BALTIC FLOWS

Citizen Activity in Water Monitoring – How to Boost It?

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Contents

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1. Why monitor water?

Water monitoring refers to a comprehensive field of gathering information of the condition and details of a water system. Everyone can do it with their nose by smelling it or with eyes by visually inspecting the colour and consistency, for instance. One can observe clearly visible algae or detect other suspicious issues. There are many levels of monitoring, starting from the above and ending to highly professional methods that include very expensive hardware and extensively high level of knowledge.

Unfortunately, superficial inspection based on human senses rarely tells us anything about the actual condition of water. Detecting contents of metals, particles and chemical substances always requires a specific hardware and knowledge. Also, it is typical that these contents rarely develop at short notice but over a longer period.

The purpose of water monitoring is often to observe or verify that it is suitable for certain use. The most critical question is and always will be the following: is this water drinkable? People are also interested in knowing if the waters are safe to swim in or fish from. In addition, regular citizens are being more aware of and interested in the state of their local environment. Water quality is amongst the most important concerns, especially if one lives near to a lake, stream or river.

United States Environmental Protection Agency (EPA) has listed five major purposes for water monitoring, which are to[51]:

- Characterise waters and identify changes or trends in water quality over time;
- Identify specific existing or emerging water quality problems;
- Gather information to design specific pollution prevention or remediation programs;
- Determine whether program goals – such as compliance with pollution regulations or implementation of effective pollution control actions – are being met; and
- Respond to emergencies, such as spills or floods.

However, beneficial monitoring of any water system, like a stream, does not happen by a single measurement of water but rather requires measurements from various places and time periods.

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By observing the variation in water quality in various places over time will unveil the real state of water on a larger and valuable scale. Also, it enables drawing real conclusions of development of the state of water. This monitoring process is called continuous monitoring.

Continuous monitoring amongst regular citizens is a rising trend especially considering human body. People can use their smart phones to monitor their heartbeat anytime they want, which has led to the development solutions that allow detecting various heart-based diseases by using consumer-grade devices and easily obtainable applications. Also, solutions for continuous measurement of e.g. blood sugar are also being actively developed. Are there technologies available to be developed for regular citizens to use for continuous measurement of water? Can water monitoring generally be practiced by regular citizens who are interested in the state of their local water systems?

The questions above are yet to be completely answered, but the developed solutions are getting closer every day to the goal where any active citizens can participate in the water monitoring process. Also, the issue is not simple, as water monitoring always requires a specific device and multiple measurement points over a period of time, which would sometimes be years. The hardware must be purchasable and usable by regular citizens who are prepared to become familiar with the monitoring process. When the technological issues are solved, the following questions are: would citizens use their time and resources to monitor their local water systems and if so, why? In addition, would the monitored data be of such quality with "low cost equipment" that the retrieved data would be valuable enough to contribute to the scientific tasks set-up? Can the data collected by non-experts be trusted?

Monitoring the Baltic Sea

Encircled by a mix of Nordic, Central and Eastern European countries, the Baltic Sea is at the mercy of a diverse range of national as well as transnational practices and policies. The potential of public participation in research, environmental decision-making and conservation action to protect the Baltic Sea area has not yet been fully explored. By including citizens in the entire cycle of decision-making a continuous and desirable two-way exchange of knowledge between them and the authorities becomes possible. The involvement of members of the public in research increas-

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es general awareness of research but also the significance of research and its objectives. The Baltic Sea will need all stakeholders to combine their forces and knowledge to enhance the living environment of the citizens as well as to maintain the ecological balance and enable economic activity around the Baltic Sea. Now is the time for authorities to answer the call for more open and empowering public participation. By opening the full cycle of decision-making to citizens, it is possible to create more sophisticated solutions to environmental problems and provide positive possibilities for active citizenship.

The Baltic Sea is under attack by the cities, farms and industry situated on its shores. External nutrient loads seem to be strongly linked to the economic activity taking place in the countries situated on the shores of the sea. The suffering of the Baltic Sea causes economic losses as recreational values diminish[49,93,123,127] the fisheries struggle[85] and the value people place on the sea decreases[128].

There are plenty of people who hold the Baltic Sea dear to them, and use it for recreational purposes. People live on the shores of the sea and alongside rivers flowing into the sea. People have the interest, but they lack effective means to participate. An individual may have difficulties in identifying the possibilities for and the impact of conservation activities. Additionally even though the poor state of the Baltic Sea is recognised, it may be challenging to identify what actions can be taken and what are the impacts.

Neither authorities nor universities have been able to aid people and offer them pragmatic tools to link them with the environment. Academia has yet to fully understand the need and potential for co-operation and public participation. The state and possibilities of the Baltic Sea has intrigued researchers and scientists around the Baltic Sea region, but Academia has traditionally seen its responsibilities and roles in research, education and the dissemination of information which rises from the research, and not so much on activating, influencing and interacting with the wider public.

In a 2010 publication[48], the European Environmental Bureau presented areas to be tackled urgently. On their list, number one is transparent and publicly owned water management. Transparency is essential for the public to understand and see the logic behind decisions regarding

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their living environment. Granting better access to information and decision-making has for long been a goal for all societies trying to improve and encourage public participation.

Emerging technologies and their potential effect on society and the environment tend to have uncertainties that might lead to controversy between scientists, policy-makers and the public. A viable solution to respond to the governance issue is to open up the debate and to early involve citizens and social scientists in the process to develop a new technology.[114]

People care about their environment

The importance of opportunities for citizen participation in environmental decision-making is widely emphasised in several international agreements, such as the 2002 World Summit on Sustainable Development Implementation[130] (Paragraph 119), the 1998 Aarhus Convention[132], and the 1992 Rio Declaration on Environment and Development[131] (Principle 10). One of the major observations noted in these documents is that environmental and livelihood concerns are closely linked together[66]. Petkova et al.[108] (2002) note that public participation and citizen input tend to drive environmental decisions towards better outcomes and greater acceptability in the eyes of the public.

When public participation is involved in scientific research, it can be referred to as citizen science. This type of activity is proving to be an effective tool in tracking the rapid pace at which our environment is changing over large geographic areas. It seems increasingly popular to engage members of the general public and school pupils especially in the collection of scientific data to support long-term environmental monitoring. This type of public participation seems like an excellent way to gather large amounts of data. When it comes to environmental monitoring and regulation concerning this type of monitoring, unfortunately not all nations neither provide the information required by their own legislation nor share it with citizens.

Today most projects and public databases gather information in a defined location, website or organisation and to provide it mainly to those who are informed enough to request it. This type of collected data could for example be used to fulfil statutory obligations for nature conservation. Some networks may serve more the educational rather than scientific purposes, and some are

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more for recreational rather than active citizenship. But nevertheless the data is being gathered, and we should be smart enough to make gathering that data as easy as possible and to come up with methods how that gathered data could be used in several different contexts, and whenever possible, to serve the entire society.

The involvement of members of the public in research increases not only general awareness towards research, but also the significance of research and its objectives. A dialogue between scientists and members of the public may fertilise the debate on environmental research and the state of the Baltic Sea. The recent changes in the funding of universities have provoked a discussion of their role in society. Universities cannot stand alone and maintain their ivory towers; research and education will need to take a step closer to the wider public and society as a whole. The growing emphasis on external funding will serve as double-edged sword forcing the universities to interact more closely with the outside world, but also limiting the possibilities of excellent research and science. What needs to be kept in mind is that the language of economics may not serve in all fields of research as the best possible way due to market failure and the lack of incentives in areas such as environmental research. The Baltic Sea will need all stakeholders to combine forces and knowledge to enhance the living environment of citizens, to maintain ecological balance and to enable economic activities around the Baltic Sea.

Due to the growing EU and national level regulatory demands on how to reduce industrial or agricultural spillage or contamination of water a growing market and industry with focus on services and products that may be used to reduce pollution, provides more or less advanced solutions to cope with the problems. Cooperation between academia and industry domains may be a possible way both to fund academic research and provide more advanced industrial methods and solutions to manage reductions of pollution and ways to fulfil the more stringent requirements to avoid pollution. Many new areas of "hidden pollution" is found when research depicts how long term impact of small amounts of the modern society's waste water (e.g. pharmaceuticals, chemicals, new micromolecular substances) is accumulating into the Baltic Sea – and incorporated into the water cycle through the ecological cycle in which fish eat or absorb chemicals, humans eat fishes and indirectly accumulates new toxic or unwanted substances.

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The water cycle is one of several circular paths where the industrial society successively intoxicates the environment – and novel industrial solutions are needed to solve these problems. Further, to monitor and stop pollution paths, cooperation between academia and industrial company research is required. More, to create a large network of monitoring instances, citizen participation may be an important contribution in provision of a more complete geospatial detailed map of the problems and changes when counteractions are provided.

The questions related to clean and safe water sources are a major concern also outside of European Union. Human health is at risk because of contaminated water. In rural areas of China, 100 million to 110 million people still do not have access to safe drinking water. In a 2014 interview, Premier Li Keqiang expressed that with the support of central and local budgets and funds raised by individuals, China has begun to provide clean water to over 60 million people. The plan is to extend the initiative to another 60 million people during 2014, and the remaining 50 million the year 2015. Only after these steps will the drinking water problem is solved. According to Li[88]; "However, highly polluted water still accounts for more than 10% of China's total water resources; a plan is required to resolve this issue".

> ***The BalticFlows consortium has been highly active in dissemination and communication activities.*** Some of the ideas and themes outlined in this report have already been introduced in events and publications related to the BalticFlows project, such as the website or Facebook page of the BalticFlows project, Baltic Sea Policy Briefing 1/2014 published by the Centrum Balticum or other publications by the project personnel.

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2. The active citizen

Environmental information gathering is costly, labour intensive and time consuming. In order to make good decisions for environment, citizens and businesses, we need to have the right information. With wide-scale data gathering, information could be provided to all parties interested in gaining from this knowledge. But for wide-scale data gathering, active citizens are needed. How and why would such activities take place, and by whom? This is when the active citizen is often thought of.

Active citizens can use crowdsourcing; participate in the free time activities organised by hobby groups or in official environmental monitoring programmes. In some of the national and local programmes, volunteers have been granted a special level of authority to take actions or make decisions regarding environmental issues.

Private citizens are more and more interested in their own living environment, and the interest towards monitoring with the latest sensor technologies can be seen in lifestyle and consumer choices both in healthcare and environmental field. Technology oriented universities and research facilities have identified the interest and supported these types of activities, but also created new opportunities and development trails for new products. Technological development in both sensor nodes and in communication technologies have made also environmental monitoring capable of entering new fields and parameters, as well as more precise monitoring results delivered by non-experts. The development of data management and communication technologies have allowed and instrumented private people with real time connections to online databases, where

THE CHRISTMAS BIRD COUNT

One of the oldest and longest running citizen science projects in the world is the Christmas bird count in the United States. In this project the volunteers have been collecting data on birds since the year 1900 and thus provide unique and invaluable data to scientists on several different fields concerning unforeseen issues, such as global warming and its effects – not to mention activating ordinary citizens interested in birds and ornithology. The reason behind such activities is simple, since nothing too complicated can persist that long: people do care – they have interest in the issues and in the data gathered. Depending on the technological tools available for environmental monitoring, all monitoring no longer requires an expert to implement research.

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data streams and stored data can be utilized for social media, entertainment as well as business purposes. The prerequisites to acquire, transport and store large amounts of data are existing, and can be used for environmental monitoring purposes.

To allow crowdsourcing to take place, data management process, active citizen, means to collect the data and the supporting framework needs to be in place, and hence the report works it's way through the notions of the BalticFlows consortium has learned during the project regarding citizen participation in environmental monitoring of aquatic environments.

In the surveys conducted at the BalticFlows project, people viewed participating in environmental monitoring positively. Wellbeing of local rivers and streams seemed to be of interest to the respondents of the surveys, but the modern day volunteer is not necessarily willing to donate a fixed amount of time on a regular basis. To balance the needs of the monitoring programme, researchers, regional authorities and the active citizens participating in the monitoring process, it is seen important to cooperate with all of the stakeholders, and pay attention to the needs and requests of the active citizens. How and when would the active citizen like to contribute?

In order to maximize the benefits of citizen science for a disparate and diverse group of participants, it is important to understand what motivates the people to participate in such activities. A number of studies have been made on volunteer motivation[14,102,103], and according to the Azavea and SciStarter publication "Citizen Science Data Factory"[23] these can be summarized as follows:

- Altruism and the desire to assist a larger cause
- Advancing fields of research
- Learning opportunities on a topic of interest
- Community engagement and social networking
- A desire to publicly display one's knowledge
- Ideological beliefs, especially regarding the need for freely accessible data
- Guilt, political correctness, or other social concerns
- Preparing for a career change
- Personal enjoyment or friendly competition

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In most cases citizen science projects provide learning opportunities for the participants, varying in the intensity and topic. To increase the participation and engagement, the Citizen Science Data Factory[23] recommends including new projects with aspects of community engagement, social networking, and friendly competition, which are more readily employable and show particular promise for contributory data collection projects. Altruism, egoism, ideological beliefs, social concerns, and preparing for career changes, on the other hand, are not factors that are easily controlled or integrated into citizen science projects to increase participation and engagement.

Individuals and groups can be encouraged to participate in citizen science activities in several manners, including:

- Social incentives, utilising social media networks,
- Psychological incentives, utilising gamification, and
- Tangible incentives, utilising financial rewards.

These concepts are briefly discussed below.

Social incentives via social media networks. Social media can facilitate a strong sense of community among citizen scientists, even when geographically dispersed. Sharing activity with e.g. Facebook, Google+, Twitter or Pinterest is a popular means of celebrating one's contributions, in addition to engaging others with the activity. Robson's[115] (2012) study on citizen science found that recruiting volunteers through social networks, including Facebook and Twitter, was just as successful as recruiting through traditional media channels, such as press releases and news articles.

In the Baltic SeaNow.info project, passivity in promoting the webpage and technological problems were the most challenging setbacks in the project. The activity of the public could be raised during the events with an inviting setting and a visually pleasing voting system, where individuals could take part in the voting with moving small, round pebbles typical to the Baltic Sea shores to sea-through boxes. This way the voting was at all times visible and concrete to the attendants, but was vulnerable to bias.

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Social media platforms offer several tools and methods for supporting citizen science activities:

- Authentication. A one-stop account login can be used for secure user registration and authentication, after which citizen scientists can use their social media username and password to log in to a citizen science project. Project coordinators could further utilise the login to request permissions to access user profiles and "friend" lists to support recruiting of new members.
- Social Plugins. These can be used to add value and content to citizen science websites and participant networks. For example, Facebook "Like" and Google "+1" button plugins allow users to share favourite citizen science web pages with friends, an "Activities Feed" plugin allows project coordinators to display a stream of recent likes and comments from participants, and a "Recommendations" plugin allows participants to share personalised page recommendations with other members of the community.
- Analytics, data storage. For example, Facebook and Google offer sophisticated website analytics tools generating detailed analyses of user community demographics for project coordinators. These are useful for planning outreach activities and supporting recruiting efforts. Statistics can also be used as data for social science research. In addition, social media sites can provide massive storage capacity on demand for data generated by citizen science.[23]

A study[97] described two primary reasons why individuals use Facebook and other social media: (a) a need to belong to a larger group and (b) a need to present oneself to others in a positive manner[97]. For example, Facebook satisfies these needs via its user profile pages, groups, and the ability to "follow" other users. Such social mechanisms can be applied to citizen science projects to increase community engagement and encourage ongoing participation.

Disincentives. If social media login would represent the sole means of accessing citizen science online resources, some users not active in the social media scene may be discouraged from participating or even de facto excluded from the citizen science community. In addition, privacy-related terms and policies may cause concerns amongst users. Hence, citizen science online services should also provide conventional registration and login for

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those who have opted out of the large social networks.[23] Utilising mobile applications and connections may provide a way to organise data collections fulfilling only the means for data acquisition and transmission to a common data storage, and bypass any social media accounts.

Psychological incentives via gamification. The term "gamification" relates to applying leader-boards, scoring, rewards, teaming, and other game-like features in a non-game environment to encourage competition, engagement, collaboration, interaction, and other gaming behaviours. The motivation for the gamification transformation is simple: if a non-game project is perceived as a game, it is more likely to attract and retain motivated participants in a similar manner as an actual game would. [23]

Many projects comprise a rewarding scheme as part of a gamification and user engagement strategy. In a survey of 77 small to medium-sized citizen science projects[140], rewards ranged from role advancements to T-shirts and other promotional items, with "public acknowledgment" constituting by far the most common type of reward. Scores, badging, quests, and "levelling up" will be important schemes for improving user engagement and unlocking a significant amount of "cognitive surplus"[120].

Disincentives. Some concerns have been expressed regarding some of the most common gamification features. For example, leaderboards have proven to motivate the people at the top of the board but demotivate the rest of the user community. "Laddered" leader-boards, which only show the few ranks above and below the user may mitigate some of this effect, but some experts suggest that leaderboards have little net effect on user engagement.[23]

Participation was a key element in the BalticSeaInfoNow project, and the participants were regularly paid attention to. Especially the volunteers and participants enjoyed to receive the reports and data collections from the areas they had been active in. The "disneysation" of the society was visible in the project and the activity levels of the participants: once the content was at least partly entertaining the activity levels were surely to rise, at least momentarily. Multiple channels of communication (social media, webpage, discussions, e-mails etc.) were seen crucial to the participation activity level.

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Tangible incentives via financial rewards. One of the main benefits of citizen science is the ability to tap an eager and dedicated group of individuals that freely volunteer their time and effort to advance scientific research. Monetary incentives are contrary to many of the key motivations for volunteerism and citizen science, including altruism, guilt, ideological concerns – or having fun. This been said, “challenge” projects, in which a substantial financial reward is offered for solving a problem or submitting the most data within a pre-specified period, appear to enjoy broad acceptance in the volunteer and citizen science community. There are also several crowdsourcing efforts unrelated to citizen science that offer financial incentives to participants, which are not adapted to the needs of scientists, but primarily used by companies that required data entry and visual image-tagging.[23].

Disincentives. A major concern in including financial incentives into the citizen science business model would be the potential for participants to take advantage of the system by completing as many paid tasks as possible without fully engaging in them.[46] As the official environmental monitoring is in large extent organised by the state or municipality, these responsibilities cannot be expected to be organised solely by active citizens as part of their free time activities. The political and societal framework on environmental monitoring could include actions, where environmental monitoring activities beneficial for the society are rewarded or acknowledged by the city, municipality or state with concrete incentives such as reduced fees for transportation, reduced tax, or other public incentives such as public parking.

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3. Participation programmes

Today most projects and public databases gather information in a defined location, website or organisation and provide it mainly to those who are informed enough to request it. Environmental monitoring via citizen activity is often promoted with such claims, that it would in the long run, not only raise the level of interest towards the environment, but also lessen the expenses as the labour is most often free, and lessen the amount of officials needed to conduct the environmental monitoring measurements. Neither of these claims can however be realised unless the environmental monitoring via citizen activity gains legitimacy of some level, and the data gathered reaches the audience. At the same time environmental monitoring is facing a challenge of decreasing funding rates.

The challenge of decreasing funding rates may encourage citizens to take actions and monitor the state of the environment themselves. However, without cooperation on the actions of environmental monitoring, the citizens, authorities and companies may end up forming their own databases and their own community, contributing only to the aspects serving their own interests. This may lead to duplication of efforts, if the information flow or the datasets are inadequate.

The national environmental monitoring programmes take into consideration the recommendations and obligations set by the European directives, such as the Water Framework Directive and the INSPIRE Directive, but the scope of these frameworks does not yet actively engage citizens in the environmental monitoring work. A Directive is a legal act of the European Union, guiding the member states to a particular result, leaving the means of achieving those results to be decided by each member state. Directives to be profoundly taken into account in setting up of environmental water monitoring programmes are listed in Table 1.

Environmental monitoring is one of the most suitable and used forms of citizen science. Monitoring the environment offers the wider public a means and the possibility to be involved in scientific research[82] and data collection in a meaningful way. When large numbers of the public are involved in this type of data collection, integrated and structured ways of engaging the public are necessary. While scientific environmental programmes gain access to a larger workforce, citizen scientists gain knowledge and expertise in the field of their interest[12,13,95,121]. Citizens who partici-

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pate in citizen monitoring initiatives may also come to feel empowered by their knowledge of environmental conditions and their ability to assist and make a difference[66].

Table 1. Directives to be taken into account at the set-up of environmental water monitoring programmes

Directive name	Identification	Description
The Nitrates Directive	91/676/ETY	Protection of waters against agricultural pressures
Water Framework Directive	2000/60/EY	Integrated river basin management for Europe, refers and partially includes other water related directives
Bathing Water Directive	2006/7/EC	Provide better and earlier information for citizens on the quality and quality management of bathing waters, such as rivers, lakes, ground waters and coastal waters. Linked with Water Framework Directive.
Groundwater Directive	2006/118/EY	Assessment and management on the effects of human activity on groundwater quality
Inspire Directive	2007/2/EC	Infrastructure for Spatial Information in the European Community
EU Floods Directive	2007/60/EC	Assessment and management of flood risks
Marine strategy Framework Directive	2008/56/EY	Aims to achieve Good Environmental Status (GES) of the EU's marine waters

Public participation in environmental monitoring can be achieved via different models, which may range from allowing access to official data to collecting data as well as defining the system and logic behind the data-collections. The first step in involving citizens in environmental monitoring is to provide information, such as the official statistics or measurement data to the public. Once the data collection and the public participation moves beyond this point, a plurality of legitimate perspectives needs to be considered. In general, the promotion of public participation and active citizenship is pushing the creation of new types of monitoring systems that integrate various types of knowledge from environmental experts to experts in data systems and law.

