluation of EU water-related frameworks [48]

Policy implications: evaluation of the integration of hydrological extremes and representation of impacts in the different steps of EU water-related frameworks and policies for the test sites

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS21	Test sites reports on data and stakeholders	11 - HZG	18	Test sites reports on data and stakeholder availability
MS22	Prototype of the integrative participatory modeling chain	11 - HZG	24	Prototype of the integrative participatory modeling chain
MS23	First conclusions on prioritization method	11 - HZG	36	Internal discussion on prioritization method for choosing adaptation measures
MS24	European policy analysis	14 - ADELPHI	44	Analysis of EU climate change policies and water policies interfaces

Work package number [9]	WP14	Lead beneficiary [10]	8 - METOFFICE
Work package title	Communication and dissemination		
Start month	1	End month	48

Objectives

This WP coordinates the outreach activities and the dissemination of project's results. The main objective is to design and implement an effective dissemination strategy for the target audiences, which include SMEs, the research community, and public authorities at EU, national and regional levels as well as the general public. The WP activities will be structured in three logically distinct lines of activities.
a) Development a well designed public website and communications platform to facilitate the exchange between the project partners users and stakeholders. The platform will allow the users to access project reports, training material, information on sector-specific workshop, videos, facts-sheets and other material related to IMPREX.
b) Definition and delivery of communication and dissemination activities targeted to specific key audiences and national and international research iniatives such as IAHS Panta Rhei or WMO High Impact Weather (e.g. customised workshops and publications, such as policy briefs and fact sheets).
c) Development and delivery of a hydro-meteorological monthly to seasonal risk outlook tool for the European continent. Having the possibility of engaging with a semi-operation product the users will learn about the project in a hands-on fashion. Such a platform will also provide a natural feedback loop to allow the users to provide information of their needs and/or preferences.

Description of work and role of partners

WP14 - Communication and dissemination [Months: 1-48]
METOFFICE, ECMWF, ARCTIK, BSC, DELTARES, IVM, ADELPHI
Task 14.1: Development and delivery of communication dissemination & exploitation plans (Arctik, Adelphi, ECMWF, Met Office, BSC)
A dissemination and exploitation plan will be developed at the beginning of the project. It will contain detailed information about the activities planned for the duration of the project. The document will also provide an overview of the overall dissemination and exploitation strategy, key messages, target audiences, and communication activities. One of the tasks of this plan will be the identification of a narrative for IMPREX which will in turns help us create a clear message for our target audience. This strategy will be developed in close consultation with specialised beneficiaries.
A preliminary version of the dissemination plan will be developed for month 2, including short-term goals (logo, visual guidelines, preliminary project leaflet). The final version of dissemination and exploitation strategy plan will be submitted by month 6 of the project. The dissemination and exploitation plan will be updated on an annual basis throughout the project. Clear and evaluable objectives will be included and assessed year-by-year.

Task 14.2: Visual identity and IMPREX logo (Arctik)
A coherent and recognizable visual identity for IMPREX will be developed. The layout and colours associated with this identity will then be applied to all standard publications (e.g. fact sheets, case studies, leaflet, website…) to give a unique, but clearly IMPREX-related, visual identity. The design in general and the logo in particular will be clean, photo-oriented and will tell the story of the project at a glance. The visual identity will respect the European Commission visual guidelines for research project.

Task 14.3: Establishment of a community around a well-designed web-site (Arctik)
A dynamic web site based on the example of previous project such as HEPEX, ENHANCE, EUPORIAS, will be the basis for community development around IMPREX. Personas representing different target group will be created. These will be the basis for the development of content in the content matrix. The webpage will be a platform for sharing information and ensures a continuous process of exchange and feedback between the users and the providers of hydrological-risk information.
An active twitter account and a weekly digest will be put together and maintained in order to keep the relevant audience-community engaged. The weekly digest will be tailored differently from week to week for attracting and involving different audiences (scientists – non scientists).
Case studies, stories and guest posts will be the main tools used to keep the community of users involved but a Search Engine Optimisation strategy will be explored as an option to ensure long-term visibility.

