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SCENT: citizen sourced data in support of environmental monitoring

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***Abstract*— Citizen participation in the environmental policy making process is a new concept still in development, however there is a growing interest in it. Present paper presents the newly funded H2020 EU project SCENT[1], which aims to use smart collaborative technologies, to enable citizens to become the 'eyes' of the authorities and policy makers and to monitor land-cover/use changes through everyday activities. In particular, SCENT will design and implement a toolbox of innovative technologies to improve current maps and make flooding prediction models more accurate. Such technologies include low-cost and portable sensors, an innovative crowd sourcing platform, serious gaming applications for large-scale image collection, machine learning for image and text classification, numerical models for mapping land-cover changes to quantifiable impact on flood risks and a harmonization platform, consolidating data and adding it to Global Earth Observation System of Systems (GEOSS)**

Keywords—citizens observatories; hydroinformatics; flooding

I. INTRODUCTION

Human-induced modifications of the natural environment, combined with increased threats from climate change, increase the critical importance of environmental monitoring. Climate change in particular is a factor that may affect most the environment, and adaptation to such changes entails planning for future and taking actions to mitigate the effects. Planning the adaptation and mitigation steps, involves systems for monitoring of the Earth by satellite, and by sensors on the ground and in the ocean. Such monitoring systems provide many different types of data, including land use, crop patterns, deforestation, as well as data relevant for forecasting and management of risks due to natural disasters such as floods. Information and Communications Technologies (ICTs) are indispensable for proper functioning of these environmental monitoring systems and for providing help and assistance before, during and after a natural disaster.

Europe invested a lot of resources in infrastructure and services to broaden Earth observation capacity through Copernicus Programme, in particular in the land monitoring service component. Its cost during the period 1998-2020 is estimated to be of the order of 8.4 billion Euros. In parallel, through its H2020 research programmes EU promotes the use of ICTs to mitigate the impact of climate change and broadening the use of technologies for natural disaster and emergency prevention, mitigation and response.

The fast pace of innovation growth and technological development provides continuous introduction of new versions of tools, new models and new technological functions. Yet, the continuous requirements for improved environmental monitoring increase the burden of investing in additional equipment or of maintaining the current monitoring infrastructure to potentially unsustainable levels. Innovative ways of complementing the in-situ infrastructure with citizen-sourced data from thousands of mobile sensors at a lower cost are thus being sought as a complementary approach for obtaining the required observations. Furthermore information from citizens on potential natural disaster risks through Internet and other means is an important component of risk management plans. Effective systems for managing such risks are those in

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which expert knowledge is combined with citizens observations through innovative use of ICTs.

Citizen-sources data, or Citizen Observatories represent a recent initiative to take advantage of both crowdsourcing and citizen science, allowing communities to take a more important role in monitoring their environments. Citizen Observatory concept is meant to complement the existing ongoing monitoring initiatives, using a methodology that will ensure the quality and provenance of data. Collected data is processed and analyzed by professionals, supported by ICTs, and delivered back to the citizens as relevant knowledge through applications (see [1] for an example application in water and [2] in the domain of air quality).

Citizen participation in the environmental policy making process is however still in its infancy. The majority of citizens, either as individuals or as groups, often feel and are disengaged from influencing environmental policies, therefore methods and tools that will facilitate the process of engaging citizens in data collection are sought and developed. Through data collection citizens also raise their awareness about environmental issues and become more likely to participate in environmental planning and policy.

This article presents the concept of the ongoing H2020 funded research project SCENT (Smart Toolbox for Engaging Citizens into a People-Centric Observation Web), which aims to create a toolbox that will enable citizens to participate in environmental monitoring together with the authorities and policy makers. This is to be realized using a range of smart collaborative technologies that will enable monitoring land-cover/use changes through citizens' everyday activities as well as through dedicated data gathering campaigns. In this way, the costly in-situ infrastructure will be enriched with a people-generated and people-centric web of observations.