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Development of Information and Communication Technologies (ICT) has significantly aided public participation in environmental monitoring. In contemporary society, modern ICT can be considered as one of the central elements of monitoring as well as a force for change. ICT is in a key role in facilitating activities such as data collection and search, presentation, validation and communication between stakeholders, as well as to further include the spatial nature of environmental monitoring data (Geographic Information Systems, GIS). The relevance of environmental monitoring technologies is demonstrated by using remote sensing data or disseminating the information via webGIS applications. Currently, citizen participation is confined to single efforts and ad hoc initiatives[58], and there is still no citizen initiative support and integration framework of environmental decision-making. According to Whitelaw[139] (2003), there seems to be a wide acceptance for the development of framework described above. Sustainable development, planning theory and practice, public participation, community development and governance are all such concepts that support the initial idea of supporting citizens to participate in environmental work by legitimate means.

The interest towards the participation for environmental decision making has been widely noticed to increase in the last decades[1,63,110]. As Luyet et al.[90] (2012) note, the public participation around the world has been part of a wide range of environmental applications including integrated watershed management[70,76,118], agricultural development[24,144], ecosystem management[80], environmental governance[113], forest management[20,22] and planning[18,19]. This has also been reflected in several international agreements such as the Aarhus Convention, the Earth Summit, the European Landscape Convention, and the European Water Framework Directive[90].

When reviewing the stakeholder participation in the environmental framework, there can be identified several advantages but also disadvantages in such activities, as shown in Table 2.

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Table 2. Advantages and risks of public participation (adopted from Luyet et al.[90], 2012)

Advantages of participation	**Risks of participation**
Better trust in decisions[7,104,111]	Expensive process[86,96,136]
Improving project design using local knowledge[8,62,69]	Time consuming process[89,122,136]
Better understanding projects and issues[47]	Potential stakeholder frustration[55,64,110]
Integration of various interests and opinions[35,60]	Identification of new conflicts[28,55,74]
Optimizing implementation of plans and projects[69,81]	Involvement of stakeholders who are not representative[73,122]
Public acceptance of the decisions[73,110]	Empowerment of already important stakeholder[20]
Fostering and developing social learning[8,10,73,105]	

To support and facilitate stakeholder participation, the targeted participatory techniques must be evaluated and determined. Naturally, the objectives and the degree of involvement of stakeholders need to be defined before moving on to the practical participatory techniques[110]. Several such techniques to support the stakeholder participation have been identified in the literature[64,67,134]. Currently, there seems to be no standardised method to choose the most relevant participatory technique[89,134]. This seems to be causing controversy in itself, once the national monitoring programmes consider citizen participation as part of their activities. Some programmes solve the issue by allowing several smaller initiatives and project to take place (bottom-up model) as others first create the template and allow participation via a pre-set method only (top-down model). Naturally, the national programmes also evolve in time, and try to engage in and create new ways of participation, such as in the Finnish Monitor2020 Programme, which acts as a testbed for several different types of approaches.

The choice on the most suitable participatory techniques depends on many factors (according to Luyet et al.[90], 2012), as illustrated in Figure 1.

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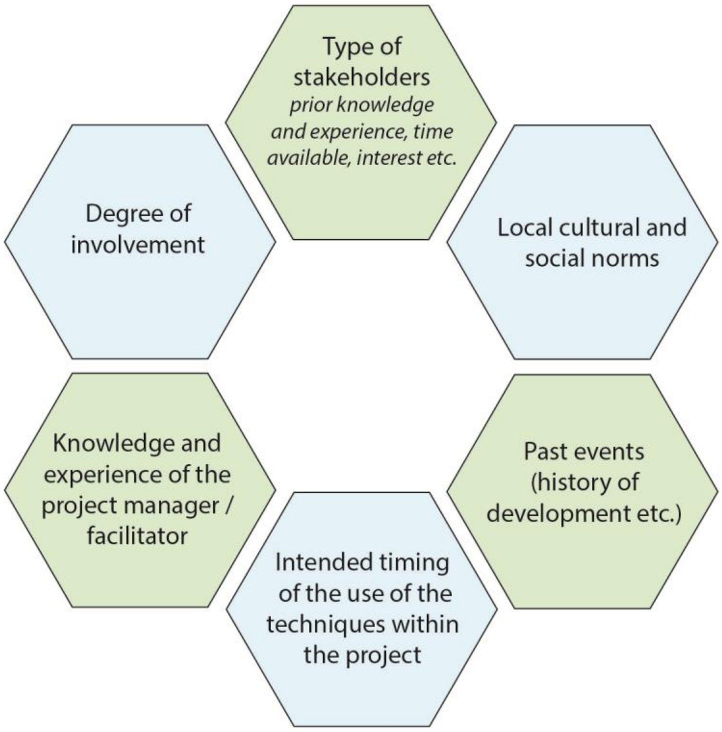

Figure 1. Relevant participatory techniques in project involving stakeholders depend on several factors (adopted from Luyet et al.[90], 2012).

Before any project including or facilitating environmental monitoring, the set-up of the monitoring techniques, the limitations of technologies, and the very important questions "who should participate?" and "how should they participate?" need to be considered. To answer the question "when?", the notion of project phases needs to be introduced[63,125]. Analysis and identification of objectives, designing technical solutions, decision-making, implementation, and assessment can include and be open to stakeholder feedback, if not to include stakeholders actively in the process.[90]

The BalticFlows consortium gathered information from different types of NGOs, regional authorities and other stakeholders, who organise volunteer activities on water and environmental monitoring within the regions of Hamburg, Tallinn, Turku, Uppsala and Riga. Based on the mutual mentoring and identified best practices, as well as future goals, the consortium conducted a list of items to be considered, when setting up environmental monitoring programmes, where active citizens can participate. The discussions are summarized in Table 3. The most common way to or-

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ganise participation on environmental monitoring in the regions mentioned, seems to be via independent NGO's, operating on evaluating, inspecting and sending out information on the current state of the environment, thus provoking actions from both citizens and regional authorities for contributions towards environmental conservation and good ecological status. The observations and environmental monitoring is mostly seen as an early warning system, to inform any abnormal or alarming observations to the wider public, as well as to the correct authority for further inspections. However, more creative methods of involving active citizens were also present, such as allowing citizens to act as official public inspectors on environmental matters, and gain the rights to patrol and document violations after proper training on a volunteer basis (Public Inspector status at Latvian State Environmental Service), or to allow a sponsorship to take place between the private citizen and a specific water body (Stream Sponsorship programme, NABU, Hamburg).

A community and structure around environmental monitoring is seen necessary to make the activities appealing, and to encourage participation. The find the most suitable structure, it is recommended to engage all stakeholders and stakeholder organisations in the discussions and development of the monitoring activities and programme.

Table 3. Setting up an environmental monitoring programme or project

Mobilising and organising volunteers	Consider target group, and select an array of information channels best suitable for them. Would social media channels be more natural for the target group, or is perhaps e-mail newsletter the best way to contact the target group?
Providing information	Is it possible to provide all information collected openly? Is there security or safety issues that need to be considered? How about application program interface, can the data be provided as open data, and allow it to be further exploited?
Instructions	Does the active citizen need specific instructions how to utilize the tools for monitoring? What type of training is required, and what is the best way to provide training, while keeping the interest and enthusiasm towards environmental monitoring alive?
Data structure	How can the active citizen send in the monitoring data? Does it require checking or validation, is an expert necessary?
Compensation	If experts are required, how and via which organization are they compensated? Could the compensation for experts and and active citizens be non-monetary, perhaps status, membership, access to tools and information?
Status	Can the volunteer get an official status for their activities, is a contract required? What is the status, purpose and meaning of the data gathered? Can it be provided alongside official records, are there official records to compare the information to?
Evaluation of the data	Is a similar dataset available? Can trends on the data be compared to a similar dataset, can the data be enriched or evaluated, to secure validity?
Brake the barriers	If the communities can raise enough interest and active citizens are interested to improve the environmental status of the water bodies, how can the materials, equipment and necessary laboratory tests be secured? Can the NGOs, regional authorities, research organisations and active citizens work together, and how can the funds for such activity be raised?
Create connections	Connections between the organisations, between individuals, between official structures will improve the cooperation. To avoid duplication of efforts, can the cooperation be eased with standard procedures, such as including the contact information of environmental programmes to the local educational program where relevant?

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Citizens' interest to participate in environmental water monitoring

In the BalticFlows project, the consortium conducted two surveys as part of the Work Package 4, "Water Monitoring Via Citizen Activity", to people of various ages and educational backgrounds amongst appropriate target groups (e.g. residents living near streams or small rivers as well as environmental activists). The first survey explored their willingness to install and maintain a small water quality monitoring device. The second survey, amongst the same target groups and especially the active users of social media, explored whether sensor technology is seen as a useful means of creating self-published content, or whether manual creation is more preferable.

Based on the first survey and analysis, by giving citizens a chance to involve in the monitoring process and providing them easy-to-use devices and platforms, they will provide a new dimension to water quality measuring and information sharing for researchers to further analyse and citizens to be more aware of the state of their nearby rivers and streams.

In the second survey and analysis, citizens saw sensor technology as an attractive and potentially useful way of creating content for social media purposes and via social media networks.

When planning new environmental monitoring programmes and projects, it is seen important to understand what the social media networks are utilised for, and what type of information would be preferred by the active citizens to be shared.

Surveys results and analyses have been published independently and as a part of this report, and can be found at the end of the report as Annex 1 and Annex 2.

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4. Sharing is caring

A growing number of projects initiated by civil society organisations are supported by different tools, such as the Europe for Citizens Programme. The “smart citizen trend” where projects are initiated by companies, private organisations or individual citizens, where different categories of active citizens are engaged to report environmental parameters, captured by eye or technical equipment, seems to be a growing trend. Enormous possibilities lie today to utilize the internet-communication enabled citizens to monitor important information on a wide scale using their own smartphones, report this to internet databases of different types – social media channels, directly to “cloud databases” collecting raw data, alarm reporting systems or other channels. Via this type of activity, a large number of data and sampling events, replacing a lot of expensive professional equipment seems to provide new possibilities to researchers but also the citizens themselves to analyse and interpret the patterns and phenomenon of active citizenship. These “mobile samplers” are also able to get information from areas where fixed installations would not normally be installed. Data that is acquired is however not always to be trusted, since the equipment or methods may not always be well defined and calibrated or the users may lack of personal training how to use it. Therefore, the large amount of data stored from different “uncalibrated” sources needs to be managed with statistical methods and perhaps also combined with information from other sources.[17]

There seems to be a lot of possible improvements regarding the quality and accuracy of technical monitoring gadgets that are expected to be used together with smartphones to capture environmental parameters, and related measurement methods. But to achieve more reliable and accurate data, the balance between item price and accuracy is a difficult topic to manage, especially if the add on gadget is financed by private citizens themselves. Technology is advancing and the possibilities to use new generations of sensors advances in the same way as smartphones develop in performance and feature sets, making the activities and acquiring of add-ons easier and more accessible. Many of the “smart city” projects with crowd participation are focused on environmental parameters in air (toxic gas, particles, sound, light and similar parameters) since these types of parameters are relatively easy for regular citizens to capture with sensors already existing, and since with citizens spend most of their time in non-aquatic environment. Another note-

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worthy detail with citizen participation in water related environmental monitoring is that the technical equipment, such as sensors or ready-made add-ons for water analyses are still not available as low-cost components in the same way as for air quality.[17]

Through two surveys for the citizens in the participating regions, BalticFlows project has analysed and the citizen's willingness to participate in automated water quality measurements once the technology for this is mature enough for wide-spread use. The surveys were distributed with the help of the local and regional environmental organisations within the participating regions. By using the e-mail lists and websites of the local environmental organisations and student groups of environmental fields, the survey was able to reach a relatively high amount of answers. Survey analyses are included in this report as Annexes 1 and 2.

Initiatives and projects involving active citizens

To target the environmental organisations whom to contact and to analyse more closely on the potential citizen groups, BalticFlows project has studied and analysed the success of other projects including active citizens. Several already completed and ongoing projects addressing environmental monitoring and active citizenship were studied in order to recognize the most promising types of citizen groups, the best methods in activating citizens to participate in environmental monitoring and to gain knowledge of the current level of such activities. According to Silvertown[121] (2009), the best way for the public to understand science is to participate in it, and therefore the growing number of participants involved in citizen science[6,121] is an indication of an increase in the level of scientific knowledge and environmental awareness among the general population[45].

BalticSeaNow.info

In the project an interactive voting system was used in different events, questionnaires and handed out the Secchi discs with the instructions of use. Web-page was supposed to be used as a portal, but due to technical problems, the observations were e-mailed to the researchers and project personnel. 400 discs (with a diameter of 30 cm) were distributed to individuals, and 50-60 of those individuals were actively collecting data during the project.

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Secchi3000

SYKE (The Finland Environmental Administration) has taken some steps in the direction of making measurement instruments simpler by developing Secchi3000 Turbidity analyser, in which a standard mobile phone camera serves as the measurement instrument analysing the water quality.

The Secchi3000 was designed as an inexpensive and simple solution to measure water quality. One of the objectives of the Secchi3000 tool was to allow non-experts and common citizens to participate and promote water quality issues. The actual measurement process with the Secchi 3000 is rather simple: The Secchi3000 container is filled with water from a lake, river or sea, and the measurement structure is placed inside the container. A photograph can then be taken with a mobile phone through a hole in the lid. The EnviObserver application (developed by VTT, Finland) was used to take the photograph, which is sent by the application to a server simultaneously with metadata, for instance, the measurement location. An algorithm is used to analyse the photograph at the server. Target areas are then found from the picture and, based on the brightness values of the target areas; the algorithm computes water quality parameters. In conclusion, the results are stored in databases and user will also receive them to the mobile phone.

Järviwiki

Järviwiki, also known as Lakewiki, is a web service built and maintained in cooperation by authorities and active citizens. The webpage provides information on each Finnish lake over 1 ha in extent and tools for sharing different parameters, observations and pictures. Each lake has its own page, as does each drainage basin, region, municipality, ELY centre and river basin district. In addition, Järviwiki can be used for sharing information and documentation on lake restoration projects. Some of the basic information on these pages originate directly from authority databases and cannot be modified by the active citizens or other users. Most of the other content on the portal is user-editable, and contributions are encouraged.

IBM CreekWatch

Mobile phone applications are one of the easiest and most accessible tools for regular citizens to participate in environmental monitoring. IBM Research has provided an iPhone application Creek Watch for monitoring the condition of waters. When passing any kind of waterway, river or

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stream, the Creek Watch application is a tool to report how much water and trash is visible at the time. Reporting via the application utilises the everyday object of the citizen, a mobile phone and its camera function. The Creek watch announces that the data is aggregated and shared with water control boards to help them track pollution and manage water resources.

The Creek Watch App uses four pieces of data:

1. The amount of water: empty, some, or full.
2. The rate of flow: still, moving slowly, or moving fast.
3. The amount of trash: none, some (a few pieces), or a lot (10 or more pieces).
4. A picture of the waterway.

The data helps watershed groups, agencies and scientists track pollution, manage water resources, and plan environmental programs.[68]

EEA Eye on Earth with WaterWatch and AirWatch

Eye on Earth was a 'social data website' for creating and sharing environmental information in a socially meaningful way. The online 'environmental community' facilitated by the European Environmental Agency (EEA), technology leaders, cutting-edge innovations and cloud technology invited all to participate in the formation of new data and information based on individual observations and measurements. A variety of formats for the data and information, such as maps, graphs and tabular spreadsheets, as well as various other tools were provided for use on the platform. The interactive maps could be viewed, created, manipulated and shared. It represented a good practice for implementing the principles of a Shared Environmental Information System (SEIS) for Europe and was used to support the European efficiency in collecting and providing environmental information to the wider public as well as research. Users were able to select, whether they wished to share information with closed groups selected by the user himself/herself or with all other users.

At 2008, WaterWatch was the first application to be used on the Eye on Earth platform, providing an online interactive map of Europe presenting the latest available official water quality data (in line with the EU Bathing Water Quality Directive) from over 22,000 monitoring stations in 28

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countries. EEA facilitated the development of Eye on Earth with partners such as Microsoft Corporation and Esri, a U.S.-based developer of GIS mapping software.

The Eye on Earth project was mentioned at the 2012 United Nations Conference on Sustainable Development[129] (paragraph 274). After this, no further updates on the project, or developments on related watches or internet services, could be found. Such a platform would have made it possible to allow non-professional active citizens to carry out research-related tasks such as observation, measurement or computation and to provide their own data and measurements to profit the wider society

Water Insight

Remote sensing products and services are important support tool for research depending on the availability of such satellite data. Water Insight provides remote sensing products and services able to analyse the water quality on their high resolution products. Small companies and research groups may obtain vast potential and expertise in processing satellite data for large areas and performing and supporting optical in situ measurements for also detailed monitoring. Water Insight has developed a hand held water quality scanner, the WISP-3, for collecting optical in situ measurements. It is especially suitable for monitoring of water supply reservoirs, monitoring water quality at swimming water locations, intensive monitoring during periods of expected algal blooms as well as flexible and fast monitoring of ecological restoration projects. Water Insight was founded in 2005 in order to provide innovative operational tools and services to increase the efficiency and effectiveness of water quality management. Water Insight advertises that their easy-to-handle in situ instrument provides the concentrations of: Chlorophyll pigments, suspended particulate matter (SPM), Cyanaopycocyanin pigments (of blue algae) and coloured dissolved organic matter (through WISPweb)[138].

Citclops

Optical monitoring has proven to be a viable option among sensor based environmental monitoring, especially in monitoring including volunteer activities and active citizens in water quality monitoring due to the fact that using this technology, the measuring device does not need to be dipped in the water or water does not need to be inserted in the device. Using this method, such

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variables as the depth of the sample, the background or experience of the volunteer may not affect the data gathered as much as with other types of monitoring.

The objectives of the Citclops project are (according to the project website http://www.citclops.eu):

- To enable citizens' participation in acquiring environmental data in coastal and oceanic areas through the use of existing devices, such as smart phones as sensors.
- To develop improved low-cost sensors and systems for monitoring water colour, transparency and fluorescence, in a location-aware manner allowing for the analysis of spatial patterns.
- To provide recommendations in sectors such as energy, transport, fisheries, health and spatial planning, interpreting collected data through artificial intelligence techniques.
- To disseminate interpreted information to two kinds of users: citizens (individuals and associations) and policy makers (e.g. local administrations).
- To produce applied results by developing: (a) new applications for mobile devices; (b) friendlier and more flexible user interfaces; and (c) social-networking capabilities to connect citizens and their associations to policy makers.

Monitor 2020

Finnish national monitoring strategy of the state of the environment defines strategic targets for the gathering, storage and utilisation of environmental data, as well as means of, and measures for, achieving these targets, up to the year 2020.The main strategic goals of the program are[77]:

- Securing a sufficient level of information to support decision-making and comply with legal requirements;
- Higher quality and maximised cost efficiency throughout the production process for monitoring; and
- Easier utilisation of information.

One of the key factors of the Monitor2020 programme is the possibility of combining different types of data to reach and answer different interests towards the environment via GIS based solu-

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tions, such as allow environmental considerations, land use, engineering, biodiversity and social factors as separate layers on a location based information source. Developing the monitoring solutions would also allow the architecture of organisations and monitoring solutions to be simplified, decentralized and thus lower the costs or administration efforts via automated data handling. The family of different citizen solutions to environmental monitoring include such topics as Bird watch (active programme since 1920's), hunting and animal countings (1970's), Algal watch (2010), Lake wiki (2011), JellyFish Watch (2012), Alien species Watch (2013), River Watch (2013) and MySwim Water Watch (2013) water quality monitoring with Secchi 3000 equipment.[77]

The target of the Monitor2020 programme is to combine different environmental monitoring data, in a more efficient and open way, to maximize the utilization of such information. The monitor2020 programme will therefore provide guidelines and suggestions to the ongoing projects and initiatives on the selection and sharing of the information as well as technical architecture.[77]

Other activities related to co-operation in water monitoring

To support the volunteer activities and active citizenship in the field of environmental monitoring the United States Environmental Protection Agency keeps an online platform related to environmental monitoring and volunteer activities, and one section covers water related activities (for further information, http://water.epa.gov/type/rsl/monitoring). The online platform is used both by parties organising the environmental monitoring activities and by citizens engaged in this kind of activities. Via the webpage it is possible to find programs on environmental monitoring active in different parts of the nation, guidebooks and factsheets on the basic functionalities on environmental monitoring, and also support in organising such activities. The webpage also demonstrates the use of different funding channels for citizen monitoring and activity programmes, and provides links to different funding options, such as The Michigan Volunteer River, Stream and Creek Cleanup Grant Program (VRSCCP). To improve the waters, small grants are provided to local units of government in order to help implementing volunteer clean-up attempts of rivers, streams and creeks. These grants are directly assigned for the clean-up and removal process of trash and debris from rivers and streams. The main idea behind the funding is to support the volunteer activities. Disposal costs, hand tools, supplies refreshments and other possible volunteer apprecia-

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tion materials are possible to be covered by the program-awarded grant funds. Eligible candidates to apply and receive funding are local units of government. To conduct the actual clean-up efforts, the units are allowed to work with non-profit organizations and grassroots groups.

