TOR Reference No.:	Authors: Enrico Zini, Giuseppe Sgorbati (ARPA Lombardia – Italy)
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TERMS OF REFERENCE FOR WORK UNDER THE AUSPICES OF IMPEL	

1. Work type and title

1.1 Identify which Expert Team this needs to go to for initial consideration	
Industry	☐
Waste and TFS	☐
Water and land	☑
Nature protection	☐
Cross-cutting – tools and approaches -	☑
1.2 Type of work you need funding for	
Exchange visits	☑
Peer reviews (e.g. IRI)	☐
Conference	☐
Development of tools/guidance	☑
Comparison studies	☑
Assessing legislation (checklist)	☐
Other (please describe):	☐
1.3 Full name of work (enough to fully describe what the work area is)	
Supporting the implementation of the EO (Earth Observation) methods for the detection and assessment of illegal abstraction and over-abstraction of water.	
1.4 Abbreviated name of work or project	
WODA: Water Over-abstraction and illegal abstraction Detection and Assessment	

2. Outline business case (why this piece of work?)

2.1 Name the legislative driver(s) where they exist (name the Directive, Regulation, etc.)
Water Framework Directive (WFD) 2000/60/EC Common Agricultural Policy Industrial Emission Directive (IED) 2010/75/UE

Copernicus EU Earth Programme (Regulation (EU) N° 377/2014)

2.2 Link to IMPEL MASP priority work areas

1. Assist members to implement new legislation	☑
2. Build capacity in member organizations through the IMPEL Review Initiatives	☐
3. Work on 'problem areas' of implementation identified by IMPEL and the European Commission	☑

2.3 Why is this work needed? (background, motivations, aims, etc.)

1) Background and motivations: Water use and environmental threats

Over the past thirty years, droughts have dramatically increased in number and intensity in the EU. The number of areas and people affected by droughts went up by almost 20% between 1976 and 2006.

Agriculture is a significant water user in Europe, accounting for around 33% of total water use reaching up to 80% in southern Europe where irrigation enables crop production in areas where water would otherwise be a limiting factor. Water consumption through evapotranspiration and plant growth accounts approximately 70% of water abstracted and does not return to a water body.

The impact of droughts can be exacerbated when they occur in areas where water resources are not being properly managed resulting in imbalances between water demands and the supply capacity of the natural system. Ineffective water management have negative impacts both on quantity and on quality of the available water resources, for instance: over-abstraction of surface water may not ensure the minimum ecological flow (endangering the survival of riverine ecosystems); over-abstraction of groundwater on coastal areas can lead to the intrusion of saline water into the aquifer, furthermore, over-abstraction of ground water on lowlands can cause soil subsidence (thereby affecting the flow of water on rivers, channels and sewers and the level of lakes and reservoirs).

Over-abstraction occurs not only for irrigation use but even for industrial and civil uses and can cause in some cases dramatic effects on soil subsidence, for example: the current rate of soil subsidence of the metropolitan area of Bologna (Northern Italy), due to groundwater over-abstraction, is about 3.5 cm/year. Soil subsidence can be amplified by other concurrent phenomena: non-sustainable land development policies, because soil sealing prevents the rainfall to recharge the exhausted groundwater; by oil or natural gas extraction from underground and by tectonic dynamics. The terms of reference for the sustainable water abstraction should be set in the River Basin Management Plans (RBMPs).
The Blueprint highlights in particular the role of non-authorized abstraction in over-abstraction and the responsibility of Member States in ensuring law enforcement
Besides the over-abstraction, which is related to the exploitation of water resources beyond the limits of sustainability of the ecosystems, also in situation in which competent authorities did not set up water rights, the illegal water abstraction seems to be rather widespread, particularly in arid and semi-arid regions and during drought events. The following cases should be considered:

- abstraction without permit,

- abstraction beyond the amount allowed by permit.