The concept of the SCENT toolbox will be demonstrated and tested to help communities living in flood prone areas, using two pilot case studies in the Danube delta in Romania and in the Kifisos catchment around Athens in Greece. Nevertheless the concept is generic and can be used for other environmental issues and concerns. The project started in September 2016 and continues for three years. There are 10 institutions involved in the project; research and academic institutions as well as SMEs.

II. SCENT CONCEPT

The SCENT project proposes the development of a toolbox (see Figure 1) that will contain a significant pool of new citizen-generated observations of land-cover/use using low-cost, portable sensors (smartphones, light-weight soil-monitoring sensors, cameras mounted on multicopters) and innovative applications. In order to achieve these aims it will use the welth of available information on popular platforms such as Flickr and Panoramio. These data sources will be consolidated, semantically annotated and harmonised following the Open Geospatial Consortium (OGC) and INSPIRE directives and standards through the SCENT open-source based harmonisation platform [3].

Data collected in this manner will be offered to the GEOSS portal and relevant national repositories as web-service enabled data. A resource registry/catalogue is currently developed for the SCENT offered observations so that discovery of these resources by policy makers is intuitive.

A key component of SCENT will be the semi-automated classification of outdoor images in order to enrich the metadata depiction of the image content. The SCENT intelligence engine will use advanced machine learning technologies to extract visual content from a variety of user supplied ground level outdoor images. The engine will segment and classify images based on low-level features such as colour, texture, shape and spatial layout in order to create a low-level semantic description of the scene content (e.g. trees by a lake, urban street with cars parked). The segmented areas of the image can be shown to human viewers (via the SCENT gaming app) for classification and validation [4][5].

SCENT will implement two parallel mechanisms to engage Internet users in crowd-sourcing activities: a gamification platform and a plugin for CAPTCHA. The gamification platform will be designed to allow users to login in order to annotate images online. The concept of SCENT is illustrated in figure 1.

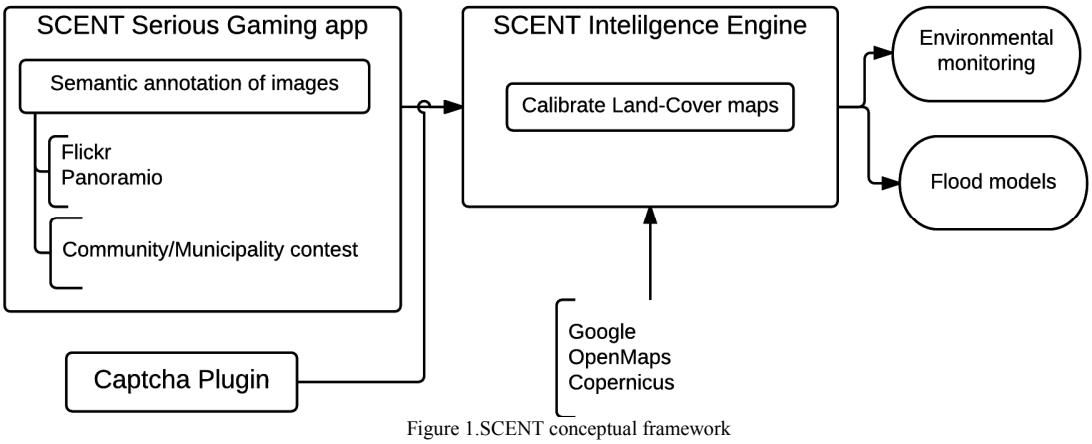

Figure 1.SCENT conceptual framework

SCENT toolbox will be evaluated with respect to floods, an important environmental issue. Data collected and mobilised through the SCENT toolbox will enable quantification of flood extent and flood volumes when utilised with appropriate hydrodynamic and hydrological models.

The second pilot will be implemented in the Danube Delta region in Romania. Danube Delta is the largest wetland in Europe suffering from human interventions leading to dramatic changes.