Task 14.4: Direct outreach activities (Arctik)

Each year the dissemination and exploitation plan (task 8.1) will identify a set of sectors that will be specifically approached. We will specifically give high priority to the private sector, in particular SMEs both at the European and national levels. Multipliers such as Business Europe, European Business Network, Eurochambre, and the Enterprise Europe Network will in particular be approached with tailored messages and materials. A few representatives of these networks will join the Science and Service Adivory Board.
EU programmes dedicated to SMEs will also be part of the overall mapping exercise. Looking in particular at EMAS, EcoAP, EBAE, ECAP, Retail Forum, Consumption & production platform, EFO / EFP and their own communities as important multiplier sources and actors.
A first step will be to place editorial content that refers to IMPREX on the websites and – where possible – in print publications produced by the identify stakeholders.
A second and parallel step will be to liaise with the identified actors to participate to their conferences or exhibitions (EBN congress, EEN annual conference, SME week).
Project video(s) will serve as an easy and dynamic way to target the different audience with key messages and call for actions.
Finally, the consortium partners will organise a press brief to disseminate the results of the project. The press brief can be organised within the final conference or as a separate event in Brussels.

Task 14.5: Development and delivery of a hydro-meteorological monthly to seasonal risk outlook tool for the European continent (METOFFICE + other partners)
Building upon the development of the seasonal prediction systems and the hydrological prediction systems that will occur within WP3 & WP4 and linking to other relevant activities in Europe, IMPREX will develop and deliver a semi-operational tool able to inform decision makers about the likelihood of occurrence of high risk hydrological events in the forthcoming months. Whilst the ultimate ambition is to develop a multi-model ensemble of hydrological predictions, the emphasis will be put here on the development of a fully working proof-of-concept prototype. The risk outlook tool will be tested and developed over three distinct phases:
• Assessment of the skill over the hindcast period using observations and reanalyses as a benchmark
• Ex-post analysis of the forecast over the most recent season
• Experimental semi-operational prediction for the coming season.
By providing a high-profile tangible output of the project the risk outlook tool will represent the natural way to engage with new potential users. The Risk Outlook tool will be linked to currently existing (sectoral) risk outlook systems, such as operated for agriculture and droughts by JRC, for floods by EFAS, and for water transportation by BfG

Task 14.6: Risk outlook documentation and training material (METOFFICE + other partners)
Documentation and training material will be developed to ensure all potential users know what the risk outlook tool does, how it works and how its output should be interpreted in a decision-making context. This material will be developed in close coordination with the sectoral users boards to ensure it is fit for purpose and it addresses all relevant questions the users might have.

Task 14.7: Project Workshops (METOFFICE, ADELPHI)
There will be two main types of workshop:
• Workshop targeting European decision-makers in both public and private sector. These will mainly focus on the use and the limitations of the hydrological risk outlook tool. Such a tool will be used as a way to present the main outcomes of the project and their use in a decision-making context. The main audience for these workshops will be the sectors and users already involved in WP7-12. There will also be a workshop co-organised with WP4 and HEPEX to explicitly disseminate the results of WP4 activities.
• Workshop addressing the need of strategic planners and policy-makers, focusing on the long-term changes in the hydro-meteorological risk profile for European users. These workshops will provide policy briefs targeted to the people responsible for designing and implementing strategies in support of the Blueprint to safeguard Europe's water resources, the EU Climate Change adaptation strategy, disaster risk reduction, and relevant EU Directives, such as the Floods Directive and Water Framework Directive. The consortium will make sure to invite and confirm the participation of key members of the target groups at the workshop. The workshops will be held in a participatory format; if possible the workshop will be organised on the side of a larger events/conferences. Policy briefs will be formulated, which serve as discussion papers for the workshops and which will be finalised based on outcomes of the workshop.

Task 14.8: Information materials for the general public (Arctik)
Facts-sheets and YouTube videos describing the building blocks of the risk outlook tools and the key processes controlling hydro-meteorological extreme events in Europe will be developed and made available through the project website. They are aimed at a wider audience of people interested in the topic but not directly involved in IMPREX. As part of the monitoring and reporting activity, a detailed summary of the outreach activities will be drawn, including

number of conferences attended for IMPREX, editorial and interviews referring to the project, stakeholder contacted, and database growth. The first summary will be provided in M6.