Besides the tools for the monitoring, any program or project including active citizens will require proper tools for the information and communication activities closely linked to the actual monitoring and volunteer activities. To enable such activities, and to exploit the existing data, many countries have started to support different kinds of stakeholder platforms and programs to support the transparency and accessibility of environmental information. Already existing information and programs require support and attention to allow the multiplication of the results and multiplier effect to the water quality issues. An example of such activities can be found from the United States, where a national facilitation project Volunteer Water Quality Monitoring has worked to build a comprehensive support system for volunteer water quality monitoring efforts across the country. The objective is to expand and strengthen the capacity of existing Extension volunteer monitoring programs and support the development of new groups. Under the project, local priorities are taken into consideration with regional and state-wide volunteer monitoring training courses. The project will be able to enhance visibility, understanding and credibility by the interaction and communication at national, regional and local scales. Therefore, volunteer monitoring can execute the role to effectively address research, education and extension themes. The core idea behind this project is the so called Multiplier effect: Volunteer monitoring strengthens the delivery of a state's overall Extension water quality program. The data produced in this project is being exploited by a wide selection of federal, state, local and tribal agencies, as well as by researchers, educators and watershed groups. Easy access to the information is in the earnest consideration at the design phase of the project.

The project announces at their website (http://www.uwex.edu/ces/csreesvolmon/links.html), that the monitoring programs can be considered as springboards that enlarge and orientate Extension's community involvement. They create "multiplier effects" as the knowledge, concern, commitment and energy of trained citizen volunteer monitors is carried into other areas of their community’s life.

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The different types of approaches mentioned provide a great example of how differently the Citizen activity in environmental monitoring can be approached. The approach may be towards supporting the existence of different types of local activities, providing information and a centralized channel to finding these opportunities from both individual perspective and from the perspective of municipalities and other organizing parties, or developing specific tools to make such activities easier to organize and execute. As shown in Figure 2, the central actors are the Local authorities, Research and environmental organisations, and the active citizens themselves. The specific objectives of the activities may arise from the active citizens themselves, but most often the activities are influenced by the actors as well as the available tools, platforms, ongoing projects and programmes as well as funding. Even though the active citizens are usually volunteering for the activities on environmental monitoring, the equipment, access to the monitoring sites and the upkeep of webpages and databases requires access to funding, either via official programs or as charity.

Figure 2. Central actors and tools for environmental monitoring via citizen activity

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The BalticFlows consortium gained in most of the participating regions a warm welcome from the active citizen groups, such as people interested in environmental conservation actions, active users of local rivers and streams for recreational purposes and residents living nearby a river or a stream. The consortium members have set up meetings and engaged the citizen groups in the events and dissemination activities, as well as in the surveys related to environmental monitoring and social media. Participating regions share an interest and passion towards the Baltic Sea and the rivers and streams that flow into the sea. With a clear set of tools for monitoring and sharing information, the regions would most likely form a great environment in which the triple helix or even the quadruple helix activities related to environmental monitoring would thrive.

Most stakeholders acknowledge the need to protect the Baltic Sea, but the role and responsibility of the general public is still missing from the wider picture. Conventions and strategies clearly recommend that regional and local government as well as organisations engage the public and stakeholders in activities promoting a healthy Baltic Sea and actively promote public participation in decision-making[79]. Raising public awareness and promoting the active role of citizens could lead to greater public participation in the protection of the Baltic Sea. The general awareness of research and its objectives could be enhanced with the help of tangible means of participation, well-planned monitoring systems and the possibility to have an active dialogue between actors on national and international levels as well as private persons and officials. More awareness, information sharing and involvement in the public arena are necessary to protect the Baltic Sea. Many individual actors might have the will and the awareness, but lack the means and channels to participate[79].

By offering citizens the means to participate in environmental monitoring, we at the same time offer tools to take part in the conservation of the Baltic Sea, to be active citizens and to share their knowledge. Participation and discussion can be activated, if people are provided with relatively easy tools to participate in an interesting subject. On the other hand, it is hard to expect activity and participation if a person does not believe that his/her actions really make a difference. This is why an active and vivid public discussion is needed. Visible support for and communication of all of steps in the conservation and protection of the Baltic Sea may provide the citizens with greater confidence in action and the possibilities available for wider public participation.

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Turku University of Applied Sciences has shown activity in including the wider public in the research and conservation activities. Their recent BalticSeaNow.info project, which was disclosed above, conducted a survey aimed at those working in the protection of the Baltic Sea. The aim of the survey was to clarify the Baltic Sea experts' thoughts about the need for involving the public and the opportunities provided with inclusion. Ideas on the role of citizens in the protection of the Baltic Sea were investigated in the survey by means of open-ended questions. The questions covered also the concept of a Baltic Sea identity as a mean to gain more interest and participation. A Baltic Sea identity was considered a difficult matter, as the runoff area of the Baltic Sea is extensive and not all residents live next to the coast. According to the project, a common identity could also prove difficult to establish as the cultural background of the states in the Baltic Sea region differ from one another. In order to promote and encourage public participation in environmental research and public discussion new ideas and approaches are needed. A Baltic Sea identity was considered an important channel to foster participation, as people are prone to act in favour of things they consider their own. Improving the relationship with nature and increasing the appreciation of nature might prove to be practical ways to boost the development of a mind-set enabling and encouraging public participation as well as furthering the development of a Baltic Sea identity.

Environmental problems do not respect national borders. This is especially true when considering environmental problems in the Baltic Sea, which affect the citizens of several countries either directly or indirectly. Today citizens have a possibility to be involved with environmental decision-making via commenting on proposals of the environmental evaluations in progress. The citizens could however play more participative roles in the entire cycle of policy-making from objective setting and planning for new openings through monitoring existing conditions and monitoring results[66]. Where possible, replacing human senses with technology can further minimize problems with volunteer data collection.

Today most projects and public databases gather information in a defined location, website or organisation and to provide it mainly to those who are informed enough to request it. This type of collected data could for example be used to fulfil statutory obligations for nature conservation. Some networks may serve more the educational rather than scientific purposes, and some are

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more for recreational rather than active citizenship. But nevertheless environmental data is already being gathered, and we should be smart enough to make gathering that data as easy as possible and to come up with methods how that gathered data could be used in several different contexts, and whenever possible, to serve the entire society.

Encouraging citizens to presume a participative role in knowledge creation and environmental policy-making requires a powerful way of thinking. To inform policy and management decision, the traditional "from top to bottom" structure of information flow which describes specialist-intensive policy-making structures will be challenged by the exploited information gathered by citizens. The constant and desirable bilateral exchange of knowledge between citizens and authorities will be possible by including the citizens in the entire cycle of policy-making[41].

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5. Trust the data?

How would it be possible to use the data gathered by non-experts, not scientifically trained volunteers, for decision-making or scientific research? Environmental monitoring projects gathering data recorded by citizen scientists have not been without controversy. The applicability of the data has been a hot topic for both scientists and authorities. On the other hand, citizen scientists provide a valuable resource not available with traditional monitoring practices[44,45].

Perspective of Information Technology

Below are stated several important issues to be managed when creating valuable and usable data, assuming communication from sensor to database is working in a reliable way using modern ICT technology;

Traceability of how monitored data is acquired, access to calibration data, unique ID and type of sensor including its feed of raw data and calibrated data, calibration method and other data used for correlation of data. Depending on the user and purpose of usage of data, different methods may be applied when retrieving this data from the database (the cloud). Different Data Fusion and Data Analytic methods may be applied to improve the data, but these methods are relying on know how about how data is collected.

Database storage formats and data retrieval APIs (application program interface) shall follow some established open standard(s) that enables integration with data from other sources - and Data Fusion Analytics or general presentation.

Recommendations how to use the sensors may be critical, so instructions and method show to deploy sensors for untrained citizens would be necessary. Training may be needed, but if the sensor includes some DIY (do it yourself) instructions, this would be even better, and training should be complemented with locally supported sensor intelligence.

If data is used for official public information or research, it is important that some level of scientific correctness or "trust" in information presented is warranted. This may only be true if traceability to data source and measurement methods is known.

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If it data is provided by Citizen contribution, it is also recommendable that data is provided free to use without any commercial restrictions – allowing access and usage both for public information, innovation processes or academic research.

There are some advances related to how to trace sensor data, especially wireless sensors with respect to the above mentioned traceability. Since this type of sensor is less reliable than always mains powered industrial sensors in a controlled laboratory environment – the sensor should be equipped with substantial and sufficient information within the data feed about identity and calibration status. Methods are defined that may be used on low cost sensors that does not increase the price substantially, but significantly increases the "trust value" of data. If other parameters (other types of sensor data) are added to the data feed that compensates for the lack of laboratory environment that is common for this type of data acquisition, compensation algorithms may be applied to increase the correctness of the data both locally in the sensor and later in the cloud, using data fusion.

To illustrate a simple example: a water sensor is constructed to measure turbidity, this may be a low cost wireless sensor deployed in a river stream. To get a reliable value from this sensor, it may be wise to add information about optics used (wavelength, filters), depth and position in the river stream (geographic position and pressure or length of deployment wire) together with other parameters such as water temperature and optionally other parameters that will be used in data fusion applications.

One solution may be to add PnP (Plug and Play) abilities to the sensor; this corresponds to how an Operating system automatically loads the correct software driver to a new mouse on your PC when you plug the USB connector into the PC. There are different examples of how to do this for a sensor – a combination of TED (sensor electronic datasheet and ID) and software protocols such as IEE1451 where the sub clause IEEE 1451.5 is proposed to be used for wireless sensors. To apply such software addition to identify the sensor and enable full traceability is important if we choose to "trust the data" in a citizen deployed environmental network.

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Since the citizen of today is often using his or her smart phone for all other tasks, an important item to be added in our list above – deployment and handling methods – may be solved by wireless services at installation time. One important prerequisite is the distribution of information; this may be solved by MOOC services (Massive Open Online Courses) in combination with local communication with the sensor during installation and deployment. We assume that the citizen does not remember all the information about how to handle a sensor-based device and how to deploy it – and also that if it is a sensor that is deployed into water and then occasionally managed and maintained by this citizen. To add a local communication link with the citizen and his or her smartphone where the sensor reports if installation is performed in a correct way would increase the “trust” of the measured data. This is also applicable if the sensor is carried along and only water is sampled and put into a measurement device.

Data communication from sensor to data storage in the Cloud (Internet servers) may be unreliable and susceptible for intrusion or modifications, therefore it is recommended that usage of IP communication with support for error correction frames and optionally encryption is used.

Storage format for sensor data in the cloud databases and API to retrieve data is defined in most western countries at national level. Unfortunately, these “standards” are not internationally approved standards. Many systems are using SQL databases, JSON and RESTful APIs, so it is possible to convert data between different systems. We assume that several EU projects are trying to harmonize and create universal solutions for partially overlapping standards.

EEA (European Environmental Agency) is pointing towards OGC (Open Geospatial Consortium) proposal for SWE (Sensor Web Enablement) technology SenseML where WaterML may be standardizing water information. Organizations from other program initiatives (such as ict4water.eu) suggest different APIs for general monitoring of different data.

Data communication from sensor (human sensors or automated sensors) to data storage may be based on any type of equipment from specialised M2M/ham radio to smartphone Apps. Mobile phone applications are one of the easiest and most accessible tools for regular citizens to participate in environmental monitoring, but in larger rural areas where the need for communication has been existing before arrival of smartphones and fast mobile networks, there are several solu-

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tions where Citizen enrolment has been important – as example Australian networks for Shark warning, Coral reef preservation, hydrological monitoring networks are using other methods for communication where supervision of equipment is volunteered. The Australian SharkSmart allows and encourages citizens to report their sightings of sharks via plurality of communication channels, such as phone calls or tweets to the SharkSmart service collecting and visualising these sightings on their webpage and twitter account. The webpage has been built using CSS/HTML, which allows users to turn off style sheets and view the website content without graphics as well.

As in many cases, the environmental monitoring itself can be a lengthy process, the citizens could be offered other means to support in the monitoring process. Cooperation and support could be received in the form of unattended data transport, as this would lessen the need of training.

Data Mules is a similar approach for rural areas where no fast mobile network is available. As an ex-ample, a “private turist” could be walking around in remote natural environment, as her/his mo-bile phone automatically connects to a monitoring station and retrieves stored data. This data is forwarded to a common database when the “private turist” is back to civilisation and better net-works.

Physical Web (iBeacons, or Eddystone Google Beacons) and other proximity aware solutions are a way to connect wireless sensors to mobile units without too much work with specific Smartphone Apps. This may be a possible way to connect low cost fixed or mobile low cost monitoring sensors to citizen smartphones where the data transport to internet storage is provided.

Is the collected data reliable?

Environmental monitoring and citizen science projects are raising new questions as the popularity of such activities rise. The number of the participants is continuously increasing as well as their free time available to make observations. Both Sparks et al.[124] (2008) and Courter et al.[31] (2012) remind us all, that with traditional observations-recording projects, there is a phenomenon of a weekend bias, where the effects of more volunteers being available during the weekends for observations can affect the records and be taken into consideration when analysing the data[45].

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However, both of the studies mentioned that weekend bias seems to be declining due to the recent changes in the traditional working week.

Naturally, data collected by non-expert volunteers will be having some reliability issues, but we must keep in mind that with modern measurement technologies can overcome some or even most of the limitations presented by human sensory data. Most projects and studies still gather data provided by volunteers relying on human senses. Naturally, data collected as part of citizen science and crowdsourcing projects are not without weaknesses and data reliability issues either. There is a risk that poor quality, misleading or even maliciously submitted data eventuate from minimum amount of education, knowledge and expertise of participating relatively anonym active citizens. Incomplete or inaccurate data can appear when formal scientific methods are abandoned and non-standardized or poorly designed data collection methods are used.[2]. Since the active citizens act as volunteers in collecting the data, it is at all times possible, that the interest towards a certain type of action or project diminishes. Weekend bias or other gaps in the data collection process, such as location of the data gatherers and data collection points, may lead to low quality of data and even to a failure of an entire project. Afterwards, these issues have caused citizen science data being perceived as low quality and not worthy or too risky of being considered in serious scientific research by many in the scientific community [2].

To overcome the challenges set by the layout of any project relying on the active citizens and citizen science, a large amount of research has been undertaken to improve the data quality. Relatively simple techniques can be considered to validate data input (e.g., syntax, format and values) by checking compliance against schemas. A comparison with data sets from alternative sources or comparison with historical trends may sometimes be in place for more accurate data quality assessments. Especially with new types of data, the previously mentioned approaches are not possible in case there are no other sources of comparable data or there is no longitudinal data to perform trend analysis. Exploiting social network analysis tools to provide a measure of the trust of the data can be considered an alternative and complementary approach to data quality enhancement services. Alabri et al.[2] (2010) are certain, that even though not applied to citizen science data, a number of different trust models and trust metrics have been developed by re-

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searchers in the context of Web 2.0, and that some of them could be applicable to data sets and projects involving active citizens.[2]

The volunteer monitoring programs may offer great support for professional researchers and natural resource agencies. If a careful analysis and validation of the data collection program and tools are executed, the results should be usable and trustworthy. For monitoring and overseeing such programs, projects and data collections, a professional with advanced training and experience accustomed to solve and analyse the validity of data is necessary. Documenting the cause of impairment, quantifying effects, and developing plans to solve problems as well as purely numerical results with no straightforward interpretations will require an expert to analyse and interpret the data. This is also necessary for the active citizens to understand the meaning and logic behind the data collection activities.[50]

To improve and ensure the data quality in projects and activities including active citizens, training of the data collectors is an important step towards more accurate data. As long as the data collectors are given appropriate training to guide them, citizen scientists can be as accurate as professional scientists when collecting data[98]. Training is also a way to ensure the commitment of new project members or active citizens interested in data collection and help them to increase their skills and knowledge of the environment and research.

Training or supporting materials may range from workshops and online tutorials to field guides and train-the-trainer sessions: for example, CitSci.org offers a train-the-trainer model for all new project administrators. The Cornell Lab of Ornithology has developed a special model for developing a citizen science project. A nine-step process includes visualizing data and disseminating project results, as well as training the participants[12] . Cornell projects, such as eBird, offer extensive training materials which provide vast learning opportunities for the participants. Recorded bird sounds, regional field guides, and in-depth project tutorials may also act as a prize for the active citizen and offer them tools for personal growth. In a popular platform of Zooniverse each project begins with a short training exercise for the participants.[23]

Modern technology offers an ideal means of training and communicating with network participants, as well as means to transfer data easily and effectively. The level of training required will

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depend on a wide range of factors from the level of expertise of the volunteers to technical issues related to the set-up of the data collection. It is suggested that a large sample size and geographic area will help reduce the possible error caused by non-expert volunteer data collectors. Reliable scientific results are possible with well-designed protocols and appropriate data analysis methods. In order to ensure high-quality data collection in citizen science programmes, Bonney et al.[13] (2009) suggest having (a) clear data collection protocols, (b) simple and logical data forms, and (c) support for participants[45].

In a traditional environmental monitoring project engaging the wider public the volunteer is first trained, activated, and then performs monitoring when suitable and reports his/her observations through a form into which data needs to be typed. But what if the data would be collected through technological sensors instead of human sensors? Especially in the field of water quality monitoring, it is difficult to know what exactly the water sample collected from one's backyard river actually contains – unless the sample is sent to a laboratory for detailed analysis. Most volunteer-based projects are gathering other, more easily accessible data for the volunteers to report in. For example, the colour of the water or visible algae blooming on the water surface is relatively easy to report. By looking into the opportunities provided to us by the modern day technology, volunteers could in the future perhaps conduct research and data gathering via automated sensors analysing the data on-site, instead of requiring the long journey to the laboratory and to the hands of a professional.

According to Silvertown[121] (2009), the best way for the public to understand science is to participate in it, and therefore the growing number of participants involved in citizen science[6,121] is an indication of an increase in the level of scientific knowledge and environmental awareness among the general population[45].

In citizen science a partnership between volunteers and scientists is established to address various research questions. In this way, professional surveys may acquire additional resources and scientific research may connect to public outreach and education, as these partnerships have expanded in number and scope[13,87]. Even if for the participating active citizens the collection of the data is a leisure time activity, the data collected in this way is used in serious purposes, such as for natural resource management[16], environmental regulation[107], as well as scientific research[29].

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Therefore the data quality is of great importance and could have far-reaching environmental, social or political implications[34,50].

The data quality has been examined in several studies by determining predictors of participant success in several citizen science programs[37]. It seems that the accuracy rates within these programs vary, and that the results are not always made available to the participants or the wider public. By standardising the monitoring protocols, designing the protocols and tools in cooperation with professionals and field-test them with citizen scientists working under realistic conditions, the data quality and analyses could be improved[42].

In their article related to improving and integrating data on invasive species collected by citizen scientists, Crall et al.[34] (2011) suggest some observations and recommendations suitable for other types of data collected by active citizens as well:

1. Data quality assessments are needed for existing monitoring programs
2. Volunteers can easily acquire skills to species geolocation
3. Assess working in groups
4. Assess volunteer certification
5. Assess technology's role in data quality
6. Determine eligibility criteria for specific skills that can be adopted across programs

Crall et al.[34] (2011) also suggest testing the accuracy rates of the new citizen science tools and programs with the existing monitoring protocols. The level of accuracy can then be more closely assessed, depending on the research question being examined and the ability to perform post-hoc statistical manipulation on the data. Regular monitoring of performance would be in place to ensure the training and sampling design will remain adequate. Once proper protocols are tested and established, they should be standardized and monitored to ensure the data quality[39].

The use of geographic information systems and GPS is becoming more popular and easily accessible. Use of such systems is becoming easier for citizens and researchers, and it is therefore used more in also natural resource management. Some citizen science programs are currently using these technologies to track the exact location of sampling or data gathering[34], but evaluation of

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the accuracy of GPS used by volunteers in such programs or projects is currently still missing[71,112] (see more details in referred sources). Crall et al.[34] (2011) assume that the main limitation of these technologies may be forcing them to be available for a too large numbers of volunteers.

Grouping volunteers with professionals to acquire more accurate data, especially when relying on human sensors such as vision or hearing and identification of alien species, could prove to be efficient and successful. Bloniarz and Ryan[11] (1996) tested this type of grouping in their study of tree identification between arborists and volunteer teams. Grouping and organising such actions in mixed groups of experts and non-experts could result in more accurate data as well as provide the active citizens with more knowledge and learning opportunities, making the activities more attractive.

Certification of the volunteers and their newly acquired skills does not alone provide a feeling of honour and achievement for volunteers but it may also improve volunteer commitment to a program[9]. Master naturalists programs established throughout the United States are an example of a successful and meaningful certification model appreciated by the active citizens[92].

The sampling designs may change and be improved by technological advancements. Such a simple method as an automated error checking capability on an online form might help to improve the quality of collected data[13,33]. The technological improvements of smartphones and their applications allow automated entry of location coordinates while performing the data collection[34]. It is credible that these tools would improve data quality in different citizen science programs, even though the ability has not yet been tested in depth[126,143].

Individual's perceived capability to perform a specific task is defined as self-efficacy[5], which is used in prognosticating work and education settings performance[72,133]. Easy to obtain from volunteers, this information could be used to efficiently concentrate training on particular volunteers[34,54,94].

Data quality can be defined as the fitness of data for scientific research and concerns its completeness, validity, consistency, precision, and accuracy[141]. Data management and data quality practices vary among different programs and projects, and it seems that not all data produced by citizen science projects have a system to assure the data quality[23,33].