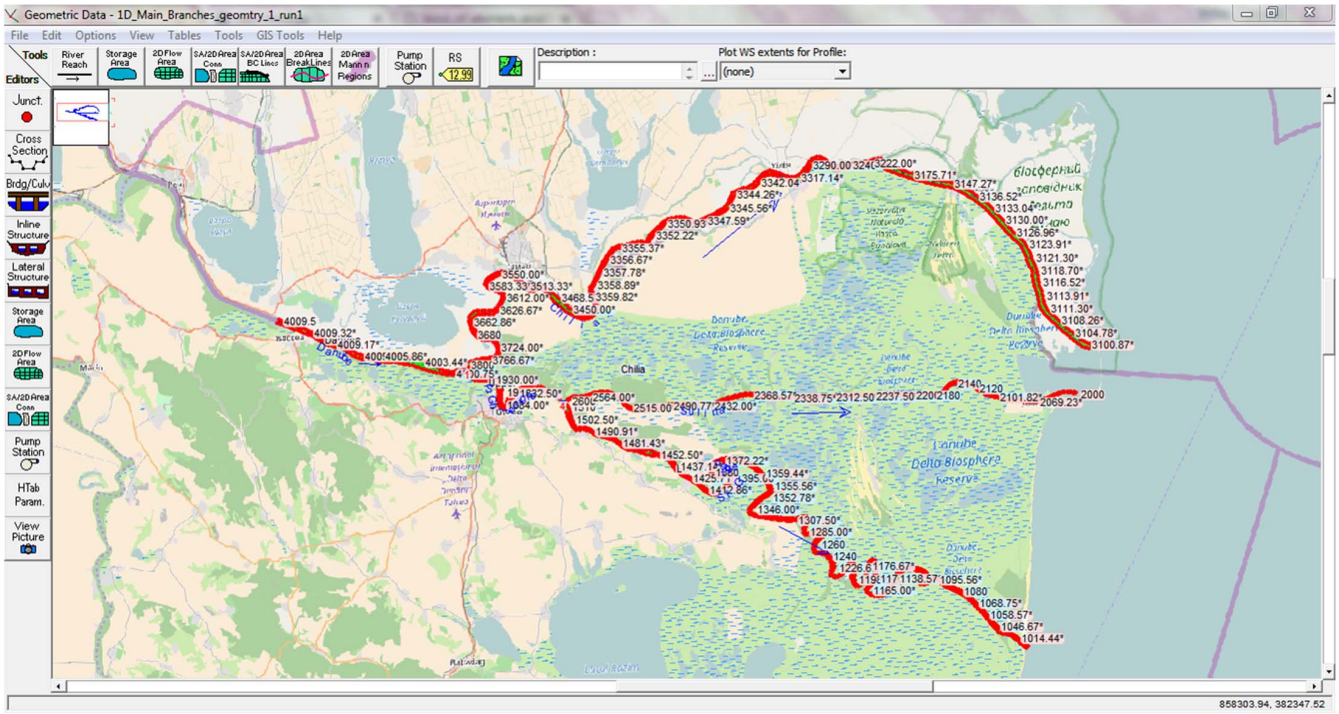

Figure 2.River network of the Danube delta model in HEC-RAS

The first pilot relates to the urban environment around the Kifisos river in Greece. The catchment covers 380km^2, and almost 60% of its watershed is urbanised. The majority of the hydrographic network has been altered due to distinct land-use of urban expansion, being an area where 4 million citizens are living. Because the city development occurred without an appropriate plan for drainage works when floods occur they have a significant impact on infrastructure.

These interventions result in disturbances of the water and ecological balance. A dynamic and detailed knowledge of land-cover and -use changes related to this rural environment is required and is not covered by current land-use maps e.g. by Copernicus Land Monitoring service.