Task 14.9: Synthesis publications for policy and decision makers (Adelphi, Arctik)
The sectoral assessments of improved utilisation of forecasts and foresights (WP6) as well as the analysis of diverse risk management adaptation strategies (WP713) will reveal important lessons for policy and decision making at multiple levels (from local to EU). To ensure up-take of IMPREX's research results in political decision making and review processes, outcomes of WP6 - 13 will be synthesised and relevant policy lessons formulated in the following set of targeted publications:
• Fact sheets summarising lessons learnt for decision makers from the case studies carried out in WP6
• Brochure on climate risk management and adaptation strategies focusing on climate-sensitive decision-making and the importance for the water sector based on results of WP13.

Participation per Partner

Partner number and short name	WP14 effort
2 - ECMWF	7.00
6 - ARCTIK	8.00
7 - BSC	6.00
8 - METOFFICE	24.00
12 - DELTARES	4.00
13 - IVM	3.00
14 - ADELPHI	11.00
Total	63.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D14.1	Communication strategy plan	6 - ARCTIK	Report	Public	6
D14.2	Dissemination and exploitation plan	6 - ARCTIK	Report	Public	6
D14.3	First summary of outreach activities	6 - ARCTIK	Report	Public	6
D14.4	IMPREX logo & website	6 - ARCTIK	Websites, patents filling, etc.	Public	6
D14.5	Protoype hydrometeorological risk outlook	8 - METOFFICE	Demonstrator	Public	36
D14.6	Policy briefs of EU Water-related actions	14 - ADELPHI	Report	Public	48
D14.7	Synthesis brochure on risk mgmt	14 - ADELPHI	Report	Public	48

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D14.8	Brochure, videos and press briefing on climate risk mgmt	6 - ARCTIK	Websites, patents filling, etc.	Public	48
D14.9	Fact sheets on lessons learnt	14 - ADELPHI	Report	Public	48
D14.10	Workshp agenda and participant lists	8 - METOFFICE	Report	Public	46

Description of deliverables

• D14.1: Final Communication strategy plan (Arctik) (M6)
• D14.2: Dissemination and exploitation plan (jointly with WP2 and WP6) (Arctik) (M6)
• D14.3: First summary of outreach activities (Arctik) (M6)
• D14.4: IMPREX website, visual identity and logo (Arctik) (M6)
• D14.5: Semi-operational hydro-meteorological monthly to seasonal risk outlook tool for the European continent plus training material (METOFFICE and ECMWF) (M36)
• D14.6: Four policy briefs focussing on the Blueprint, EU adaptation strategy, disaster risk reduction, and water related directives respectively (ADELPHI, Arctik) (M48)
• D14.7: Brochure on climate risk management and adaptation strategies focusing on climate-sensitive decision-making and the importance for the water sector (ADELPHI, Arctik) (M48)
• D14.8: Project videos and press briefings (METOFFICE, Arctik) (M48)
• D14.9: Fact sheets on sectoral and cross-sectoral lessons learnt and best practices from sectoral surveys (Adelphi, Arctik) (M48)

D14.1 : Communication strategy plan [6]

Final Communication strategy plan

D14.2 : Dissemination and exploitation plan [6]

Dissemination and exploitation plan (jointly with WP2)

D14.3 : First summary of outreach activities [6]

First summary of outreach activities

D14.4 : IMPREX logo & website [6]

IMPREX website, visual identity and logo

D14.5 : Protoype hydrometeorological risk outlook [36]

Semi-operational hydro-meteorological monthly to seasonal risk outlook tool for the European continent plus training material

D14.6 : Policy briefs of EU Water-related actions [48]

Four policy briefs focussing on the Blueprint, EU adaptation strategy, disaster risk reduction, and water related directives respectively

D14.7 : Synthesis brochure on risk mgmt [48]