Typical cases of illegal water abstraction occur when wells are operating without permit, or when water is pumped form rivers or channels without permit.

2) Technical framework: opportunities and experiences

Earth Observation (EO), especially satellite remote sensing, can provide well established methods for the monitoring of water abstraction. The detection of illegal water abstraction is a further step forward and is feasible only if permits are organized in a proper GIS. At first instance, EO methods for the monitoring of water abstraction could be summarized as follows:

1) Methods for the monitoring of crop evapotranspiration.

2) Methods for the monitoring of soil subsidence.

Evapotranspiration is the amount of water dispersed into the atmosphere by the vegetation-soil system. Satellite remote sensing allows for the estimation of two different evapotranspiration parameters:

a) Evapotranspiration under standard conditions (ET_c): is a theoretical value generally computed through the Penman-Monteith equation (FAO Guidelines No. 56); it approximates the evapotranspiration of a crop under standard irrigation conditions and represents therefore the optimum crop water requirement.

b) Actual evapotranspiration (ET): is the actual amount of water evapotranspired by crop. In arid non irrigated areas ET is close to zero. Under standard irrigation conditions ET approximates ET_c while under over-irrigation or abundant precipitations, ET tends to an upper limit called potential evapotranspiration (PET). The monitoring of ET is a powerful tool to assess irrigation efficiency and detect water stress situations.

a) and b) methods require meteorological information from ground weather stations (generally: net solar radiation, air temperature, air humidity, wind speed). Besides evapotranspiration, remote sensing provides information about crop type and growth state (phenology and biomass). In some semi-arid regions the contribution from rainfall and surface water is negligible and most of the required water comes from groundwater, thus ET_c directly represents the crop water requirement from groundwater. If well permits are up-to-date and archived in a geo-referenced database, the detection of areas where water is abstracted from illegal wells (or in excess of the levels prescribed in the operational permits of the wells) is quite straightforward. On the other side, in temperate regions where irrigation comes mainly from surface water and only partly from groundwater, the detection of illegal water abstraction through EO and GIS methods may be very difficult.

Methods 2) are based on satellite SAR (Synthetic Aperture Radar) differential interferometry. These methods allow to measure vertical displacement of soil with sub-millimeter accuracy. Under specific geological conditions, quite common in sedimentary basins (e.g. Po River Basin), groundwater over-abstraction causes soil subsidence. Because different concurrent factors may affect soil subsidence, e.g. tectonics, extraction of natural gas or oil, … the measures of soil displacement must be carefully analyzed.

A wide variety of satellites capable of providing images useful for the implementation of the above

mentioned methods is already available or will be in the near future. From a cost/effectiveness point of view, the most viable solutions are represented by medium and high resolution satellites whose images are (or will be) available for free because they allow to perform a periodical monitoring over wide areas (e.g. a region, a river basin) at a sustainable cost.

Among the satellites currently operational there are: NASA Landsat 8 (resolution: 30m - 100m) and NASA Terra and Aqua (resolution: 250m - 500m - 1000m).
With regard to the near future satellites, the EU Copernicus programme is going to launch five constellations of satellites called the Sentinels (operated by ESA). The most suitable constellations for the purposes of the present project are:

- SENTINEL-1, based on SAR sensors (resolution: 5mx20m), useful for soil subsidence monitoring. The first Sentinel-1 satellite was launched on 3 April 2014 and images are already available.

- SENTINEL-2 based on high-resolution multi-spectral optical sensors (resolution: 10m - 60m), useful for ET_c monitoring at local scale.

- SENTINEL-3, based on medium-resolution multispectral optical sensors (even on thermal infrared), (resolution: 500m - 1000m), useful for ET_c and ET monitoring at regional scale.

In addition for the specific purpose of illegal water abstraction Very High Resolution images (acquired by commercial missions) should also be considered. It should be highlighted that in the context of Copernicus there is a space Data Access scheme acquiring space data from 'contributing' missions for the Copernicus services (to complement the Sentinels data).