Data collected through SCENT toolbox will be made available to models that will represent floods in Kifissos area and Danube Delta. A hydrodynamic model is initially build

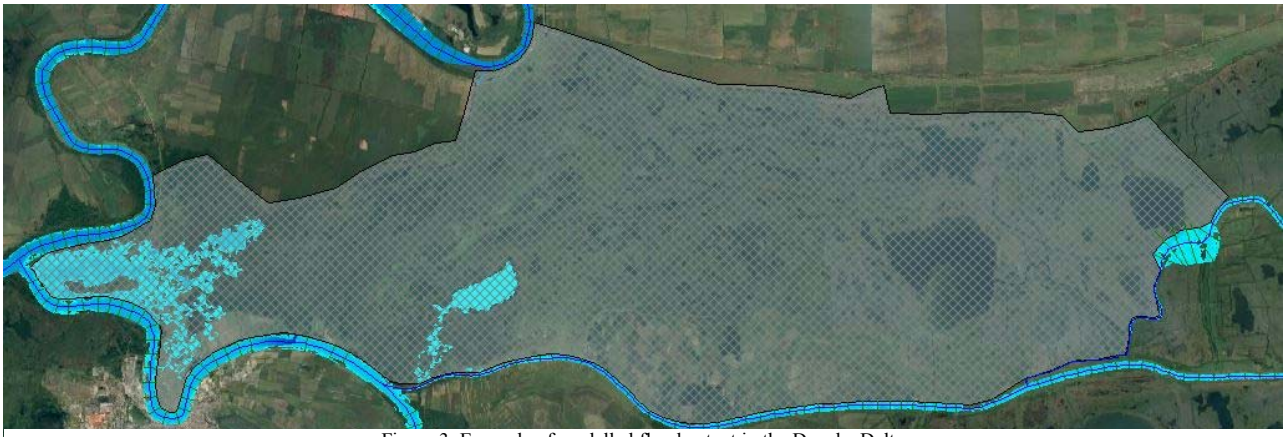

Figure 3. Example of modelled flood extent in the Danube Delta

based on current available data (see figure 2). The free source modelling tool HEC-RAS for river flow analysis is used to determine flood extent.

In HEC-RAS [6] land cover maps are used to determine the roughness coefficient of the model in order to show the propagation of flow over land. With data collected through SCENT, an improved land cover will be made available to the models. An example of modeled flood extent in an area of the Danube Delta is represented in figure 3.

III. Determining System Architecture

In order to define SCENT system architecture an intensive user requirements campaign has been designed and carried out. The main purpose of the collection of the end user requirements was to ensure that all user needs are addressed by introducing the appropriate system specifications in the design of the SCENT toolbox.

In this direction, the final system architecture is shaped to respect the aforementioned specifications. An iterative procedure that starts from the identification of the end-user requirements, proceeds with the definition of the system/technical requirement and finishes with the system architecture was followed.

SCENT consortium organised two workshops in Tulcea, Romania and Athens, Greece where local stakeholders from different domains (volunteers, experts, etc.) were invited. Having compiled the input received from the questionnaires the consortium gave to the stakeholders more details on the solutions that will be offered by SCENT to cover their needs. An interactive discussion followed, where the consortium identified their satisfaction level, a prioritisation of their requirements and finally the key features of the SCENT toolbox, as visualised in figure 4

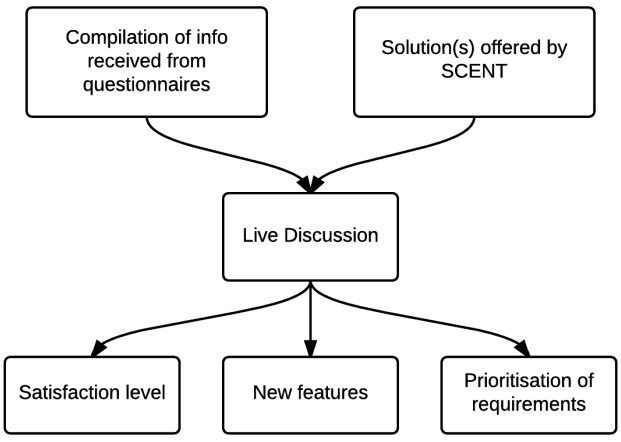

Figure 4. Process schematic for stakeholder involvement in determining SCENT architecture

SCENT consortium structured the discussion based on the following focus areas:

1. Focus areas for authorities, NGOs and "operational" people
   - Existing monitoring systems: alarms potential, challenges & gaps (relation to policy making)
   - COs & their potential for influencing flood management & prediction: relevance, sustainability, data quality, data privacy
   - CO cookbook: multidisciplinary panel, accurate data sources, online discussion forum, KPIs, data quality assessment tools
   - Gamification& serious games for engaging citizens: Basic & Alternate Reality Gaming (ARG) edition, Captcha plugin
   - Crowd-sourcing platform: smartphones & image capturing: Social media, chat, image annotation (free text, drop-down, icons), Features on the smartphone relevant to flood
   - Training & early childhood education programme
   - Exploitation of the toolbox and continuation of the SCENT movement
2. Focus areas for experts
   - Existing monitoring systems: alarms potential, challenges & gaps (relation to policy making)
   - Challenges and gaps in land-cover/use maps: accuracy, renewal period, taxonom
   - CO cookbook: multidisciplinary panel, accurate data sources, online discussion forum, KPIs, data quality assessment tools
   - Portable sensors & drones for on-site data collection: Water level/temperature, soil moisture/conductivity, air temperature, Digital Elevation Model (DEM), Weight, size, battery charging
   - Authoring tool for customizing the platform with respect to local/social features
   - Assessment of crowd-sourced data contribution for flood modelling& flood risk
   - Exploitation of the toolbox and continuation of the SCENT movement

The stakeholders were asked to give their input on what do they need and how are they going to use the offered solutions. In the end a set of end user requirements was collected from each focus area and was carefully analysed in order to provide the final set of the prioritised user requirements.

The resulted final classification for Functional User Requirements was:

1. SCENT Scope (GEN): aspects that are generic and are relevant to the project scope

2. Sensors (SENS): aspects relevant portable or in-situ sensors, drones
3. Serious games (GAME): aspects relevant to gamification and SCENT serious gaming applications.
4. Crowd-sourcing platform/application (CROWD): aspects relevant to collecting citizen sourced information via the SCENT platform
5. Authoring tool (AUTH): aspects relevant to the authoring tool and the user interface for local and regional authorities
6. SCENT Intelligence Engine (SIE): aspects relevant to the machine learning algorithms for image and text classification and the intelligence engine
7. Flood models (MODEL): aspects relevant to flood models, assessment of crowd-sourced data to their improvement
8. Harmonisation platform (HARM): aspects relevant to the harmonisation platform and standards
9. Citizen or Authorities Engagement (ENGAGE): aspects relevant to increasing and sustaining the engagement of citizens/volunteers as well as authorities; aspects relevant to training

The obtained Classification for Non-Functional User Requirements was

1. Interoperability (INTER) = the ability of making individual parts of the system and the current available systems to work together
2. Performance (PERF) = the amount of useful work accomplished by the SCENT toolbox compared to the time and resources used, depending on the context, involving response time, throughput, utilization of computing resources, bandwidth and/or data transmission time
3. Usability (USE) = ease of use and learnability of the system; possibility of customisation, including support for local languages
4. Reliability (REL)= ability of the toolbox or a specific component to perform its required functions under stated conditions for a specified period of time; data reliability and credibility
5. Security (SEC)= something that gives or assures safety and prevent abuse
6. Legal (LEG)= using data and knowledge and SCENT system components according to rules and regulations
7. Openness (OPEN)=the ability and willingness to provide data in an open way, using well defined catalogues and open access

Based on the above identified functional and non-functional requirements SCENT will define its architecture.

IV. Conclusions

The field of crowd-sourcing for environmental governance is an emergent one. Five research projects were funded by EC, within the framework of FP7, focused on understanding Citizens' Observatories. While they vary widely on aspects monitored (from air quality to ocean monitoring, from safety of public spaces to noise in city environments), all of them use a crowd-sourcing application for active citizen involvement. However in all these cases the involvement of citizens is limited to either sensing or in one case to interpreting images.

With SCENT a new level of engagement and data collection is achieved because two types of solutions are proposed: i) crowd-sensing solutions, in which citizens act as a source of data relevant to environmental aspects; and ii) the ability of humans to interpret data, including multimedia, for which state-of-the-art artificial intelligence solutions normaly have numerous shortcomings.

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