Brochure on climate risk management and adaptation strategies focusing on climate-sensitive decision-making and the importance for the water sector

D14.8 : Brochure, videos and press briefing on climate risk mgmt [48]

Project videos and press briefings

D14.9 : Fact sheets on lessons learnt [48]

Fact sheets on sectoral and cross-sectoral lessons learnt and best practices from sectoral surveys

D14.10 : Workshp agenda and participant lists [46]

Agenda and participant list of two workshops (Task14.7) (METOFFICE, ADELPHI) (M46)

Schedule of relevant Milestones

Milestone number[18]	**Milestone title**	**Lead beneficiary**	**Due Date (in months)**	**Means of verification**
MS25	Draft communication/ outreach plan	6 - ARCTIK	6	Draft communication/ outreach plan
MS26	Website and leaflets available	6 - ARCTIK	6	Website and leaflets available
MS27	Risk outlook in pilot phase and semi-operational	8 - METOFFICE	36	Risk outlook in pilot phase and semi-operational

Work package number [9]	WP15	Lead beneficiary [10]	1 - KNMI
Work package title	Ethics requirements		
Start month	1	**End month**	48

Objectives

The objective is to ensure compliance with the 'ethics requirements' set out in this work package.

Description of work and role of partners

WP15 - Ethics requirements [Months: 1-48]
KNMI
This work package sets out the 'ethics requirements' that the project must comply with.

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D15.1	H - Requirement No. 1	1 - KNMI	Ethics	Confidential, only for members of the consortium (including the Commission Services)	6
D15.2	H - Requirement No. 2	1 - KNMI	Ethics	Confidential, only for members of the consortium (including the Commission Services)	6

Description of deliverables

The 'ethics requirements' that the project must comply with are included as deliverables in this work package.

D15.1 : H - Requirement No. 1 [6]

Details on the procedures and criteria that will be used to identify/recruit research participants must be provided

D15.2 : H - Requirement No. 2 [6]

Detailed information must be provided on the informed consent procedures that will be implemented.

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification

1.3.4. WT4 List of milestones

Milestone number[18]	Milestone title	WP number[9]	Lead beneficiary	Due Date (in months)[17]	Means of verification
MS1	GA meeting 1	WP1	1 - KNMI	12	General Assembly meetings
MS2	GA meeting 2	WP1	1 - KNMI	24	GA meeting 2
MS3	GA meeting 3	WP1	1 - KNMI	36	GA meeting 3
MS4	GA meeting 4	WP1	1 - KNMI	48	GA meeting 4
MS5	Midterm review	WP1	1 - KNMI	21	Midterm review
MS6	Final review	WP1	1 - KNMI	39	Final review
MS7	Internal workshops to summarise the main users' requirements	WP2	6 - ARCTIK	12	Internal workshops to summarise the main users' requirements
MS8	Reference seasonal forecast data sets	WP3	7 - BSC	12	Reference data sets collected and disseminated (retrospective forecasts (ECMWF), seasonal forecasts
MS9	Regional domains prepared	WP3	3 - SMHI	24	Regional domains prepared for dynamical downscaling with non-hydrostatic regional climate models in very high resolution
MS10	Updated data sets of short term and seasonal predictions	WP3	3 - SMHI	24	Updated version of data sets available (short term predictions (SMHI), seasonal predictions (BSC), downscaled weather events (KNMI)
MS11	New developments tested for high resolution climate scenarios	WP3	3 - SMHI	32	New developments tested (Climate scenarios (SMHI))
MS12	Hydrological input data for sectoral surveys available	WP4	2 - ECMWF	6	Input data for sectoral case studies for current modelling and forecasting of hydrological extremes
MS13	Retrospective runs with hydrological models completed	WP4	2 - ECMWF	12	Output of the first run of the models for sectoral applications to produce state-of-the-art reforecasts of hydrological extremes
MS14	Forecasts for hydrological risk outlook available	WP4	8 - METOFFICE	30	Provision of near-real-time monthy-seasonal hydrological forecast data from the improved hydrological models to allow the creation of a hydrological hazard outlook tool (WP8)