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Several studies indicate that active citizens are able to collect data comparable to that collected by professional researchers when specific quality assurance methods are used[3,21,42,53]. This is particularly true for projects that involve the collection of quantitative rather than qualitative data[56]. Quality assurance efforts should be considered and evaluated for practices such as deletion of inaccurate or biased data, training, expert validation and location validation.[23]

Furthermore, there appears to be a direct correlation between public participation and data sharing in successful citizen science projects. Data sharing is an important task not just to spread knowledge of the activities and lessons learned, but also to encourage ongoing participation and underscore the value of volunteer contributions.[23,117]

Sharing the data collected in citizen science projects can be implemented in several different ways. Most projects including active citizens provide access to the information, but not necessarily to the raw data, to anyone. Some projects may limit the data access to members or data collectors only to ensure the use of data in an appropriate way. The main focus of most citizen science projects lie in the dissemination of contributed data to inform scientific research, authorities and citizens themselves, and it needs to be taken into consideration that different audiences may require the use of different dissemination or sharing channels. One of the most popular methods of sharing information is via the publication of papers in peer-reviewed journals. Such activities and the importance of publishing scientific articles can be made more visible and understandable to the active citizens participating in projects by active participation and dissemination in these activities. The Galaxy Zoo project, for example, has generated some of the most highly cited peer-reviewed papers in the field of astronomy, listing and providing access to the articles and scientific research gained from the work of active citizens participating on their website.[23]

To encourage knowledge sharing, BalticSeaNow.info project used visualisation and explanation of collected data. The participants continued to be active during the project only if they understood what was the data collected for and what did the data actually mean. Project reports were shared to the participants: technical terms had either been explained or replaced with less technical ones to allow the participants and readers of all levels to have a better grasp on the content, and to avoid language only suitable for the small group of environmental experts.

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6. How's the (future) market?

In the future, emerging technologies will be inseparably linked to citizen science. Spanning several spatial, temporal, and social scales, and by being designed to achieve a number of different outcomes, successful citizen-science projects will depend upon new technologies to allow participants and organisers to communicate and interact effectively[43,95,99,119].

Scientific research is influenced by emerging technologies by intensifying data collection, enhancing data management, automating quality control, and speeding up communication. New technologies and skills (e.g. mobile applications, sensor networks, gaming) will appeal to a diverse set of citizen-science participants, but could potentially marginalise those who are reluctant or not able to digest them. Hence, for a broad and inclusive approach to new technology adoption in citizen science, global, regional and local organization networks and professional associations, as well as open-access peer-reviewed journals and cyberinfrastructure support systems, could help organize the growing citizen-science community and provide future direction to the field traversing through technological transformation.[100]

New technologies, such as mobile applications, wireless sensor networks, and online gaming, show significant potential for advancing citizen science. Mobile apps involve software developed for use on handheld devices such as smartphones and tablets. Wireless sensor networks consist of spatially distributed sensors that monitor various parameters, such as temperature, sound, vibration, pressure, motion, or pollutants. Gaming includes alternate and augmented reality games, context-aware games, and games involving social networking. Alternate-reality games permit multiple players to combine information and form coherent stories, and utilise peer-rated performance and feedback tied to location or place to solve real-world challenges[78]. These and other emerging technologies have the potential to engage broad audiences[27], motivate volunteers[30], improve data collection[142], control data quality[75], corroborate model results[40], and increase the pace at which decisions can be made[39].

During later years, traditional GIS presentations where low resolution data is presented as coloured data on a map may be complemented with high resolution data presented as an overlay on more advanced smartphones or smart 3D glasses providing VR – Virtual Reality (in the future by

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means of AR – Augmented Reality). Using smart glasses, sensor data may be superimposed with colours or warning signs on top of the picture of the surrounding reality. Using such reality enhancing vision support, a quick check with the AR-glasses of the summer beach before jumping into it may reveal if the water is safe to swim in. Many other similar applications may appear with this type of technology – as soon as the monitoring equipment will provide the required data feed.

Citizen science projects and activities exploit standardised field protocols to collect and visualise data required for monitoring socio-ecological systems at multiple spatial and temporal scales, and projects may address both local issues and grand societal challenges. Wireless sensor networks may connect the laboratory to the natural environment, shifting focus from elite science to the real world, where data collection, analysis, and interpretation are performed by citizens going about their everyday lives, in cooperation with professional scientists. For example, a daily bicycle commute could automate air-quality monitoring, gardens could grow into networked micro-environment monitoring stations, and scientists could eventually integrate continental-scale citizen science datasets with professional datasets augmented by locally relevant citizen observations.[100]

A certain problem related to the usage of lower cost sensors used by mobile citizens is how to assure the quality and accuracy of the sensors compared to laboratory equipment. On the other hand, todays "official" monitoring methods are based on a combination of few advanced monitoring measurement stations and statistical averaging over time and spatial areas. This method may give accurate and general average data sets – but does not depict the dynamics in fast changing pollution situations. A short time with a high level of pollution such as when a large truck with dirty exhaust passes on a road may give a small average contribution if sampling time and averaging measurement system is used. As a contrast, if a high density of low cost wireless sensors with higher sampling speed is measuring the same street and vehicle, much higher pollution during a shorter time will be measured and reported. This will give more valuable real time information to identify and track unwanted pollution contributors.

Furthermore, in the past decade the internet is evolving from a global network of websites into a smart "cloud" – a common expression for internet-based servers where a huge amount of open

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data can be stored, processed (data fusion) and managed (big data analytics) in different ways. For citizen science, more specialised storage can be built up as a storage service with a web access service, where many citizens can use smartphones with built-in sensors or external sensor gadget accessories to push data into the storage. Technical software solutions are quite similar to web-browsing, using the same type of software protocols – autonomously using a dedicated "app" on the smartphone. In addition to the dedicated monitored data, GPS or network positioning, time and individual profile is normally stored in the database. This will successively build up a position with reference to place and time – and balanced data values (using averages from many monitoring equipment).[17]

In addition to data storage, cloud servers may also offer applications with statistical refinement of these data values into a presentation data set that may be presented using standard web interface methods (browser or dedicated smartphone apps). Software algorithms may also be used to "scrub the data", i.e. compensate for lower resolution or quality monitoring sensor equipment with different calibration status results in a little more reliable data values. Averaging and also prediction of possible data sets in areas where no data is available may give impressive results when presented on a GIS (map) with all data from different sources and often also at different time.[17]

Roles of technology

The manner in which citizen scientists contribute to the scientific activities and objectives may vary across projects. In some cases, participants are involved in a single step of the research process, whereas others involve participants in a broader context. According to Bonney et al. (2009)[12], the typical research process for citizen science projects can been conceptualized as:

1. Gathering teams/resources/partners,
2. Defining research questions,
3. Collecting and managing data,
4. Analysing and interpreting data,
5. Disseminating results, and
6. Evaluating program success and participant outcomes.

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The roles mentioned above are described in more detail in the following;

1. Gathering teams/resources/partners. Technology can be used to expedite team formation, help program coordinators to locate professional scientists and identify participants, as well as assist professional scientists and program coordinators with locating required resources. Shared databases (e.g. Citizen Science Central, SciStarter, and the Citizen Science Alliance) provide information on best practices, training materials, and searchable databases to assist individuals in locating projects, resources and partners. The expansion of these tools and developments in social media platforms will increasingly facilitate participant connections and enable development of new projects based on freely available and scientifically vetted protocols and evaluation practices.[100]

2. Defining research questions. Research questions can be formulated via top-down (i.e. scientist driven) or bottom-up (i.e. community driven) processes[38]. With modern technology, citizen scientists may develop new questions aided by e.g. data visualisation, or scientists may see previously impossible challenges (e.g. geolocating place names, topographic features, and transportation networks) as achievable given a number of now-available "citizen sensors"[57] (Goodchild 2007). For example, Zooniverse is a suite of scientist-driven projects featuring a common portal (http://www.zooniverse.org) allowing individuals to register, join projects, and become de facto members of project teams[27], and CitSci.org (http://www.citsci.org) facilitates the formation of bottom-up and top-down projects on local, regional or national scale, and enables scientific discovery through meta-analysis of data integrated across different projects[99].

3. Collecting and managing data. Technology can improve the rate and quality of data collection through location-based, real-time mapping services[91]. For example, a mobile app by Project BudBurst (http://budburst.org) simplifies data collection by automatically including the participant's location[59], wireless sensor networks enable automated monitoring of chlorophyll and temperature profiling data along lake transects[36], and smart phones are being transformed from basic communication tools to "networked mobile personal measurement instruments"[106,145]. Automated augmentation of data collection with behaviour and context-aware alerts (e.g. a location-aware alert that a given observa-

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tion is outside the normal range) is already taking place[78] and inexpensive plugin sensors that for mobile devices may also become commonplace[84]. As computing itself will become more ubiquitous[147], but sensors will albeit require calibration, data must be validated, and citizen scientists will require adequate orientation or training[100]. Geographic coverage will remain a challenge for large-scale observations, but gaps may be addressed with advanced analytical methods (for further details: Kelling et al.[75], 2009).

4. Analysing and interpreting data. Challenges in analysing large-scale data will foster innovation in statistical analysis and modelling[75]. Grid and cloud computing will expand data storage and analytic capabilities, while enhanced visualisation and analysis tools will allow more versatile examination of captured data[100]. In addition, citizen scientists carrying mobile, networked, air-quality-monitoring devices could collect and interpret air-quality data on-the-fly while walking around a given site[142]. Here one could overlay such data with locations of known pollutant sources, in order to more precisely determine the spatial extent of environmental contamination[36].

5. Disseminating results. Technology will enhance the ability of scientists and practitioners to consolidate scientific information across projects in a centralised manner, promote collaborative writing, and create virtual forums and communities[65,137], and by this contribute to increasing collective capital[25,26]. However, in order to avoid potential bias and inaccuracies, it is important to distinguish scientifically valid information from opinion or advocacy[61], which could be addressed via e.g. “wiki” models offering open peer-review forums[65].

6. Evaluating program success and participant impacts. Studies indicate that participants in citizen-science programs, compared to the general public, show greater scientific knowledge, skills, and positive approach toward science and the environment[9,12,15]. However, it is challenging to evaluate changes in multiple impact categories (e.g. attitudes, behaviour) during an individual’s participation when such data does not exist[32]. Standardised and electronically available impact measures would enable objective comparison across diverse projects. New technologies may play a role in providing tools to track indi-

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viduals as they participate in a wide array of citizen science programs throughout their lifetime, while protecting participant privacy[100].

Future trends and challenges

Successful citizen science programs involve promoting long-term community-level involvement and activities, exploiting appropriate cyberinfrastructure, developing diverse goals and evaluation strategies, engaging under-represented audiences, ensuring projects' financial stability, and effectively disseminating results[13]. Emerging technologies will address these factors, but also emphasise other aspects of participant culture including:

- Diversity of participants,
- Motivation and retention of volunteers, and
- Technology adoption, appropriateness and preparedness

These factors are described in the following, and in Figure 1 the factors are also shown in context with the six above mentioned key research process steps of citizen science;

> ***Diversity of participants.*** Future citizen science will be characterised by networked and open science and the use of gaming, encouraging involvement of younger and more ethnically diverse participants[101]. Emerging technologies will broaden participation in citizen science and allow data collection by unorthodox communities in scientific projects. For example, in Evolution MegaLab, participants from 15 European countries surveyed shell polymorphism, and via open-source software, a team of collaborators and crowdsourcing approaches, engaged more than 6,400 individuals[146]. However, despite wider gain, new technologies may unintentionally expand the "digital divide" between those who adopt or have access to technology and those who avoid or lack it[52]. In addition, diverse views on how to advance science, which scientific methods to use and how to share information across international boundaries may hamper data sharing and data re-use, thus limiting long-term benefits[109]. Therefore, as citizen science adopts new technologies, sensitivity to social, cultural, economic, and political factors will be paramount to the success of multinational, multi-cultural projects involving local or traditional ecological knowledge[4].

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Motivation and retention of volunteers. As described earlier, citizen scientists may be motivated by contributing to authentic scientific research, by social interactions within participation[135], or by competition and symbolic rewards, such as virtual "badges"[27,30,40]. Award systems are based upon competition, pitting teams or individuals against each other, as in the popular online Fold-It game[30,59] wherein enjoyment is an intrinsic underlying motive for participation[103]. Gaming and a sense of belonging to a group make scientific exploration and discovery enjoyable, and the positive influence of gaming on motivation to participate underlines the essentiality of incorporating recreation into citizen science.[100]

Technology adoption, appropriateness and preparedness. Extensive adoption will have a major influence on the infiltration of new technologies into the communities of both scientific and citizen science[116]. It appears that volunteers are more willing to adopt technology – and e.g. share their geographic location – than ever before[83]. Hence, future citizen science will represent unique composition of still indeterminable technologies, people, and sociocultural situations[36]. Given this uncertainty, the following guidelines are recommended for citizen science projects as stated by Newman et al.[100] (2012):

- Selecting appropriate technology for participants,
- Evaluating new technologies with make-versus-buy and cost-benefit analyses, paying particular attention to reliability,
- Adopting well-established, well-documented, and well-supported technologies,
- Considering interoperable, customizable, open-source solutions where possible, and
- Following best practices and use standardised data-collection and data-management protocols where available.

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7. Conclusions

This report has considered the importance of environmental water monitoring around the Baltic Sea, especially the citizen activity related to it. Taking into account the amount of the interesting water areas around us, the only way to notably grow the amount of knowledge of water areas is to enable active citizens to participate in the process as a whole.

The modern day volunteer is not necessarily willing to donate a fixed amount of time on a regular basis. To balance the needs of the monitoring programme, researchers, regional authorities and the active citizens participating in the monitoring process, we see it very important to cooperate with all of the stakeholders, much like the quadruple helix model used in Open Innovation 2.0 approach.

Communities and structures around environmental monitoring are seen very necessary to make the activities appealing and to encourage participation. No standardised methods to encourage citizen participation exist, but participation is based on single efforts and ad-hoc initiatives. A citizen initiative support and integration framework for environmental decision-making on European Union level is much called for.

Various communities, both present and previous initiatives to enable and boost citizen activity in environmental water monitoring have been presented in detail. Despite the amount of resources and effort that has been utilized we are yet to achieve a recognized, operating and coherent network that can not only provide active citizens the possibility to concretely participate in the process but also provide trustworthy information to anyone interested including various authorities and experts.

Citizens, also known as non-experts, and the environmental water monitoring data they would collect, causes somewhat wide controversy; whether the data is reliable at all, not to mention the huge potential this resource can provide to everyone. Scientists and authorities share their concerns regarding the usage of data collected by untrained volunteers. Citizen science projects not only raise these concerns but also aim at answering them. The reliability issues are recognized, and we state that with modern technologies we can overcome these issues. Active citizens partic-

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ipating in environmental water monitoring can be properly trained, and by developing automated measurement systems and on-site analysis methods the data, although not perfectly accurate, will definitely provide more opportunities than disadvantages.

Technology will ease possible citizen contribution in the field of environmental monitoring using wireless low cost monitoring equipment, but it is not really a commercial market since reward systems are not encouraging participation of any large number of citizens. Some environmental enthusiasts or social media addicts may keep delivering for a longer time than academic projects lasts, but systematic models for a sustainable, stable and long time delivery system does not seem to exist yet. On the other hand, European Union and regional country authorities and local administrators focus on conservative, classic technology with a low number of larger and expensive and scientific installations. How shall the potential of citizen contribution be properly harnessed and exploited?

The future, as stated in this report, holds many answers to the question above. Visions of future trends and challenges have been outlined. The current level of technology is not the fundamental barrier. It is the people and social responsibility from top to below. Mature industrial countries where the society has developed complex processes and structures that formally serve the citizens' needs have even created social patterns that reduce social responsibility, social innovations and engagement. Engaging citizens in common processes where direct visibility and value creation will surely increase inclusion processes and create more sustainable social and democratic societies.

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References

1. Abelson J, Forset PG, Eyles J, Casebee A, Martin E, Mackean G. Examining the role of context in the implementation of a deliberative public participation experiment: Results from a canadian comparative study. *Social Science & Medicine*. 2007;64:2115-28.

2. Alabri A, Hunter J. Enhancing the quality and trust of citizen science data. . 2010:81-88.

3. Au J, Bagchi P, Chen B, Martinez R, Dudley SA, Sorger GJ. Methodology for public monitoring of total coliforms, escherichia coli and toxicity in waterways by canadian high school students. *Journal of Environmental Management*. 2000;58(3):213-230.

4. Ballard HL, Trettevick JA, Collins D. Comparing participatory ecological research in two contexts: An immigrant community and a native american community on olympic peninsula, washington. In: Wilmsen C, Elmendorf W, Fisher L, eds. *Partnerships for empowerment: Participatory research for community-based natural resource management.* ; 2008.

5. Bandura A. Self-efficacy. In: Ramachaudran VS, ed. *Encyclopedia of human behavior 4.* ; 1994:71-81.

6. Beaubien EG, Hamann A. Plant phenology networks of citizen scientists: Recommendations from two decades of experience in canada. *International Journal of Biometeorology*. 2011;55:833-841.

7. Beierle TC. Public participation in environmental decisions: An evaluation framework using social goals. discussion paper 99-06. resources for the future. *Society and Natural Resources*. 1998;14:815-826.

8. Beierle TC, Cayford C. Democracy in practice: Public participation in environmental decision. . 2002.

9. Bell S, Marzano M, Cent J. What counts? volunteers and their organisations in the recording and monitoring of biodiversity. *Biodiversity and Conservation*. 2008;17:3443-3454.

10. Blackstock KL, Kelly GJ, Horsey BI. Developing and applying a framework to evaluate participatory research for sustainability. *Ecological Economics*. 2007;60:726-742.

11. Bloniarz DV, Ryan HDP. The use of volunteer initiatives in conducting urban forest resource inventories. *Journal of Arboriculture*. 1996;22(2):72-82.

12. Bonney R, Ballard H, Jordan R, et al. Public participation in scientific research: Defining the field and assessing its potential for informal science education. *A CAISE Inquiry Group Report*. 2009.

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

13. Bonney R, Cooper CB, Dickinson J, et al. Citizen science: A developing tool for expanding science knowledge and scientific literacy. *BioScience*. 2009;59:977-984.

14. Bradford BM, Israel GD. Evaluating volunteer motivation for sea turtle conservation in florida. . 2004.

15. Brossard D, Lewenstein B, Bonney R. Scientific knowledge and attitude change: The impact of a citizen science project. *International Journal of Science Education*. 2005;27(9):1099-1121.

16. Brown WT, Krasny ME, Schoch N. Volunteer monitoring of nonindigenous invasive plant species in the adirondack park. *Natural Areas Journal*. 2001;21:189-196.

17. Brunberg K. Expert opinion by CEO kjell brunberg of upwis AB, a private company specialised in small-size sensor technology and cloud-based data processing and computing. . 2014.

18. Buchecker M, Hunziker M, Kienast F. Participatory landscape development: Overcoming social barriers to public involvement. *Landscape and Urban Planning*. 2003;64:29-47.

19. Buchy M, Hoverman S. Understanding public participation in forest planning: A review. *Forest Policy and Economics*. 2000;1:15-25.

20. Buttoud G, Yunusova I. A "mixed model" for the formulation of a multipurpose mountain forest policy; theory vs. practice on the example of kyrgyzstan. *Forest Policy & Economics*. 2002;4(2):149-160.

21. Canfield DE, Brown CD, Bachmann RW, Hoyer MV. Volunteer lake monitoring: Testing the reliability of data collected by the florida LAKEWATCH program. *Lake and Reservoir Management*. 2002;18(1):1-9.

22. Carter J, Gronow J. Recent experience in collaborative forest management: A review paper. . 2005.

23. Cavalier D, Cheetham R, Emanuele R, et al. Citizen science data factory – A distributed data collection platform for citizen science, part 1: Data collection platform evaluation. *White Paper*. 2014.

24. Chambers R. The origins and practice of participatory rural appraisal. *World Development*. 1994;22(7):953-969.

25. Chang HH, Chuang SS. Social capital and individual motivations on knowledge sharing: Participant involvement as a moderator. *Information Management*. 2011;48:9-18.

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

26. Chiu CM, Hsu MH, Wang ETG. Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories. *Decision Support Systems*. 2006;42:1872-1888.

27. Clery D. Galaxy zoo volunteers share pain and glory of research. *Science*. 2011;333:173-175.

28. Cooke B, Kothari U. *Participation, the new tyranny?* . London - New York: Zed Books; 2001.

29. Cooper CB, Hochachka WM, Dhondt AA. Contrasting natural experiments confirm competition between house finches and house sparrows. *Ecology*. 2007;88:864-870.

30. Cooper S, Khatib F, Treuille A, et al. Predicting protein structures with a multiplayer online game. *Nature*. 2010;466:756-760.

31. Courter JR, Johnson RJ, Stuyck CA, Lang BA, Kaiser EW. Weekend bias in citizen science data reporting: Implications for phenology studies. *International Journal of Biometeorology*. 2012;57:715-720.

32. Crall AW, Holfelder K, Waller DM, Newman GJ, Graham J, Waller DM. The impacts of an invasive species citizen science training program on participant attitudes, behavior, and science literacy. *Public Understanding of Science*. 2012;22(6):745-764.

33. Crall AW, Newman GJ, Jarnevich C, Stohlgren TJ, Waller DM, Graham J. Improving and integrating data on invasive species collected by citizen scientists. *Biological Invasions*. 2010;12:3419-3428.

34. Crall AW, Newman GJ, Stohlgren TJ, Holfelder KA, Graham J, Waller DM. Assessing citizen science data quality: An invasive species case study. *Conservation Letters*. 2011;4(6):433-442.

35. Creighton JL. *Managing conflict in public involvement settings: Training manual for bonneville power administration.* Los Gatos, California: Creighton and Creighton; 1986.

36. Cuff D, Hansen M, Kang J. Urban sensing: Out of the woods. *Commununications of the ACM*. 2008;51(3):24-33.

37. Danielsen F, Burgess ND, Balmford A. Monitoring matters: Examining the potential of locally-based approaches. *Biodiversity and Conservation*. 2005;14:2507-2542.