3) Tackling over and illegal water abstraction: a practical approach

IMPEL has to look at this problem supporting its Members in implementation of over and illegal water abstraction monitoring techniques, when they have directly attributed this task, or in assisting and cooperating with national and regional Competent Authorities and Water Managers.
When looking for a road map to achieve this goal, it has been considered that EC-DG Environment launched a study on the EO potential for the detection of non-authorized water abstraction (as identified in the Blueprint to Safeguard Europe's Water Resources'. It is going to issue a Guidance Document about: “Applying Earth observation to support the detection of non-authorized water abstractions”. The EC-DG ENV intends, through this document, to provide guidance to water managers to the use of EO methods in order to detect illegal water abstraction, with a particular aim at the use of groundwater in agriculture. The main EO method taken into account is the monitoring of ET_c and, secondarily, the monitoring of ET. The document will be a fundamental reference point for any further operational development of this topic.
The general aim of the EC-DG ENV is the support to Member States in WFD implementation and, furthermore, in achieving the quantitative target that was set within the Roadmap for a Resource Efficient Europe. In fact, the Blueprint highlights in particular the role of non-authorised abstraction in over-abstraction and the responsibility of Member States in ensuring law enforcement.
For these reasons, this IMPEL Projects will take into account contents and indications from EC-DG ENV above cited document, developing evaluations and, if possible, Pilot Studies to make easy the deployment of the methodology at practitioners level.

2.4 Desired outcome of the work (what do you want to achieve? What will be better / done differently as a result of this project?)

- The aim of the work is to improve the capability of IMPEL members to monitor water over-abstraction, both legal and illegal, through cost-effective EO and GIS methods. This can increase the IMPEL Members' efficiency in the use of inspective resource on field for tackling illegal abstraction of water; the increase of capabilities in interpreting water use for agriculture, civil and industrial use can be useful to foster Member States in implementation of WFD and achievement of the targets set in Roadmap for a resource efficient Europe.

- Through the development of this project, IMPEL members will acquire a better knowledge about EO methods and the opportunities provided by the Copernicus programme, also in fields other than water use in agriculture, as in land management, illegal landfills tackling, etc. (to be developed with further projects). The outcomes of this project would be very useful in the context of the evolution of the Copernicus Land monitoring service. The potential interest of Copernicus for environmental inspection is already mentioned in the Copernicus Work Programme so the needs might be further accommodated if appropriate.

2.5 Does this project link to any previous or current IMPEL projects? (state which projects and how they are related)

Could be linked to IED and WFD project.

3. Structure of the proposed activity

3.1 Describe the activities of the proposal (what are you going to do and how?)

The below activities are to be considered as the first part of a possible multi – annual project, depending on the outcomes from this activity, taking into account also further mapped needs and opportunities related to EO techniques suitable for enforcement and strategic planning.

1) Mapping IMPEL Members engagement in water abstraction control activities, mapping of relationships of IMPEL Members with National Competent Authorities for:
   - water management at planning level
   - water abstraction rights and illegal activities tackling in this field

   (instrument: questionnaire)

2) Defining the state of the art of techniques adopted by competent authorities in illegal and over abstraction of waters in use or under development/experimentation with particular attention to EO and GIS methods (instrument: questionnaire)

3) Development of 2-3 Pilot Feasibility Studies to test the suitability of EC-DG Environment Guidance Document on 2-3 sites where IMPEL members/competent Authorities are ready to use EO tools to support water issues planning and enforcement.
   Instrument: analysis of outcomes from Feasibility studies, discussion with project members

4) Elaboration of an IMPEL Guidance Document making the best use of EU-Commission study, under the light of the experience and issues from the Pilot Feasibility Studies and other information gathered with the above activities, to address at best the operational needs

5) Definition of follow-up tips: some proposal about the possible follow-up of the project will be delivered: making synergies with institutions and subjects, (e.g. the Copernicus User Forum and the EEA coordinating the Land Monitoring service, but also the NEREUS network of the European regions which uses EO data and services), participating to EU R&D proposals (in particular in the context of horizon GEO GEOSS activities).