Milestone number[18]	Milestone title	WP number[9]	Lead beneficiary	Due Date (in months)[17]	Means of verification
MS15	White Paper on novel concepts	WP5	13 - IVM	6	WP meeting for discussing White paper concepts
MS16	Draft results new conceptual models	WP5	13 - IVM	36	WP meeting draft model results
MS17	Assessment of current practice per sectoral survey	WP10, WP11, WP12, WP7, WP8, WP9	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/ projection data from WP3/4/5	WP10, WP11, WP7, WP8, WP9	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	WP10, WP11, WP7, WP8, WP9	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	WP10, WP11, WP12, WP7, WP8, WP9	1 - KNMI	48	Definition of benefits for risk assessment and decision support
MS21	Test sites reports on data and stakeholders	WP13	11 - HZG	18	Test sites reports on data and stakeholder availability
MS22	Prototype of the integrative participatory modeling chain	WP13	11 - HZG	24	Prototype of the integrative participatory modeling chain
MS23	First conclusions on prioritization method	WP13	11 - HZG	36	Internal discussion on prioritization method for choosing adaptation measures
MS24	European policy analysis	WP13	14 - ADELPHI	44	Analysis of EU climate change policies and water policies interfaces
MS25	Draft communication/ outreach plan	WP14	6 - ARCTIK	6	Draft communication/ outreach plan
MS26	Website and leaflets available	WP14	6 - ARCTIK	6	Website and leaflets available
MS27	Risk outlook in pilot phase and semi-operational	WP14	8 - METOFFICE	36	Risk outlook in pilot phase and semi-operational

1.3.5. WT5 Critical Implementation risks and mitigation actions

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
1	Operational risks: information and data not shared effectively within consortium	WP3, WP4, WP5	The Data Manager monitors information/data exchange continuously
2	Time/budget risks: delays in producing expected deliverables	WP1, WP10, WP11, WP12, WP13, WP14, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	The high frequency meeting of the Coordination Unit to identify delays, assess impacts and implement organisations/budget changes
3	Competence risks: personnel involved or recruited not able to fulfil tasks	WP1, WP10, WP11, WP12, WP13, WP14, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	Monitoring by the Coordination unit, and implementing adjustments within each organisation
4	Scientific risks, e.g. a high resolution climate model applied for a specific domain, does not produce a precipitation or temperature climate satisfactorily close to available observations	WP10, WP11, WP12, WP3, WP4, WP6, WP7, WP8, WP9	This is a common type of problem when setting up new geographical domains. Scientists at the model centres alleviate this by intensive model and process evaluation and model adjustments.
5	Engagement risks, e.g. lack of participation of stakeholders	WP10, WP11, WP13, WP14, WP2, WP6, WP7, WP8, WP9	The “stakeholder interaction landscape” is heavily populated with current developments of e.g. formulation of climate services. IMPREX partners are involved in many initiatives involving stakeholders and will utilize these networks to avoid over-exploitation of stakeholder engagement and promote synergies.
6	Technical risks, e.g. a new assimilation scheme might not be as efficient as anticipated in improving local simulation of e.g. soil moisture, with impacts on simulation of precipitation.	WP10, WP11, WP4, WP6, WP7, WP8, WP9	Developers have substantial experience in adjusting assimilation schemes and soil parameterizations to optimize performance