38. Danielsen F, Burgess ND, Balmford A, et al. Local participation in natural resource monitoring: A characterization of approaches. *Conservation Biology*. 2009;23(1):31-42.

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

39. Danielsen FM, Burgess ND, Jensen PM, Pirhofer-Walzl K. Environmental monitoring: The scale and speed of implementation varies according to the degree of people's involvement. *Journal of Applied Ecology*. 2010;47:1166-1168.

40. Darg DW, Kaviraj S, Lintott CJ, et al. Galaxy zoo: Multimergers and the millennium simulation. *Monthly Notices of the Royal Astronomical Society*. 2011;416:1745-1755.

41. De Neufville JI. *Knowledge and action: Making the link, working paper no. 445.* University of California at Berkeley, Institute of Urban and Regional Development; 1985.

42. Delaney DG, Sperling CD, Adams CS, Leung B. Marine invasive species: Validation of citizen science and implications for national monitoring networks. *Biological Invasions*. 2008;10:117-128.

43. Dickinson JL, Shirk J, Bonter D, et al. The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and the Environment*. 2012;10:291-297.

44. Dickinson JL, Zuckerberg B, Bonter DN. Citizen science as an ecological research tool: Challenges and benefits. *Annual Review of Ecology, Evolution, and Systematics*. 2010;41:149-172.

45. Donnelly A, Crowe O, Regan E, Begley S, Caffarra A. The role of citizen science in monitoring biodiversity in ireland. *International Journal of Biometeorology*. 2013;58(6):1237-1249.

46. Downs JS, Holbrook MB, Sheng S, Cranor LF. Are your participants gaming the system?: Screening mechanical turk workers. . 2010:2399-2402.

47. Duram LA, Brown KG. Assessing public participation in US watershed planning initiatives. *Society & Natural Resources*. 1999;12:455-467.

48. EEB. *10 years of the water framework directive: A toothless tiger? – A snapshot assessment of EU environmental ambitions.* Vol 2014. European Environmental Bureau, Biodiversity and Nature; 2010.

49. Egan KJ, Herriges JA, Kling CL, Downing JA. Valuing water quality as a function of water quality measures. *American Journal of Agricultural Economics*. 2009;91:106-123.

50. Engel SR, Voshell Jr. JR. Volunteer biological monitoring: Can it accurately assess the ecological condition of streams? . *American Entomologist*. 2002;48(3):164-177.

51. EPA. Developing and implementing an estuarine water quality monitoring, assessment, and outreach program. . 2002.

52. Ess C, Sudweeks F. On the edge – cultural barriers and catalysts to IT diffusion among remote and marginalized communities. *New Media & Society*. 2001;3(3):259-269.

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

53. Fore LS, Paulsen K, O'Laughlin K. Assessing the performance of volunteers in monitoring streams. *Freshwater Biology*. 2001;46:109-123.

54. Genet KS, Sargent LG. Evaluation of methods and data quality from a volunteer-based amphihian call survey. *Wildlife Society Bulletin*. 2003;31(3):703-714.

55. Germain RH, Floyd DW, Stehman SV. Public participation of the USDA forest service public participation process. *Forest Policy and Economics*. 2001;3:113-124.

56. Gommerman L, Monroe MC. Lessons learned from evaluations of citizen science programs, university of florida, FOR291, one of a series of fact sheets from the school of forest resources and conservation, florida cooperative extension service, institute of food and agricultural sciences. . 2012.

57. Goodchild MF. Citizens as voluntary sensors: Spatial data infrastructure in the world of web 2.0 . *International Journal on Spatial Data Infrastructures Research*. 2007;2:24-32.

58. Gouveia C, Fonseca A. New approaches to environmental monitoring: The use of ICT to explore volunteered geographic information. *GeoJournal*. 2008;72:185-197.

59. Graham E, Henderson S, Schloss A. Using mobile phones to engage citizen scientists in geosciences research. *American Geophysical Union*. 2011;92(38):313-315.

60. Griffin CB. Watershed councils: An emerging form of public participation in natural resource management. *Journal of the American Water Resources Association*. 1999;35(3):505-518.

61. Grorud-Colvert K, Lester SE, Airame S, Neeley E, Gaines SD. Communicating marine reserve science to diverse audiences. *Proceedings of the National Academy of Sciences*. 2010;107(43):18306-18311.

62. Habron G. Role of adaptive management for watershed councils. *Environmental Management*. 2003;31(1):29-41.

63. Hansen SH, Mäenpää M. An overview of the challenges for public participation in river basin management and planning. *Management of Environmental Quality*. 2007;9(1):67-84.

64. HarmoniCOP project. Http://Www.harmonicopPuos.de (according to luyet et al., 2012, however website now discontinued; please see e.g. http://www.harmonicop.uni-osnabrueck.de, or ridder et al. 2005). . Updated 2005.

65. Hoffmann R. A wiki for the life sciences where authorship matters. *Nature Genetics*. 2008;40(9):1047-1051.

66. Hunsberger C, Gibson R, Wismer S. *Increasing citizen participation in sustainability-centred environmental assessment follow-up – lessons from citizen monitoring, traditional ecolog-*

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

ical knowledge, and sustainable livelihood initiatives. Research and Development Monograph Series, Canadian Environmental Assessment Agency; 2003.

67. IAP2. International association for public participation (IAP2) . http://www.iap2.org/associations/4748/files/06Dec_Toolbox.pdf. Updated 2009.

68. IBM. Snap a picture. save a stream. new iPhone app brings the power of crowdsourcing to local waterways. http://www.ibm.com/smarterplanet/us/en/water_management/article/creek_watch.html. Updated 2014. Accessed December, 2014.

69. Irvin RA, Stansbury J. Citizen participation in decision making: Is it worth the effort? . *Public Administration Review*. 2004;64(1):55-65.

70. ISPWDK Indo-Swiss Participative Watershed Development Programme. Empowering the people: Experience with village development societies in promoting local governance. In: *ISPWDK programme series 1.* Hyderabad, India: Intercooperation Delegation; 2005.

71. Jones JPG, Andriamarovololona MM, Hockley N, Gibbons JM, Milner-Gulland EJ. Testing the use of interviews as a tool for monitoring trends in the harvesting of wild species. *Journal of Applied Ecology*. 2008;45:1205-1212.

72. Judge TA, Jackson CL, Shaw JC, Scott BA, Rich BL. Self-efficacy and work-related performance: The integral role of individual differences. *Journal of Applied Psychology*. 2007;92(1):107-127.

73. Junker B, Buchecker M, Müller-Böcker U. Objectives of public participation: Which actors should be involved in the decision making for river restorations. *Water Resources Research*. 2007;43(10):W10438.

74. Kangas J, Store R. Internet and teledemocracy in participatory planning of natural resources management. *Landscape and Urban Planning*. 2003;62:89-101.

75. Kelling S, Hochachka WM, Fink D, et al. Data-intensive science: A new paradigm for biodiversity studies. *BioScience*. 2009;59(7):613-620.

76. Kenney DS, McAllister ST, Caile WH, Peckham JS. *The new watershed source book: A directory and review of watershed initiatives in the western united states.* Natural Resources Law Center, University of Colorado School of Law; 2000.

77. Kettunen J. Monitor2020: Lessons learned of citizen science. http://epanet.pbe.eea.europa.eu/ad-hoc-meetings/epa-network-workshop-citizen-science-12-13-march-2013/juhani-kettunen_syke.pdf. Updated 2014.

This project has received funding from the European Union’s Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

78. Kim J, Lee E, Thomas T, Dombrowski C. Storytelling in new media: The case of alternate reality games 2001–2009. http://www.firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/viewArticle/2484/2199. Updated 2009. Accessed December, 2014.

79. Kiviluoto K, Komulainen M, Kunnasvirta A, eds. *Towards baltic sea citizenship: Experiences in public involvement, reports from turku university of applied sciences 181.* Tampere: Suomen Yliopistopaino, Juvenes Print Oy; 2014.

80. Knight TA, Cowling RM, Campbell B. An operational model for implementation conservation action. *Conservation Biology*. 2006;20(2):408-419.

81. Konisky DM, Beierle TC. Innovation in public participation and environmental decision making: Examples from the great lakes region. *Society and Natural Resources*. 2001;14(9):815-826.

82. Kruger LE, Shannon MA. Getting to know ourselves and our places through participation in civic social assessment. *Society & Natural Resources*. 2000;13:461-478.

83. Krumm J. A survey of computational location privacy. *Personal and Ubiquitous Computing*. 2009;13:391-399.

84. Kuo Y-, Verma S, Schmid T, Dutta P. Hijacking power and bandwidth from the mobile phone's audio interface. . 2010.

85. Lappalainen A. *The effects of recent eutrophication of freshwater fish communities and the fishery on the northern coast of the gulf of finland, baltic sea.* Department of Limnology and Environmental Protection, University of Helsinki and Finnish Game and Fisheries Research Institute; 2002.

86. Lawrence RL, Deangen DA. Choosing public participation methods for natural resources: A context specific guide. *Society and Natural Resources*. 2001;14(9):857-872.

87. Lepczyk CA, Boye OD, Vargo TL, Gould P, Jordan R. Symposium 18: Citizen science in ecology: The intersection of research and education. *Bulletin of the Ecological Society of America*. 2009;90:308-317.

88. Li K, McNutt M. A discussion on science between premier li keqiang and dr. marcia McNutt. *Science online magazine, American Association for the Advancement of Science*. 2014;344(6180):164-165.

89. Luyet V. *A framework for the participative process in a large environmental project. case study: The 3rd rhone river correction, ph.D. thesis no. 3342.* Swiss Federal Institute of Technology, Lausanne, Switzerland; 2005.

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

90. Luyet V, Schlaepfer R, Parlange MB, Buttler A. A framework to implement stakeholder participation in environmental projects. *Journal of Environmental Management*. 2012;111:213-219.

91. Lwin KK, Murayama Y. Web-based GIS system for realtime field data collection using a personal mobile phone. *Journal of Geographic Information System*. 2011;3:382-389.

92. Main MB. Mobilizing grass-roots conservation education: The florida master naturalist program. *Conservation Biology*. 2004;18:11-16.

93. Markowska A, Zylicz T. Costing an international public good: The case of the baltic sea. *Ecological Economics*. 1999;30:301-316.

94. McLaren AA, Cadman MD. Can novice volunteers provide credible data for bird surveys requiring song identification? . *Journal of Field Ornithology*. 1999;70(4):481-490.

95. Miller-Rushing A, Primack R, Bonney R. The history of public participation in ecological research. *Frontiers in Ecology and the Environment*. 2012;10(6):285-290.

96. Mostert E. The challenge of public participation . *Water Policy*. 2003;5:179-197.

97. Nadkami A, Hofmann SG. Why do people use facebook? . *Personality and Individual Differences*. 2012;52(3):243-249.

98. Nerbonne JF, Ward B, Ollila A, Williams M, Vondracek B. Effect of sampling protocol and volunteer bias when sampling for macroinvertebrates. *Journal Of The North American Benthological Society*. 2008;27(3):640-646.

99. Newman G, Graham J, Crall A, Laituri M. The art and science of multi-scale citizen science support. *Ecological Informatics*. 2011;6:217-227.

100. Newman G, Wiggins A, Crall A, Graham E, Newman S, Crowston K. The future of citizen science: Emerging technologies and shifting paradigms. *Frontiers in Ecology and the Environment*. 2012;10(6):298-304.

101. Nielsen M. *Reinventing discovery: The new era of networked scienc.* Princeton, NJ: Princeton University Press; 2012.

102. Nov O. What motivates wikipedians. *Communications of the ACM*. 2007;50(11):60-64.

103. Nov O, Arazy O, Anderson D. Dusting for science: Motivation and participation of digital citizen science volunteers. . 2011.

104. OECD. Citizen as partners: Information, consultation and public participation in policy making. http://www.eldis.org/static/DOC11520.htm. Updated 2001.

105. Pahl-Wostl C. Towards sustainability in the water sector: The importance of human actors and processes of social learning. *Aquatic Sciences*. 2002;64:394-411.

106. Paulos E, Honicky RJ, Hooker B. Citizen science: Enabling participatory urbanism. In: Foth M, ed. *Urban informatics: Community integration and implementation.* Information Science Reference, IGI Global; 2008.

107. Penrose D, Call SM. Volunteer monitoring of benthic macroinvertebrates – regulatory biologists perspectives. *Journal of the North American Benthological Society*. 1995;14(1):203-209.

108. Petkova E, Maurer C, Henninger N, Irwin F. *Closing the gap: Information, participation, and justice in decision-making for the environment.* Washington: World Resources Institute; 2002.

109. Pulsifer PL, Laidler GL, Fraser Taylor DR, Hayes A. Towards an indigenist data management program: Reflections on experiences developing an atlas of sea ice knowledge and use. *The Canadian Geographer*. 2011;55(1):108-124.

110. Reed MS. Stakeholder participation for environmental management: A literature review. *Biological Conservation*. 2008;141:2417-2431.

111. Richards C, Blackstock KL, Carter C. *Practical approaches to participation, SERP policy brief 1.* Aberdeen: Macaulay Institute; 2004.

112. Rist J, Milner-Gulland EJ, Cowlishaw G, Rowcliffe M. Hunter reporting of catch per unit effort as a monitoring tool in a bushmeat-harvesting system. *Conservation Biology*. 2010;24(2):489-499.

113. Rist S, Chidambaranathan M, Escobar C, Wiesmann U, Zimmermann A. Moving from sustainable management to sustainable governance of natural resources: The role of social learning processes in rural india, bolivia and mali. *Journal of Rural Studies*. 2007;23(1):219-237.

114. Robinson P, Macnaghten P, Banks S, et al. Responsible scientists and a citizens' panel: New storylines for creative engagement between science and the public. *The Geographical Journal*. 2014;180:83-88.

115. Robson C. Using mobile technology and social networking to crowdsource citizen science. . 2012.

116. Rogers EM. *Diffusion of innovations (5th ed.).* New York, NY: Free Press; 2003.

117. Roy HE, Pocock MJO, Preston CD, et al. *Understanding citizen science and environmental monitoring, final report on behalf of UK-EOF, NERC.* Centre for Ecology and Hydrology and Natural History Museum; 2012.

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

118. Sabatier PA, Vedlitz A, Foch W, Lubell M, Matlock M. *Swimming upstream: Collaborative approaches to watershed management (american and comparative environmental policy).* MIT Press; 2005.

119. Shirk JL, Ballard HL, Wilderman CC, et al. Public participation in scientific research: A framework for deliberate design. *Ecology and Society*. 2012;17(2):29.

120. Shirky C. *Cognitive surplus: Creativity and generosity in a connected age.* Penguin Press; 2010.

121. Silvertown J. A new dawn for citizen science. *Trends in Ecology & Evolution*. 2009;249:467-471.

122. Smith Korfmacher K. The politics of participation in watershed modelling. *Environmental Management*. 2001;27(2):161-176.

123. Soutukorva A. *The value improved water quality – A random utility model of recreation in the stockholm archipelago, beijer international institute of ecological economics.* Stockholm: The Royal Swedish Academy of Sciences; 2005.

124. Sparks T, Huber K, Tryjanowski P. Something for the weekend? examining the bias in avian phenological recording. *International Journal of Biometeorology*. 2008;52:505-510.

125. Stanghellini PS, Collentine D. Stakeholder discourse and water management – implementation of the participatory model CATCH in a northern italian alpine sub-catchment. *Hydrology and Earth System Sciences*. 2008;12:317-331.

126. Stevenson RD, Haber WA, Morris RA. Electronic field guides and user communities in the eco-informatics revolution. *Conservation Ecology*. 2003;7(1):3.

127. Toivonen AL, Roth E, Navrud S, et al. The economic value of recreational fisheries in nordic countries. *Fisheries Management and Ecology*. 2004;11:1-14.

128. Turner RK, Georgiou S, Gren I, et al. Managing nutrient fluxes and pollution in the baltic: An inter-disciplinary simulation body. *Ecological Economics*. 1999;30:330-352.

129. UN. Report of the united nations conference on sustainable development. . 2012.

130. UN. Report of the world summit on sustainable development. . 2002.

131. UN. Rio declaration on environment and development, annex I of the report of the united nations conference on environment and development. . 1992.

132. UNECE. Convention on access to information, public participation in decision-making and access to justice in environmental matters. . 1998.

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

133. Usher EL, Pajares F. Sources of self-efficacy in school: Critical review of the literature and future directions. *Review of Educational Research*. 2008;78:151-196.

134. Van Asselt M, Mellors J, Rijkens-Klomp N, et al. *Building blocks for participation in integrated assessment: A review of participatory methods.* ICIS, Maastricht; 2001.

135. Van Den Berg H, Dann SL, Dirkx JM. Motivations of adults for non-formal conservation education and volunteerism: Implications for programming. *Applied Environmental Education and Communication*. 2009;8(1):6-17.

136. Vroom V. Leadership and the decision-making process. *Organizational Dynamics*. 2000;28(4):82-94.

137. Waldrop M. Big data: Wikiomics. *Nature*. 2008;455:22-25.

138. Water Insight. Information from website of water insight (main page). http://www.waterinsight.nl. Updated 2014. Accessed December, 2014.

139. Whitelaw G. Linking community based ecosystem monitoring to local decision making and policy development on sustainability, Final report for the canadian nature federation and the ecological monitoring and assessment network coordinating office. http://publications.gc.ca/collections/collection_2014/ec/En14-155-2003-eng.pdf. Updated 2003.

140. Wiggins A. *Citizen science project survey results.* Published by Syracuse University, with funding from the National Science Foundation; 2009.

141. Wiggins A, Newman G, Stevenson R, Crowston K. Mechanisms for data quality and validation in citizen science. *In the proceedings of "Computing for Citizen Science" workshop at the IEEE eScience Conference*. 2011.

142. Willett W, Aoki P, Kumar N, Subramanian S, Woodruff A. Common sense community: Scaffolding mobile sensing and analysis for novice users. *In the proceedings of Pervasive 2010, Lecture Notes in Computer Science*. 2010.

143. Williams K, Sader SA, Pryor C, Reed F. Application of geospatial technology to monitor forest legacy conservation easements. *Journal of Forestry*. 2006;104:89-93.

144. Wilson GA. The australian landcare movement: Towards 'post-productivist' rural governance? . *Journal of Rural Studies*. 2004;20(4):461-484.

145. Wobbrock JO. The future of mobile device research in HCI. *In the proceedings of the CHI workshop on What is the Next Generation of Human-Computer Interaction?*. 2006.

146. Worthington JP, Silvertown J, Cook L, et al. Evolution MegaLab: A case study in citizen science methods. *Methods in Ecology and Evolution*. 2012;3:303-309.

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

147. York J, Pendharkar PC. Human-computer interaction issues for mobile computing in a variable work context. *International Journal on Human-Computer Studies*. 2004;60:771-797.

This project has received funding from the European Union's Seventh Framework Programme (Regions of Knowledge) for coordination, support and capacity building under grant agreement no 319923.

Annex 1. Analysis of Citizen Survey 1

In the BalticFlows project, the consortium conducted a survey as part of the Work Package 4, "Water Monitoring Via Citizen Activity", to people of various ages and educational backgrounds amongst appropriate target groups (e.g. residents living near streams or small rivers as well as environmental activists) in order to explore their willingness to install and maintain a small water quality monitoring device.

The questionnaire was conducted from 1.11.2014 to 30.11.2014. The consortium contacted different types of student groups and environmental organisations, as they were seen as natural dissemination channels for the survey to reach wide audiences. The survey was distributed as an open link in the local languages of the project (German, Finnish, Swedish, Latvian, and Estonian). The open link was selected instead of individual survey links to identifiable individuals, as the consortium decided to keep the public participation to a maximum level, allowing the project to reach a wider array of people. Local partners from each participating region were responsible to contact and distribute the survey to similar student and environmental groups. The groups were compared and analysed to be similar in nature to the other participating regions. The environmental organisations and educational centres with students in environmental fields were contacted and a permission to send the survey link to their e-mail lists were acquired before the survey link opened, so that the survey could be launched simultaneously in different participating regions. Most of the survey links were distributed on the e-mail lists on the 1st of November by the student group lecturer or other staff member of the educational facility or environmental organisation themselves. The organisations were asked to remind the respondents 1-4 times during the month to answer the survey.

As the survey was conducted via an open link, it is possible that the respondents have shared the survey forward to their friends or family members. Some respondent groups decided to share the link on the social media or website of the organisation, even if the original method of contact was via e-mail.

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First in this analysis we characterize the respondents by age, sex and educational background. Following the characterization, we focus on certain questions asked in the survey, mostly in 'Yes' or 'No' format. We determine how males and females of different age groups and educational backgrounds are willing to assist in monitoring the environmental conditions of their local streams or rivers and, if so, which monitoring devices they prefer, e.g. smart phone or tablet. In addition we explore their interest to voluntarily assist or whether they seek compensation in return of such activities as installing, maintaining and storing a small water quality monitoring device.

Important! This analysis is based on the information that participants have filled out themselves without any supervision. Due to the non-representativeness and the sampling methods of this survey, it is not possible to state whether people would or would not be interested in the environmental conditions of their local streams or rivers, or be or not be willing to somehow participate in the monitoring process. The analysis does give an indication of the interest towards willingness to install and maintain a small water quality monitoring device, serves as a description of the survey results, and describes the interpreted utterance of female and male survey respondents of various age groups and educational backgrounds.