The development of some of the activities provided for by this project, and in particular the elaboration of the Guidance document to support the use of EU-Commission study might be carried out jointly or anyway in close collaboration CIS WG on Agriculture, if possible.

3.2 Describe the products of the proposal (what are you going to produce in terms of output / outcome?)

Output:

1) Guidance Document on water over-abstraction by EO monitoring on the basis of the EC-DG Environment study.
2) Proposal for a follow up project

Outcomes:

3) Support for WFD Implementation, tackling of quantitative water status threats
4) Increase in experience in EO method use by IMPEL Network
5) Increase in capability of IMPEL members in use of EO techniques output as indicator to prioritize inspection programs
6) Proposal for further EO techniques for monitoring water abstraction and of effect of this phenomena at land and ground level
7) Among possible outcomes of the study, there is also the practical support to the Impel Members participating to the Pilot study in implementing EO system as normal instrument for inspection prioritization on illegal water abstraction.
8) Synergies with the EU Copernicus programme (and the Land Monitoring service in particular)

3.3 Describe the milestones of this proposal (how will you know if you are on track to complete the work on time?)

- KO: Kick-Off Meeting, general planning of the activities
- KO + 1 months: definition of Questionnaire, definition of the Working Plan for the Pilot Feasibility Studies.
- KO + 2 months: selection an starting of 2-3 Pilot Feasibility Studies.
- KO + 3 months: feedback from Questionnaire.
- KO + 6 months: Interim Meeting: discussion of issues from Questionnaire and progress on Pilot Feasibility Studies.
- KO + 10 months: Draft Guidance Document.
- KO + 12 months: Final Meeting, presentation of Final Guidance Document and Follow-Up Tips.

3.4 Risks (what are the potential risks for this project and what actions will be put in place to mitigate these?)
• Level of engagement of IMPEL Members in water abstraction regulation. Contacts with Water Managers with the help of CIS WGs and IMPEL network could be useful to broaden the expert and users base • Scarcity of statistics about water over-abstraction. Expert opinions should compensate the lack of quantitative information. • The limited number of Pilot Feasibility Studies could not be fully representative of the European situation. Pilot sites should be selected in areas which include many different environmental and water management conditions. • Because the planning of Pilot studies will be carried out after the approval of this project, the outlook for the budget may need corrections. It will be decided if provide for displacement of part of the activities in next year or if asking for further financing, if available. • Time to close the project may be longer, because the development of experimental activities in Pilot studies may face technical problems to be solved. It will be reported as soon as possible to IMPEL and EC to justify the extension of the time needed.

4. Organisation of the work

4.1 Lead (who will lead the work: name, organisation and country) – this must be confirmed prior to submission of the TOR to the General Assembly)
Enrico Zini, ARPA Lombardia, Italy
4.2 Project team (who will take part: name, organisation and country)
Malta, + TBD. It will be sought for participation of Impel Members from different climate and land structure to increase the representativeness of the work
4.3 Other IMPEL participants (name, organisation and country)
Tbd
4.4. Other non-IMPEL participants (name, organisation and country)
It will be sought also the participation of EU-Comm CIS WGs and other stakeholders

5. High level budget projection of the proposal. In case this is a multi-year project, identify future requirements as much as possible

	Year 1 (exact)	Year 2	Year 3	Year 4
How much money do you require from IMPEL?	29,060	-	-	-
How much money is to be co-financed	0	-	-	-
Total budget	29,060	-	-	-