1.3.6. WT6 Summary of project effort in person-months

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	WP15	Total Person/ Months per Participant
1 - KNMI	35	2	30	0	19	2	5	0	0	0	0	0	0	0		93
2 - ECMWF	0	0	20	23	0	1	0	0	0	0	0	0	0	7		51
3 - SMHI	0	0	44	26	0	0	0	8	0	0	0	0	0	0		78
4 - IRSTEA	0	0	0	12	0	0	0	24	0	0	0	0	0	0		36
5 - PIK	0	0	0	0	0	0	0	0	0	0	0	24	0	0		24
6 - ARCTIK	3	6	0	0	0	0	0	0	0	0	0	0	0	8		17
7 - BSC	0	5	36	0	0	0	0	0	0	0	0	0	0	6		47
8 - METOFFICE	0	6	31	16	0	0	0	0	0	0	0	0	0	24		77
9 - TUC	0	0	12	6	0	0	0	0	0	0	7	0	0	0		25
10 - UREAD	0	0	22	18	0	0	4	0	0	0	0	0	0	0		44
11 - HZG	0	2	0	0	0	3	0	0	6	0	0	0	38	0		49
12 - DELTARES	0	1	0	23	0	0	28	0	0	0	6	0	0	4		62
13 - IVM	0	0	0	0	34	0	5	0	0	0	6	0	0	3		48
14 - ADELPHI	0	0	0	0	0	0	0	0	0	0	0	0	11	11		22
15 - HKV	0	0	0	0	10	0	6	0	0	0	7	0	10	0		33
16 - FW	0	0	0	6	4	0	0	0	0	0	31	0	0	0		41
17 - CETAQUA	0	0	0	0	0	0	0	0	0	24	0	0	0	0		24
· AquaTEC	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	8
18 - UPV	0	0	0	6	6	0	0	7	0	7	6	0	15	0		47
19 - POLMIL	0	0	0	0	0	0	0	12	0	0	11	0	3	0		26
20 - CIMA	0	0	0	6	0	0	18	0	0	0	0	0	0	0		24
21 - GFZ	0	0	0	0	9	0	17	0	0	0	0	0	0	0		26
22 - BfG	0	0	0	8	0	0	0	0	31	0	0	0	0	0		39

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	WP15	Total Person/ Months per Participant
23 - WFN	0	0	0	0	0	0	0	0	0	0	0	24	0	0		24
Total Person/ Months	38	22	195	150	82	6	83	51	37	39	74	48	77	63		965

1.3.7. WT7 Tentative schedule of project reviews

Review number [19]	**Tentative timing**	**Planned venue of review**	**Comments, if any**
RV1	20	TBD	
RV2	38	TBD	

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It can generally not be changed. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry into force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a written justification.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Abstract

8. Project Entry Month

The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

9. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

10. Lead beneficiary

This must be one of the beneficiaries in the grant (not a third party) - Number of the beneficiary leading the work in this work package

11. Person-months per work package

The total number of person-months allocated to each work package.

12. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

13. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

14. Deliverable number

Deliverable numbers: D1 - Dn

15. Type

Please indicate the type of the deliverable using one of the following codes:

R	Document, report
DEM	Demonstrator, pilot, prototype
DEC	Websites, patent fillings, videos, etc.
OTHER	
ETHICS	Ethics requirement

16. Dissemination level

Please indicate the dissemination level using one of the following codes:

PU	Public
CO	Confidential, only for members of the consortium (including the Commission Services)
EU-RES	Classified Information: RESTREINT UE (Commission Decision 2005/444/EC)
EU-CON	Classified Information: CONFIDENTIEL UE (Commission Decision 2005/444/EC)
EU-SEC	Classified Information: SECRET UE (Commission Decision 2005/444/EC)

17. Delivery date for Deliverable

Month in which the deliverables will be available, month 1 marking the start date of the project, and all delivery dates being relative to this start date.

18. Milestone number

Milestone number:MS1, MS2, ..., MSn

19. Review number

Review number: RV1, RV2, ..., RVn

20. Installation Number

Number progressively the installations of a same infrastructure. An installation is a part of an infrastructure that could be used independently from the rest.

21. Installation country

Code of the country where the installation is located or IO if the access provider (the beneficiary or linked third party) is an international organization, an ERIC or a similar legal entity.

22. Type of access

VA	if virtual access,
TA-uc	if trans-national access with access costs declared on the basis of unit cost,
TA-ac	if trans-national access with access costs declared as actual costs, and
TA-cb	if trans-national access with access costs declared as a combination of actual costs and costs on the basis of unit cost.

23. Access costs

Cost of the access provided under the project. For virtual access fill only the second column. For trans-national access fill one of the two columns or both according to the way access costs are declared. Trans-national access costs on the basis of unit cost will result from the unit cost by the quantity of access to be provided.