General interpretation of results

In the next sections the results are introduced one question at a time. The questions raised to the focus point are seen as the most relevant ones, and characterizing the most central aspects of environmental monitoring of rivers and streams as a citizen activity. As the survey is executed via an open link meaning an open access to the survey to anyone with the web access link of the survey, it cannot be stated what are the answer rates. The survey is expected to give general guidelines and allow discussions with researchers and regional authorities on what are the opinions, possibilities and restrictions of organizing an environmental monitoring program on rivers and streams as citizen activities. The general conclusions can be found at the end of the analysis paper.

General information and characterization of respondents of the questionnaire

The survey had a total of 445 respondents, of which 272 (61.1 %) were female and 173 (38.9 %) male respondents (see Figure 1). Figure 2 shows the distribution of age groups of respondents.

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Nearly half, 203 respondents, (45.6 %) were 17-30 years old. The second most common age group was 31-45 years old, followed by 46-60 years old. As one of the main channels of distributing the survey has been via educational centres with students in environmental fields, it is not surprising that the main respondent group were 17-30 years old.

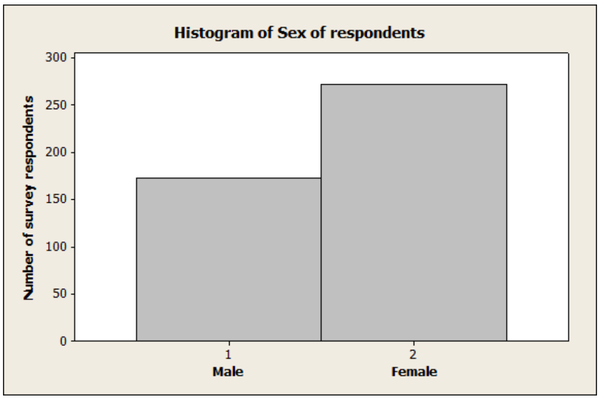

Figure 1: Histogram of Sex of respondents

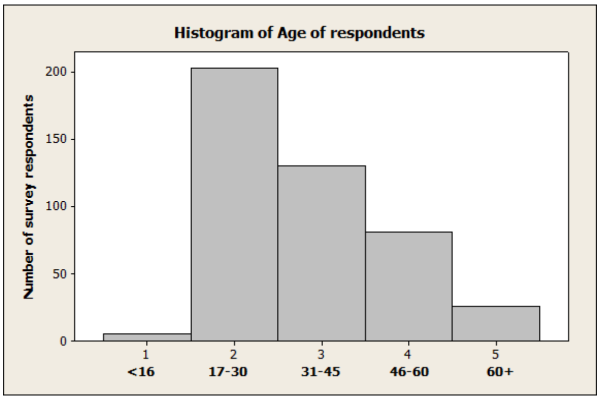

Figure 2: Histogram of Age of respondents

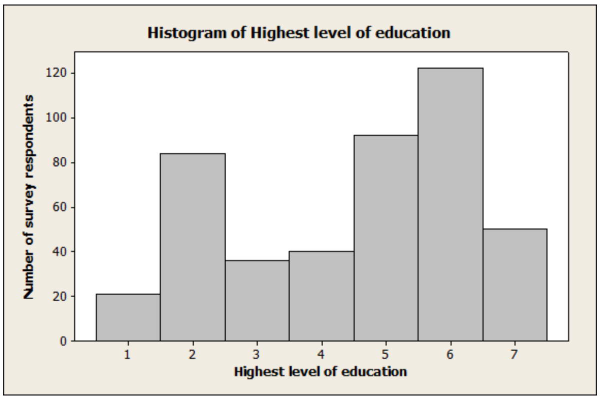

Figure 3: Histogram of levels of education

1: Basic education
2: Lower secondary vocational qualification (e.g. Vocational or trade school)
3: The upper secondary vocational qualification (e.g. Medical or business school, Institute of Technology)
4: University of Applied Sciences (e.g. Bachelor of Business Administration, Engineering)
5: Bachelor's degree
6: Master's degree
7: Post-graduate education (Lic., Dr.)

The highest level of education amongst survey respondents is shown in Figure 3. The most common education background amongst survey respondents was Master's degree with 122 respondents (27.4 %), whereas Bachelor's degree and Lower secondary education were more common than the rest. Generally, more than half of survey respondents have a university-based degree. Considering the before mentioned distribution channels, this is not surprising.

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Question-specific interpretation of survey results

Next in this analysis the questions asked from survey respondents are being separated by respondents' age, sex and education level. For the age group "under 16 years old" (<16) proper analysis couldn't be conducted due to the low sample size. In some cases this analysis also considers the respondent groups by education levels, e.g. respondents that have at least Bachelor's degree, and respondents who do not have an academic degree. Also, if relevant, this analysis points out specific age (e.g. 17-30 years old) and education level (e.g. Master's degree) groups to determine applicable trends in the survey responses.

Question 8: Would you be willing to install a small water quality monitoring device (max size a cigarette box) in a river or stream (if you had access)?

The question was answered by 438 (98.4 %) respondents whereas 7 (1.6 %) did not, which can be considered as excellent percentage to form a comparison. The question was answered with 'Yes' by 393 (89.7 %) and with 'No' by 45 (10.3 %) of all respondents.

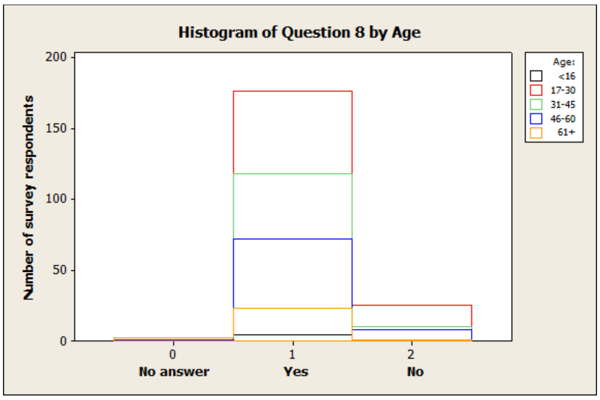

Figure 4: Histogram of Question 8 by Age

Figure 4 shows that respondents from all age groups answered relatively evenly either 'Yes' or 'No' to the question. Respondents from each age group answered to the question similarly. Relatively most often 'Yes' was answered by respondents in age group 31-45 years old.

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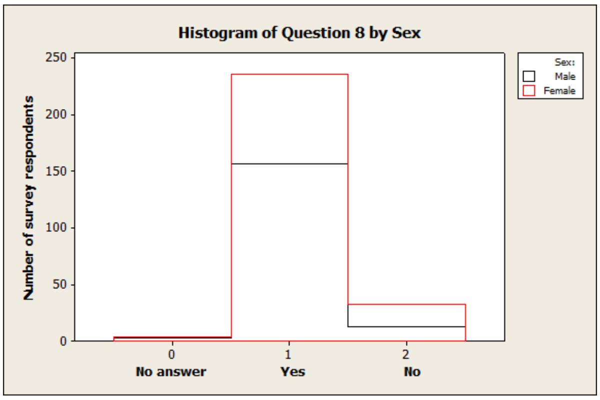

Figure 5: Histogram of Question 8 by Sex

Figure 5 shows that of the active respondents 268 were females and 170 were males. Of the female respondents 236 (88.1 %) and of male respondents 157 (92.3 %) answered 'Yes' to the question. Proportionally, males were slightly more willing to install a small water quality monitoring device in a nearby river or stream if they had access.

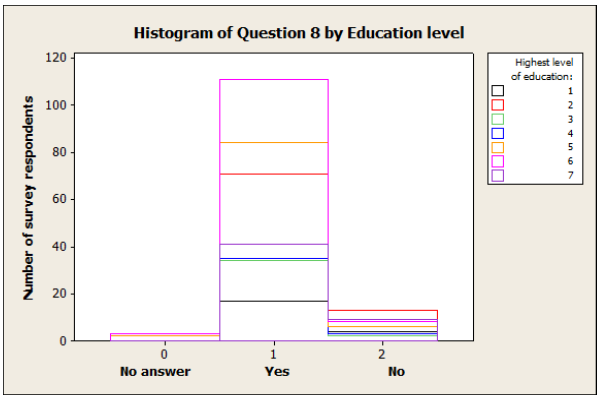

Figure 6: Histogram of Question 8 by Education level

Figure 6 shows the turnout of Question 8 by education level of respondents (the numbers are explained above in this document). Generally, the higher the level of education, the greater the likelihood to answer 'Yes' to the question becomes. For example, 111 out of 119 (93.3 %) respondents with a Master's degree were interested in installing a small water quality monitoring device. In turn, the lower the level of education, the greater the likelihood to answer 'No' to the question becomes. For example, 71 out of 84 (84.5 %) of the respondents with a Lower secondary degree were willing to install a small water quality monitoring device, i.e. every sixth respondent with such degree is not interested in such activity.

In conclusion, people are very willing to install a small water quality monitoring device in a river or stream nearby. People in the age group 31-45 years old were relatively most interested, which could mean that with age comes concern of the environment. Furthermore, education level seems to have an effect; people with Bachelor's degree or higher were more willing to install a small water quality monitoring device in a river or stream nearby.

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Question 12: Would you be willing to maintain a small water quality monitoring device?

The question was answered by 425 (95.5 %) respondents whereas 20 (4.5 %) did not, which can be considered as excellent percentage to form a comparison. The question was answered 'Yes' by 358 (84.2 %) and 'No' by 67 (15.8 %) of all respondents.

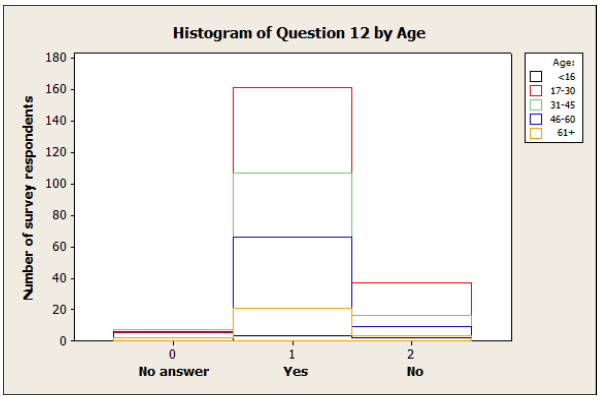

Figure 7: Histogram of Question 12 by Age

Figure 7 shows that respondents from all age groups answered relatively evenly either 'Yes' or 'No' to the question. Most respondents answering 'Yes' to the question were either in the age groups of 31-45 or 17-30 years old.

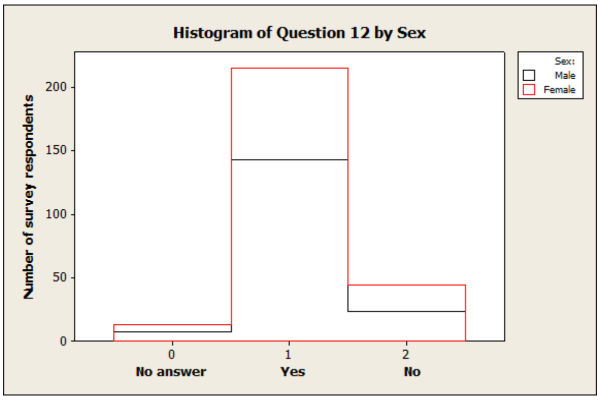

Figure 8: Histogram of Question 12 by Sex

Figure 8 shows that of the active respondents 259 were females and 166 were males. Of the female respondents 215 (83.0 %) and of male respondents 143 (86.1 %) answered 'Yes' to the question. Proportionally, males were slightly more willing to maintain a small water quality monitoring device.

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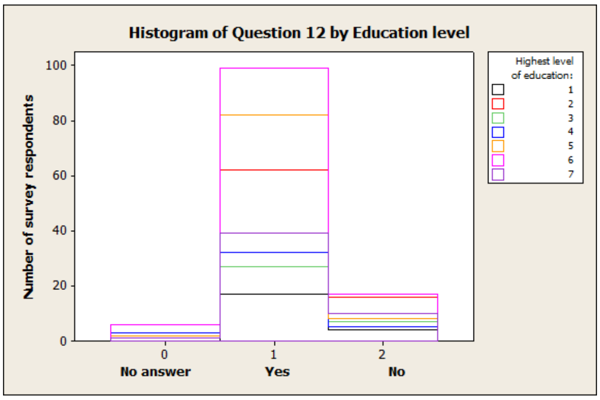

Figure 9: Histogram of Question 12 by Education level

Figure 9 shows the turnout of Question 12 by education level of respondents (the numbers are explained above in this document). Generally, the higher level of education, the greater the likelihood to answer 'Yes' to the question. For example, 99 out of 116 (84.6 %) respondents with Master's degree were interested in maintaining a water quality monitoring device. In turn, the lower level of education, the greater the likelihood to answer 'No' to the question. For example, 62 out of 78 (79.5 %) of the respondents with Lower secondary degree were interested in the maintaining process, i.e. every fifth respondent with such degree was not interested in such activity.

In conclusion, survey respondents generally from all age groups are willing to maintain a small water quality monitoring device. This could mean that people are interested in the condition of their environment, and that they are willing to participate in preserving the quality of it. However, when compared to e.g. Question 8, people generally are less willing to maintain a device but more willing to install one. This could be interpreted in such a way that people are interested in participating in the process but do not want it to be a regular burden in their everyday lives.

Question 14: If possible, would you like to have updates on your phone/tablet computer/e-mail on the current situation and environmental condition of a stream or a river of your choice?

The question was answered by 422 (94.8 %) respondents whereas 23 (5.2 %) did not, which can be considered as excellent percentage to form a comparison. The question was answered 'Yes' by 371 (87.9 %) and 'No' by 51 (12.1 %) of all respondents.

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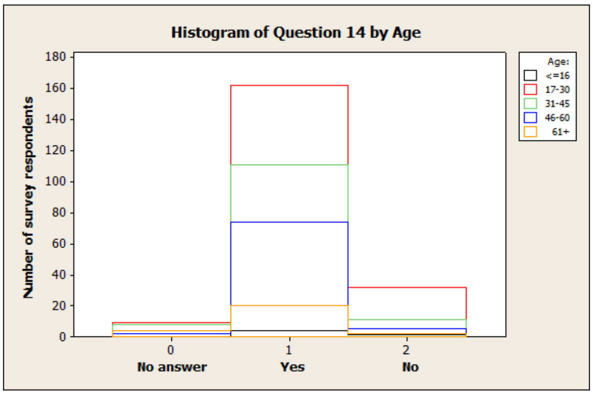

Figure 10: Histogram of Question 14 by Age

Figure 10 shows that respondents from all age groups answered relatively evenly either 'Yes' or 'No' to the question. Relatively, by far most respondents answering 'No' were 17-30 years old. Comparing the volume of age groups, answering 'Yes' was relatively equal amongst other age groups.

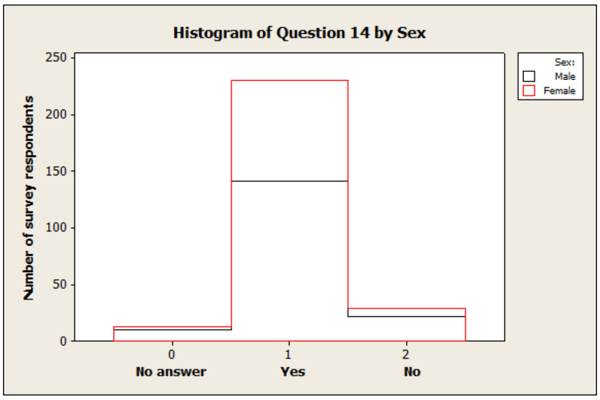

Figure 11: Histogram of Question 14 by Sex

Figure 11 shows that of the active respondents 259 were females and 163 were males. Of the female respondents 230 (88.8 %) and of male respondents 141 (86.5 %) answered 'Yes' to the question. Proportionally, females were slightly more willing to have updates on the environmental condition of the local stream or river to some of their electrical device.

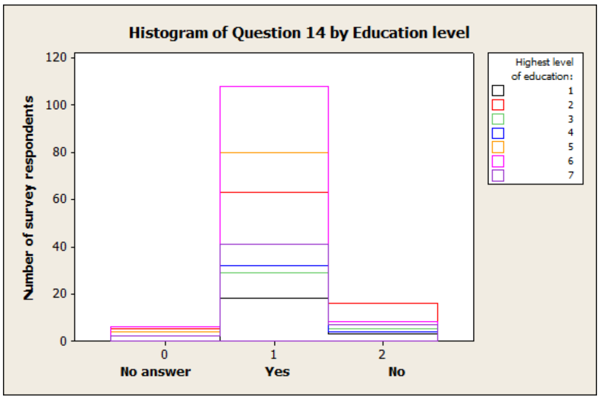

Figure 12: Histogram of Question 14 by Education level

Figure 12 shows the turnout of Question 14 by education level of respondents (the numbers are explained above in this document). Generally, the higher level of education, the greater the likelihood to answer 'Yes' to the question. For example, 108 out of 122 (88.5 %) respondents with Master's degree were interested in receiving information. In turn, the lower level of education, the greater the likelihood to answer 'No' to the question.

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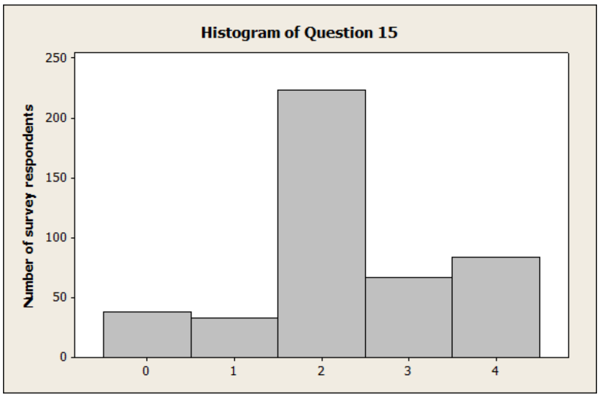
For example, 68 out of 84 (80.1 %) of the respondents with Lower secondary degree were interested in receiving information, i.e. nearly every fifth respondent with such degree is not interested in the information.

In conclusion, survey respondents generally from all age groups are willing to receive information of their local streams or rivers to their selected electronic device. This could mean that people are interested in the condition of their environment, and that they are willing to participate in preserving the quality of it.

Question 15: Which of these would be the most preferred way of information updates? (If 'Yes' to Question 14)

The question was answered with 407 respondents (whereas 38 did not), which includes answers from 36 respondents that did not answer 'Yes' to Question 14 (which was answered 'Yes' with 371 respondents). This analysis does not exclude these conflicting answers but includes them. In addition, respondents answering this question may have also answered to the open section of this question. Open answers will not be discussed in this analysis due to the wide array of the responses and due to the open answers similarity to the list of selectable answers.



0: No answer
1: Text messages
2: E-mails
3: Live updates on a smartphone or tablet computer app
4: Website to check the situation
Open answers are not listed in the histogram and not taken account in this analysis.

Figure 13: Histogram of Question 15

Figure 13 shows the distribution on how respondents prefer to receive information updates. By far the most preferred way (223 respondents) of receiving information updates was via e-mails, which is approximately 2,5 times the quantity compared to the next preferred way (Website to check the situation, 84 respondents).

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The prevailing way of receiving information is rather unexpected since e-mail is generally considered as a traditional text-based form of communication. Websites (4:) and applications (3:) are both easily accessible and can easily provide graphical analyses.

Question 16: Would you be willing to let your smartphone/tablet/home computer to analyse some of the data produced by such a device?

The question was answered by 423 (95.1 %) respondents whereas 22 (4.9 %) did not, which can be considered as excellent percentage to form a comparison. The question was answered 'Yes' by 248 (58.7 %) and 'No' by 31 (7.3 %) of all respondents. Question was answered 'I don't know' by 144 (34.0 %) respondents, which is relatively much.

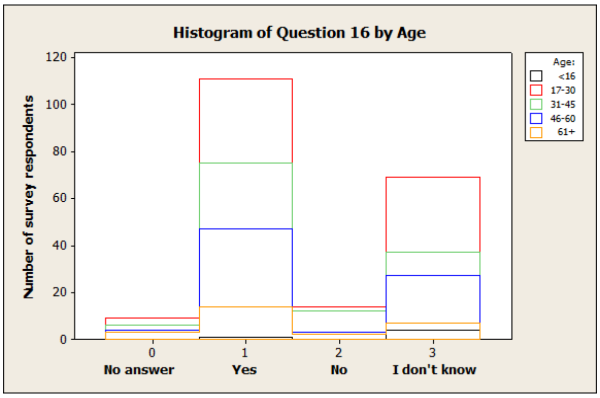

Figure 14: Histogram of Question 16 by Age

Figure 14 shows that respondents from all age groups answered relatively evenly either 'Yes' or 'No' to the question. Comparing the volume of age groups, answering 'Yes' was relatively equal amongst all age groups. Relatively most respondents answering 'I don't know' were 17-30 years old – almost half of the respondents of the age group answered this way.

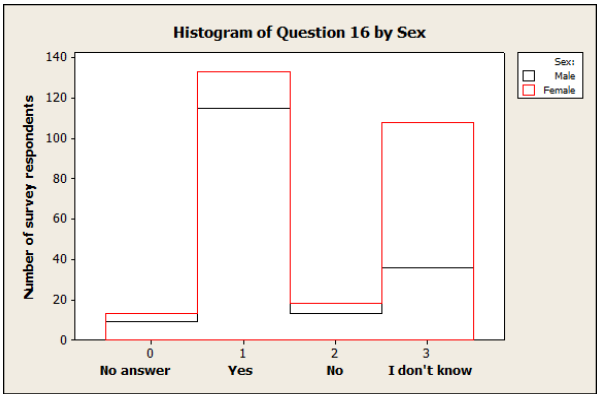

Figure 15: Histogram of Question 16 by Sex

Figure 15 shows that of the active respondents 259 were females and 164 were males. Of the female respondents 133 (51.4 %) and of male respondents 115 (70.1 %) answered 'Yes' to the question. Proportionally, males were clearly more willing to let their smartphone, tablet or home computer to analyse some of the data produced by such a device. The answer 'I don't know' was clearly

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selected more frequently by females (118 of active respondents, 27.9 %) than males (36 respondents, 8.5 %).