6. Detailed event costs of the work for <u>year 1</u>

	Travel € (max €360 per return journey)	Hotel € (max €90 per night)	Catering € (max €25 per day)	Total costs €
<u>Event 1</u>	3,240 (P.T.9 x 360 €)	1,620 (P.T.9 x 90 € x 2 nights)	500 (P.T. 8 x 25 € x 2 days)	5,360
<Kick-Off Meeting>				
<January 2015>				
<Italy>				
<10>				
<2>				
<u>Event 2</u>	3,240 (P.T.9 x 360 €)	1,620 (P.T.9 x 90 € x 2 nights)	500 (P.T. 8 x 25 € x 2 days)	5,360
<Interim Meeting>				
<June 2015>				
<TBD>				
<8>				
<2>				
<u>Event 3</u>	6,840 (P.T.19 x 360 €)	3,420 (P.T. 7 x 90 € x 2 nights +Ext. Part. 12 x 2 nights)	1,000 (P.T. 8 x 25 € x 2 days + Ext. Part. 12 x 25 € x 2 days)	11,260
<Final Meeting & Workshop>				
<December 2015>				
<TBD>				
<20>				
<4>				
<u>Event 4</u>	1,440 (P. C.T 4 x 360 €)	720 (P. C.T 4 x 90 € x 2 nights)	200 (P.C.T. 4 x 25 € x 2 days)	2,360
<First Meeting for feasibility study realization Possible: to be confirmed>				
<tbd>				
<tbd>				
<4>				
<2>				
<u>Event 5</u>	1,440	720	200	2,360

<Second Meeting for feasibility study realization. Possible: to be confirmed>	(P. C.T 4 x 360 €)	(P. C.T 4 x 90 € x 2 nights)	(P.C.T. 4 x 25 € x 2 days)	
<tbd>				
<tbd>				
<4>				
<2>				
Event 6	1,440	720	200	2,360
<Third Meeting for feasibility study realization. Possible: to be confirmed>	(P. C.T 4 x 360 €)	(P. C.T 4 x 90 € x 2 nights)	(P.C.T. 4 x 25 € x 2 days)	
Total costs for all events	16,200	8.100	2,400	29,060

7. Detailed other costs of the work for year 1

7.1 Are you using a consultant?	☐ Yes ☑ No
7.2 What are the total costs for the consultant?	
7.3 Who is paying for the consultant?	
7.4. What will the consultant do?	
7.5 Are there any additional costs?	☐ Yes ☑ No Namely:
7.6 What are the additional costs for?	
7.7 Who is paying for the additional costs?	
7.8. Are you seeking other funding sources?	☐ Yes ☑ No Namely:
7.9 Do you need budget for communications around the project? If so, describe what type of activities and the related costs	☐ Yes ☑ No Namely:

8. Communication and follow-up (checklist)

	What		By when
8.1 Indicate which communication materials will be developed throughout the project and when ***(all to be sent to the communications officer at the IMPEL secretariat)***	TOR˅ * Interim report˅ * Project report˅ * Progress report(s) ˅ Press releases News items for the website˅ * News items for the e-newsletter Project abstract˅ * IMPEL at a Glance ˅ Other, (give details):	☑ ☑ ☑ ☑ ☐ ☑ ☑ ☑ ☐ ☐	
8.2 Milestones / Scheduled meetings (for the website diary)	Kick-Off Meeting Interim Meeting Final Meeting		
8.3 Images for the IMPEL image bank	☑ Yes ☐ No		
8.4 Indicate which materials will be translated and into which languages	Tbd		
8.5 Indicate if web-based tools will be developed and if hosting by IMPEL is required	No		
8.6 Identify which groups/institutions will be targeted and how	COM JRC + Tbd		
8.7 Identify parallel developments / events by other organisations, where the project can be promoted	Tbd		

*˅) Templates are available and should be used. *) Obligatory*

9. Remarks

Is there anything else you would like to add to the Terms of Reference that has not been covered above?

In case of doubts or questions please contact the IMPEL Secretariat.

Draft and final versions need to be sent to the IMPEL Secretariat in word format, not in PDF.

Thank you.