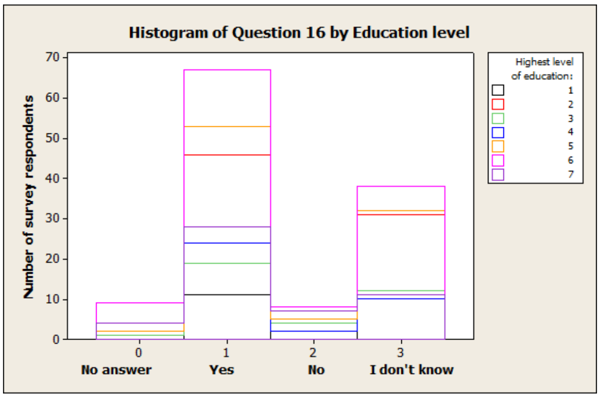

Figure 16: Histogram of Question 16 by Education level

Figure 16 shows the turnout of Question 16 by education level of respondents (the numbers are explained above in this document). Generally, the higher level of education, the greater the likelihood to answer 'Yes' to the question. Level-specific analysis is not conducted regarding this question, but the trend is same as e.g. in Questions 12 and 14.

In conclusion, most respondents are willing to let their smartphone, tablet or home computer to analyse some of the data produced by such a device. Interpreting the total number of respondents answering 'I don't know', the question itself may have been unclear, i.e. respondents had no clear conception what the analysing means in practice. There may be suspicions considering e.g. privacy issues. After all, the question itself can be considered as the most invasive to people's personal protection.

Question 17: What kind of compensation would you seek in return of such activities as installing, maintaining and storing a small water quality monitoring device? (Multiple answers)

As this question had multiple answers (and not clear 'Yes' or 'No'), this analysis considers only the answers itself and does not categorise the respondents by age, sex or education level. Also, this analysis does not identify respondents who skipped this question without answering.

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BALTIC FLOWS

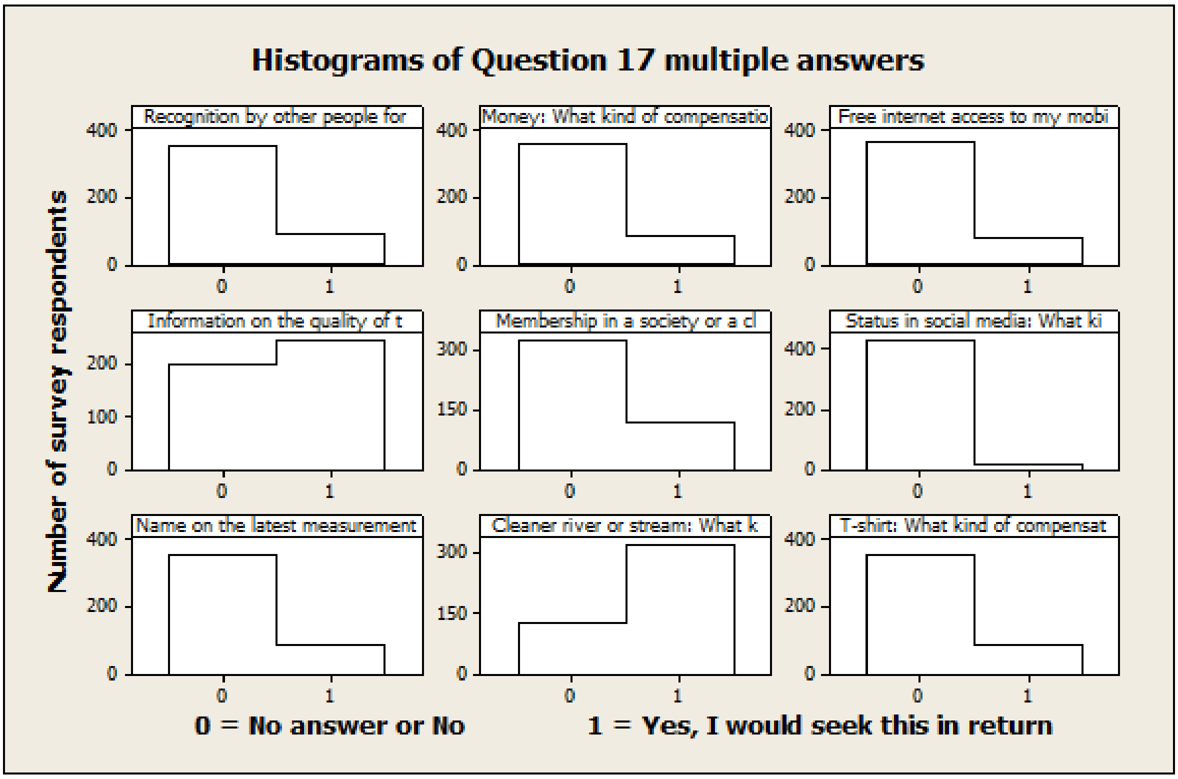

Figure 17: Histograms of multiple answers to Question 17

Figure 17 shows the multiple answers as follows from top left to right by each row:

- Recognition by other people for the important environmental work
- Money
- Free internet access to my mobile device
- Information on the quality of the water
- Membership in a society or a club related to environmental issues
- Status in social media
- Name on the latest measurement data
- Cleaner river or stream
- T- shirt

From the multiple answers, respondents answered most ‘Yes’ (meaning they would seek this in return) to ‘Cleaner river or stream’ with nearly 320 respondents, which is over 70 % of all survey respondents. Also, respondents seek in return the information on the quality of the water with nearly 250 respondents. All other benefits were generally seen as less interesting. However, this analysis cannot determine whether nearly 150 respondents did not simply answer to the category ‘Cleaner river or stream’ or whether they did not consider such activities as relevant.

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Conclusion

Based on the survey, it looks promising that if people are offered the chance and asked to locally participate in the monitoring process, they will most likely be interested in such activities. The survey results imply, that in general, the wellbeing of the local rivers and streams are of interest to the respondents, and that this fitted group seems willing to volunteer for improving the environmental situation. In return, most respondents would like to receive information and assurance that their activities are valuable and that the situation is improving.

There is some evidence that information and updates of the environmental situation are more important to those with higher educational background, but it is too far-fetched to make such propositions based on the settings of this survey. The potential of smart phones and electrical hand held devices are not yet widely seen as an interesting information channel, and it seems that the more traditional type of information channels, such as e-mails and websites serving the citizens at the time they choose, are preferred.

Data privacy issues may rise to be a central issue in activities such as environmental monitoring, but based on this survey it is too early to tell whether the general public is aware and concerned about their personal privacy related to the use of their own hand held devices. Privacy is seen as an important issue for the researchers and data utilisers to be payed attention to once the setting up an environmental monitoring programme utilising the volunteer's personal devices would be launched.

To make the environmental monitoring programme viable, it is seen important to realise the amount of maintenance the programme and devices need. However, a modern day volunteer is not necessarily willing to donate a fixed amount of time on a regular basis. Therefore, it would be ideal if the timetables and demands of the monitoring programme can be influenced and attended when it is most suitable for the volunteer her- or himself. In total, based on this analysis, by giving citizens a chance to involve in the monitoring process and providing them easy-to-use devices and platforms, they will provide a new dimension to water quality measuring and information sharing for researchers to further analyse and citizens to be more aware of the state of their nearby rivers and streams.

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Annex 2. Analysis of Citizen Survey 2

In the BalticFlows project, the consortium conducted a survey as part of the Work Package 4, "Water Monitoring via Citizen Activity", to people of various ages and educational backgrounds amongst active users of social media regarding whether sensor technology is seen as a useful means of creating self-published content, or whether manual creation is more preferable.

The questionnaire was conducted from 2.3.2015 to 2.4.2015. The consortium contacted different types of student groups and environmental organisations, as they were seen as natural dissemination channels for the survey to reach wide audiences. The survey was distributed as an open link in the local languages of the project (German, Finnish, Swedish, Latvian, Estonian) and also in English. The open link was selected instead of individual survey links to identifiable individuals, as the consortium decided to keep the public participation to a maximum level, allowing the project to reach a wider array of people. Local partners from each participating region were responsible to contact and distribute the survey to similar student and environmental groups. The groups were compared and analysed to be similar in nature to the other participating regions. The environmental organisations and educational centres with students in environmental fields were contacted and a permission to send the survey link to their e-mail lists were acquired before the survey link opened, so that the survey could be launched simultaneously in different participating regions. Most of the survey links were distributed on the e-mail lists on the 2nd of March by the student group lecturer or other staff member of the educational facility or environmental organisation themselves. The organisations were asked to remind the respondents 1-4 times during the month to answer the survey.

As the survey was conducted via an open link, it is possible that the respondents have shared the survey forward to their friends or family members. Some respondent groups decided to share the link on the social media or website of the organisation, even if the original method of contact was via e-mail. The link to the English survey was also provided in the Facebook page of BalticFlows project.

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First this analysis characterizes the respondents by age, sex and educational background. Following the characterization, we focus on certain questions asked in the survey, mostly in 'Yes' or 'No' format. In certain cases it is necessary to determine how males and females, different age groups and respondents with various educational backgrounds use social media and how many services are they registered in. Furthermore, this analysis pursues to determine the willingness of respondents to utilize various social media services in order to share and disseminate the environmental monitoring data.

Important! This analysis is based on the information that participants have filled out themselves without any supervision. Due to the non-representativeness and the sampling methods of this survey, it is not possible to state whether people would or would not be interested in utilizing social media services to share information about the condition of their local streams and rivers. The analysis does give an indication of the interest towards sharing environmental data on social media, serves as a description of the survey results, and describes the interpreted utterance of female and male survey respondents of various age groups and educational backgrounds.

General interpretation of results

In the next sections the results are introduced one question or question group at a time. The questions raised to the focus point are seen as the most relevant ones, from the basics of the social media usage to determining whether respondents would share environmental information and create content on social media services. As the survey is executed via an open link meaning an open access to the survey to anyone with the web access link of the survey, it cannot be stated what are the answer rates. The survey is expected to give general guidelines and allow discussions with researchers and regional authorities on what are the opinions, possibilities and restrictions of organizing an environmental monitoring program on rivers and streams as citizen activities. The general conclusions can be found at the end of the analysis paper.

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General information and characterization about the respondents to the questionnaire

The survey had a total of 368 respondents, of which 256 (69.6 %) were female and 112 (30.4 %) male respondents (see Figure 1). It is noteworthy that females represent a clear majority amongst the survey respondents. As one of the main channels of distributing the survey has been via educational centres with students in environmental fields, it is not surprising that the main respondent group were 17-30 years old.

Figure 2 shows the distribution of age groups of respondents. Over half (211, 57.3 %) of the respondents were 17-30 years old. The second most common age group was 31-45 years old, followed by 46-60 years old.

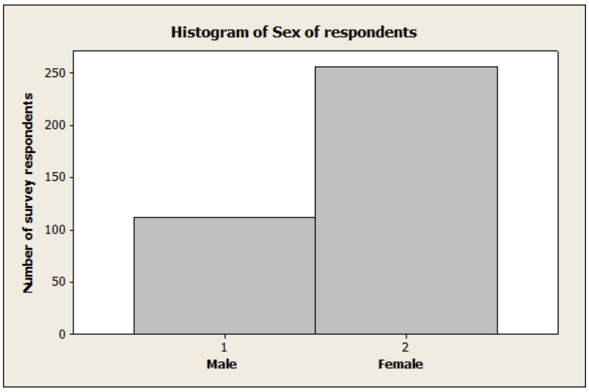

Figure 1: Histogram of Sex of respondents

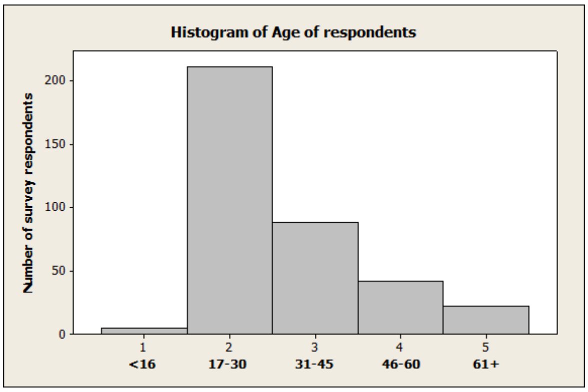

Figure 2: Histogram of Age of respondents

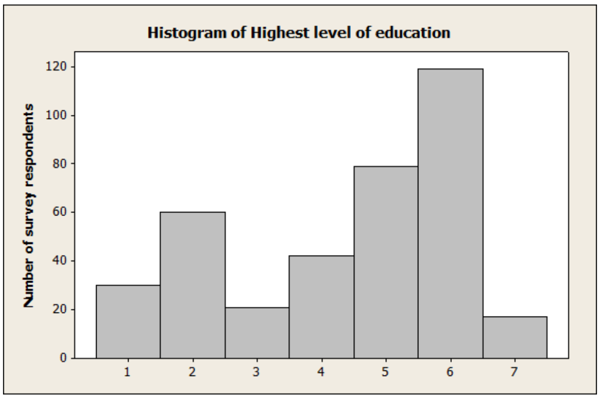

Figure 3: Histogram of levels of education

1: Basic education
2: Lower secondary vocational qualification (e.g. Vocational or trade school)
3: The upper secondary vocational qualification (e.g. Medical or business school, Institute of Technology)
4: University of Applied Sciences (e.g. Bachelor of Business Administration, Engineering)
5: Bachelor's degree
6: Master's degree
7: Post-graduate education (Lic., Dr.)

The highest level of education amongst survey respondents is shown in Figure 3. Most common education background amongst survey respondents was Master's degree with 119 respondents

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(32.3 %), whereas Bachelor's degree and Lower secondary education were slightly more common than the rest. Generally, more than half of survey respondents have a university-level degree. Considering the before mentioned distribution channels, this is not surprising.

Question-specific interpretation of survey results

Next in this analysis the questions asked from survey respondents are being differentiated by respondents' age, sex and education level. For the age group "under 16 years old" (<16) proper analysis couldn't be conducted due to the low sample size. In some cases this analysis also looks at the responses by education levels, e.g. respondents that have at least Bachelor's degree, and respondents who do not have an academic degree. Also, if relevant, this analysis points out specific age (e.g. 17-30 years old) and education level (e.g. Master's degree) groups to determine applicable trends in the survey responses.

Question 158: In which of the following services do you have an account at? (Multiple choices)

In this question respondents were asked of their usage of various social media services. The services asked were:

- Q158:1 Facebook
- Q158:2 Twitter
- Q158:3 Youtube
- Q158:4 Instagram
- Q158:5 LinkedIn
- Q158:6 Google+
- Q158:7 Wikipedia
- Q158:8 Pinterest
- Q158:12 I don't use any

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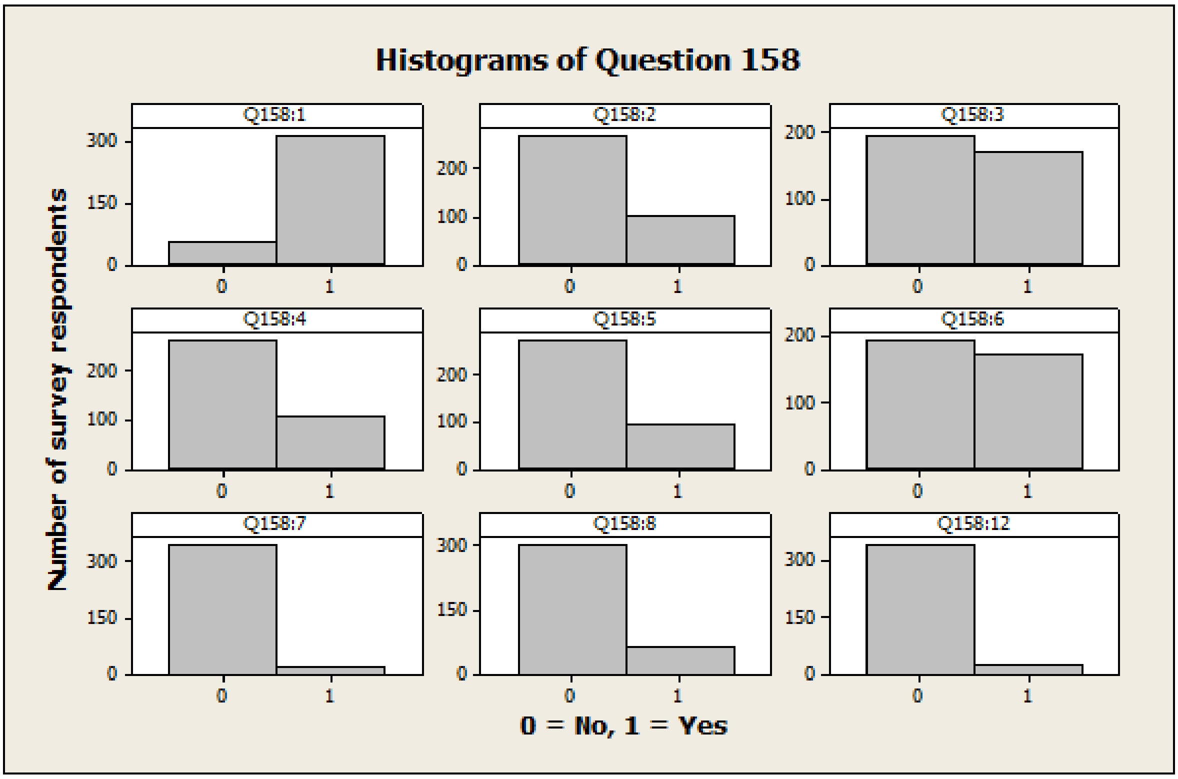

Figure 4: Histograms of multiple answers to Question 158

Figure 4 shows that from the multiple answers, respondents answered mostly ‘Yes’ to ‘Facebook with 315 respondents, which is over 85 % of all survey respondents. It was also the only choice that was answered more frequently with ‘Yes’ than ‘No’. Next popular choices, ‘Google+’ and ‘Youtube’, each had over 170 positive answers. Choice ‘I don’t use any’ was selected by less than 30 survey respondents.

Questions 159-169: How often do you usually use [social media chosen from Q158]?

Based on the previous Question 158, respondents’ most popular answers are considered more deeply. Next, this analysis focuses on the respondents’ usage of Facebook, Youtube and Google+.

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The multiple choices were as follows:

1. Multiple times a day
2. Once a day
3. A few times a week
4. A few times a month
5. Less frequently than once a month
6. I don’t use it

Question 159: How often do you usually use Facebook?

The question was answered by 315 (85.6 %) respondents which makes Facebook by far the most popular social network site in this questionnaire.

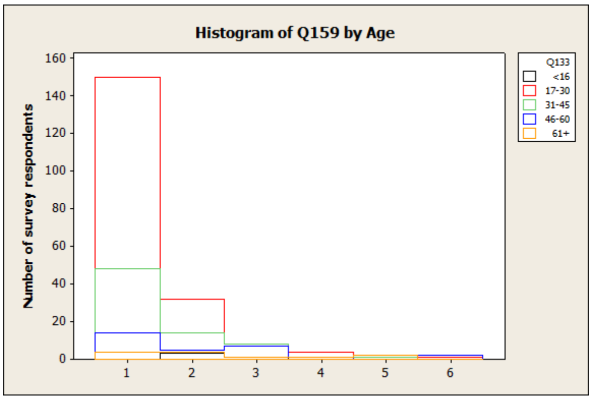

Figure 5: Histogram of Question 159 by Age

Figure 5 shows that the active answers respondents from various age groups answered differently to the question. The everyday usage of Facebook is clearly most popular in the age group 17-30 years old. General trend is that the older the respondents are, the less they use Facebook.

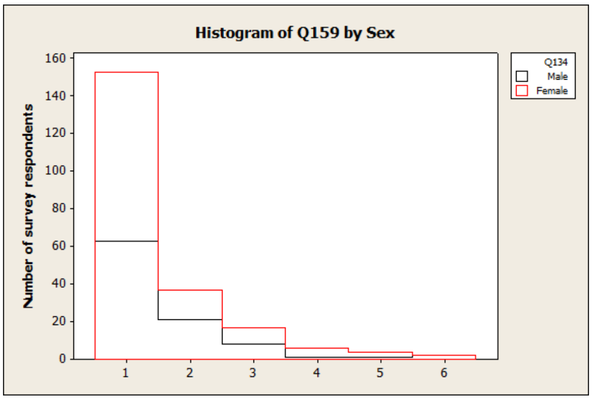

Figure 6: Histogram of Question 159 by Sex

Figure 6 shows that of the active respondents, females and males answered this question similarly. Of all respondents, over half of both female and male respondents use Facebook multiple times every day.

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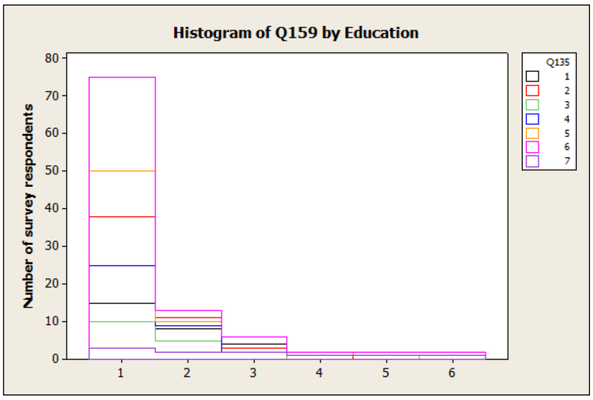

Figure 7: Histogram of Question 159 by Education level

Figure 7 shows the usage of Facebook by education level. There are no significant differences amongst various groups; a clear majority of respondents in every education group uses Facebook at least daily or multiple times a day.

In conclusion, of all respondents 216 (58.7 %) use Facebook every day multiple times, and total of 274 (74.5 %) of all respondents use it every day. This makes it a very popular social media service, which is of general knowledge today.

Question 161: How often do you usually use Youtube?

The question was answered by 172 (46.7 %) respondents. In the comparison between social media services, Youtube is the third most popular service in the questionnaire.

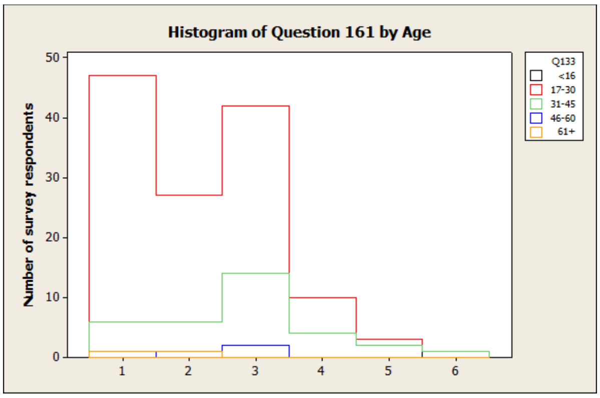

Figure 8: Histogram of Question 161 by Age

Figure 8 shows that the respondents from various age groups answered differently to the question. The everyday usage of Youtube is not nearly as popular as it is with Facebook. The dominant trend is that Youtube is used at least once, often few times a week.

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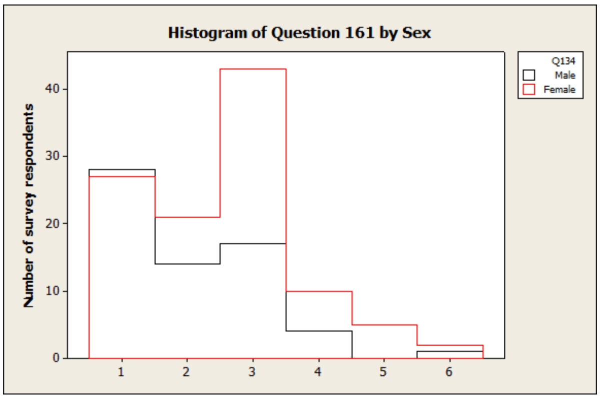

Figure 9: Histogram of Question 161 by Sex

Figure 9 shows that of the respondents, females and males answered this question differently. Males, despite them being a clear minority in this questionnaire, use Youtube more daily than females who clearly use the service few times a week.

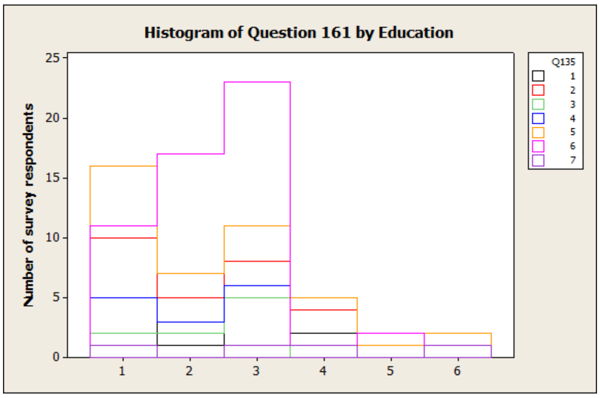

Figure 10: Histogram of Question 161 by Education level

Figure 10 shows the usage of Youtube by education level. There are no significant differences amongst various groups except one; compared to other education level groups, people with Bachelor's degree use Youtube several times a day and therefore more often than others. However, the sample size per group is too small to make a clear statement.

In conclusion, based on the analysis above, Youtube is generally used a few times a week or at least on a weekly basis. Compared to Facebook, the nature of Youtube is quite different the former being often used for daily communication, while the latter is more a service for media distribution. There are some differences in the usage between sex, age groups and education level, the clearest observation being that younger people use Youtube more frequently.

Question 164: How often do you usually use Google+?

The question was answered by 174 (47.3 %) respondents. In the comparison between social media services, Google+ is the second most popular service in the questionnaire.

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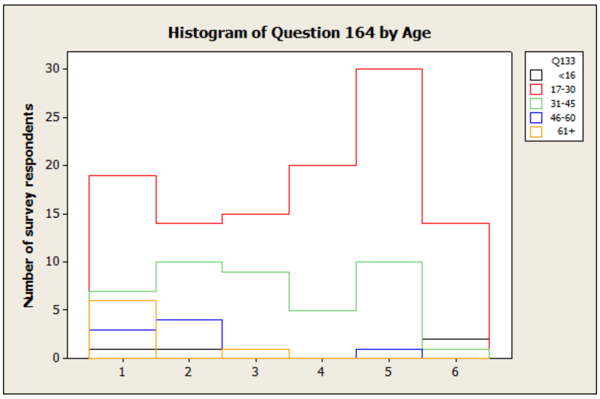

Figure 11: Histogram of Question 164 by Age

Figure 11 shows that the active answers respondents from various age groups answered similarly to the question. The sample size is insufficient in some cases to make a comparison between the age groups but the general trend is noticeable.

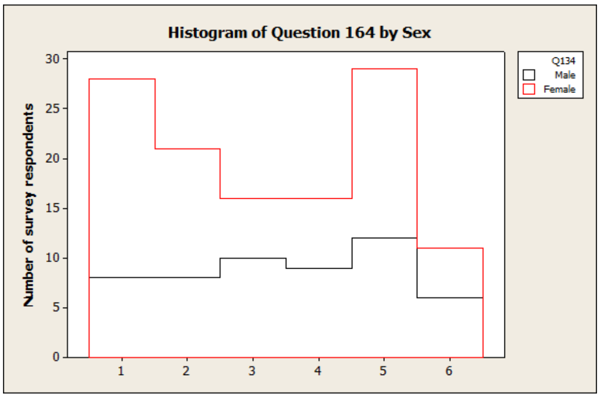

Figure 12: Histogram of Question 164 by Sex

Figure 12 shows that of the active respondents, females and males answered this question similarly. Males and females seem to use Google+ quite similarly.

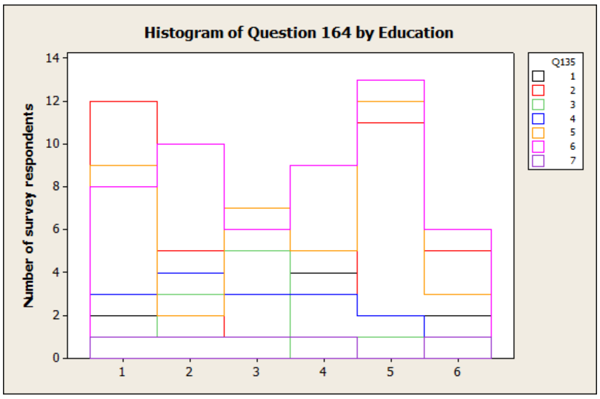

Figure 13: Histogram of Question 164 by Education level

Figure 13 shows the usage of Google+ by education level. There are no significant differences amongst various education levels. Also, the number of survey respondents per education level group per answer is rather small to draw conclusions of any anomaly.

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Based on the analysis of this survey, Google+ cannot be considered as a service to be used every day. Google+ is virtually similar to Facebook, but clearly not as frequently used. Survey respondents who have an account seem to use it much less frequently than Facebook, for example to do a monthly check-in.

Question 170: What type of information do you share on social media? (Multiple answers)

The question was answered by 343 (93.2 %) respondents whereas 25 (6.8 %) did not, which can be considered an excellent percentage to form a comparison. As this question had multiple answers (and not clear 'Yes' or 'No'), this analysis considers only the answers itself and does not categorise the respondents by age, sex or education level.

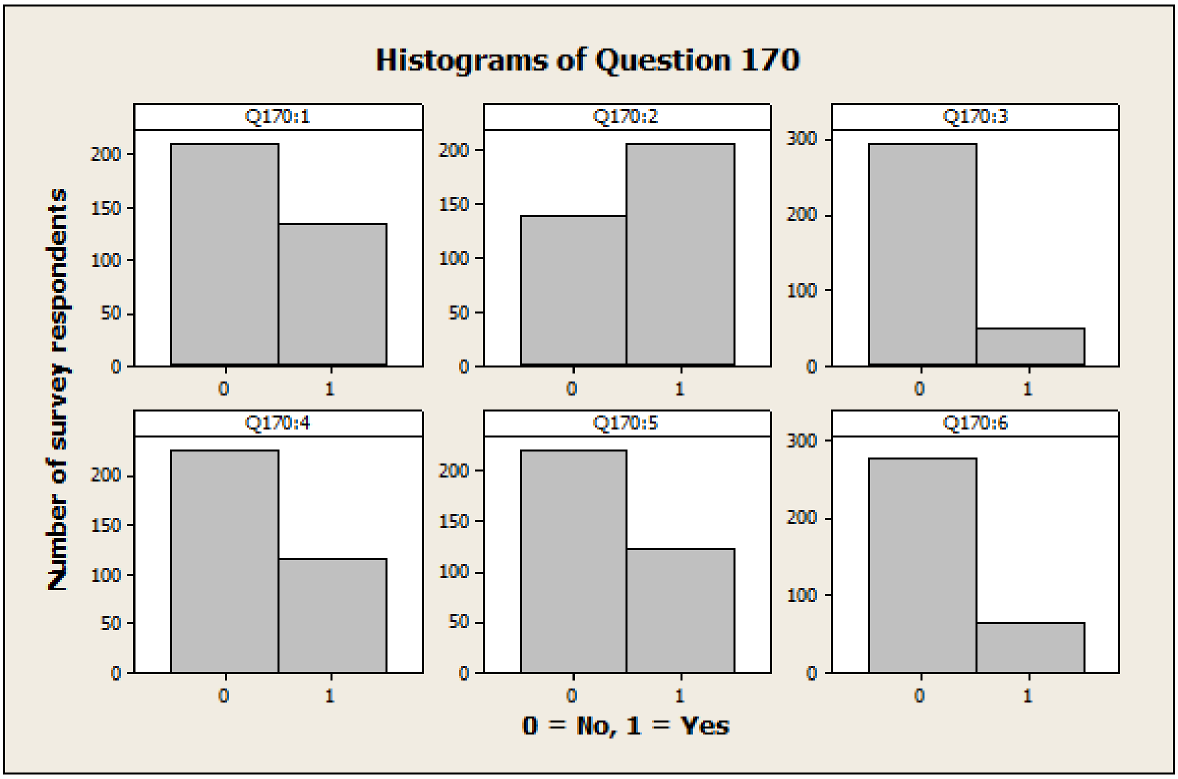

Figure 14: Histograms of multiple answers to Question 170

Figure 14 shows the multiple answers as follows from top left to right by each row:

- Q170:1 Acknowledgements
- Q170:2 Informing

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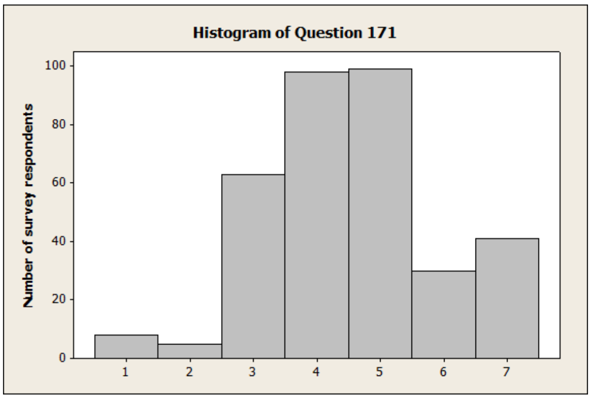
- Q170:3 Critique
- Q170:4 Mobilization
- Q170:5 Personal
- Q170:6 I don’t share information on social media

From the multiple answers, respondents answered mostly ‘Yes’ to ‘Informing’ with over 200 respondents, which is over 50 % of all survey respondents. It was the only answer that was answered with ‘Yes’ more often than with ‘No’. Choices ‘Acknowledgements’, ‘Personal’ and ‘Mobilization’ had over 100 positive answers each. Choices ‘Critique’ was clearly answered ‘No’ most often with nearly 300 respondents. Choice ‘I don’t share information on social media’ was answered ‘Yes’ by 66 (19.2 %) respondents which would mean that four out of five active respondents would share information in the social media at some level.

Question 171: How often do you create content on social media by writing, taking pictures or videos?

The question was answered by 344 respondents (93.5 %, whereas 24 did not), which can be considered an excellent percentage to form a comparison.



1: Multiple times a day
2: Once a day
3: A few times a week
4: A few times a month
5: Less frequently than once a month
6: I don’t create content myself; I only share ready made content
7: I don’t create content; I only see what others have shared and created

Figure 15: Histogram of Question 171

Figure 15 shows the distribution of how respondents create content in social media. Approximately 4 out of 5 respondents create content altogether. Clearly over half of the respondents create content on a monthly or weekly basis. Very active content creating (at least once a day) was clearly less frequent than not creating content at all. It is noteworthy that not creating own

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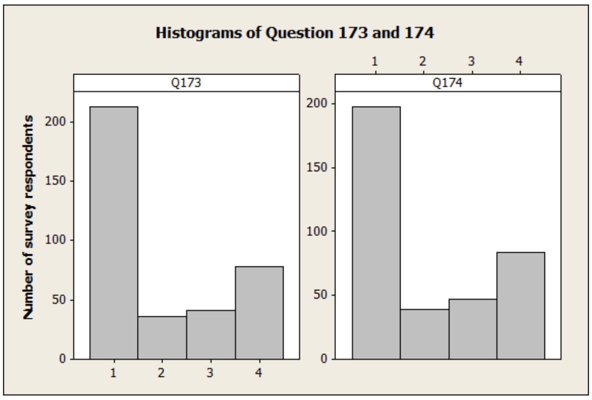
content does not mean that one does not utilize social media by e.g. making comments or statements to content created by others.

Questions 173 and 174: Let's take a moment and imagine that a water monitoring kit, connected to a mobile phone, laptop or computer would exist and collect environmental-related water data from rivers and streams. Would you be interested in collecting such data (173)? Would you be interested in sharing such data (174)?

Questions 173 and 174 were answered by all 368 respondents. This can be stated to be a very prominent question and yet easy to answer. The analysis of this question will also consider the open answers to 'Yes' regarding both questions.



1: Yes
2: Yes, on a condition that [open answer]
3: No
4: I don't know

Figure 16: Histograms of Question 173 and 174

Figure 16 shows that visually both questions were answered very similarly as clearly over 50 % of the respondents answered 'Yes' to both questions. However, some respondents answered 'Yes' on their selected condition. Total number of respondents answering 'Yes' (with or without condition) to Question 173 was 250, and respectively to Question 174 it was 238. Respondents answering 'No' were a clear minority considering both questions. Option 'I don't know' was answered roughly every fifth respondent. Regarding Question 173, the most common condition was that the application has to be very easy to use and not require unnecessary effort. Also, regarding Question 174, the sharing of information should be as easy as possible.

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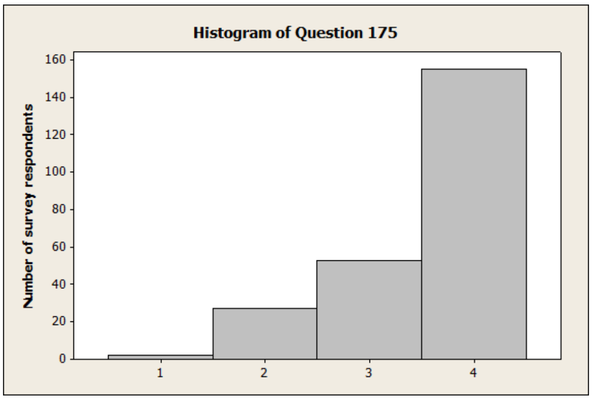
In conclusion, respondents were eager to both collect and share environmental data with their own devices. The answer 'I don't know' should require further research to determine details and causes for the answer.

Question 175: To whom would you allow access to the measurement data?

Questions 175 answered by 237 (64.4 %) respondents. The nature of the question is such that, in principle, active respondents should have answered 'Yes' to both previous Questions 173 and 174. As Question 173 was answered 'Yes' with 250 and Question 174 with 238 respondents, the number of active respondents of this question is in excellent line with previous questions.



1: Only you would see your own measurement
2: Only you and the researchers will see the monitoring results
3: Access restricted to researchers and other monitoring data collectors
4: Open access to data

Figure 17: Histogram of Question 175

Figure 17 shows that a fair majority (155, 65.4 %) of the respondents was willing to set open access to the measurement data they have collected. Also, nearly all other respondents with a more strict opinion to the access of their measurement results are willing to let the data to be accessed by researchers.

Question 177: If the environmental monitoring data would be possible to share via social media, how would you choose to share it?

The question was answered by 237 (64.4 %) respondents whereas 131 (35.6 %) did not. The nature of the question is such that, in principle, active respondents should have answered 'Yes' to previous Questions 173 and 174. Therefore, the number of active respondents of this question is in excellent line with previous questions.

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The question had multiple choices (no clear ‘Yes’ or ‘No’). This analysis considers only the answers itself and does not categorise the respondents by age, sex or education level in more detail.

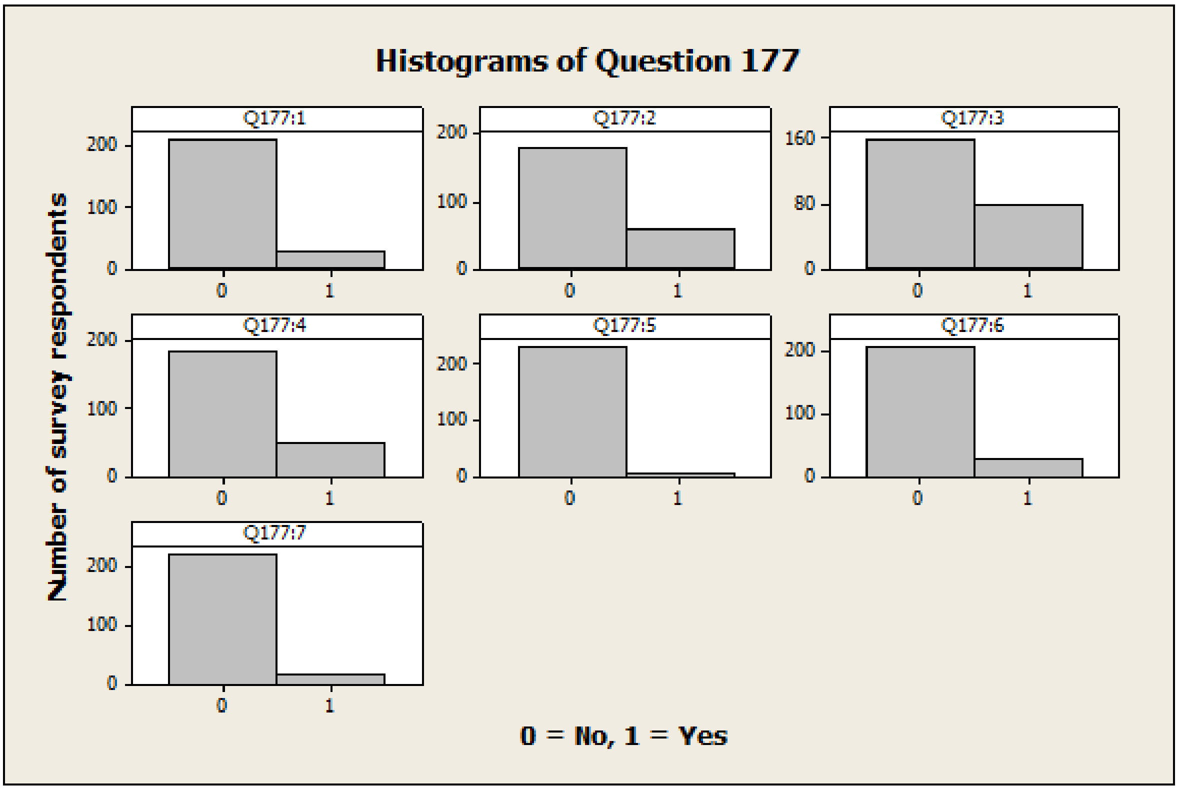

Figure 18: Histograms of multiple answers to Question 177

Figure 18 shows the multiple answers as follows from top left to right by each row:

- Q177:1 Real-time results alongside your account information, such as which school did you take or where do you work
- Q177:2 Automatically on pre-selected intervals, turn publishing content on or off
- Q177:3 Semi-automatic update: click yes to publish the latest results
- Q177:4 Manually typing or sharing any content created by myself
- Q177:5 Other (not considered in this analysis)
- Q177:6 I wouldn’t share monitoring data via social media account
- Q177:7 I don’t know

From the multiple answers, respondents answered mostly ‘Yes’ to ‘Semi-automatic update: click yes to publish the latest results’ by 80 respondents. Generally, choices of the question were selected quite unevenly and rather negatively by the respondents. Therefore, this analysis cannot state that survey respondents would be definitely willing to share their environmental monitoring data on social media.

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Question 179: Do you find it important to see / be able to share environmental data on social media?

The question was answered by all 368 respondents. This question, in addition to Questions 173 and 174 are such questions that can be answered very simply – ‘Yes’ or ‘No’. The question was answered ‘Yes’ by 259 (70.4 %) respondents and ‘No’ by 109 respondents.

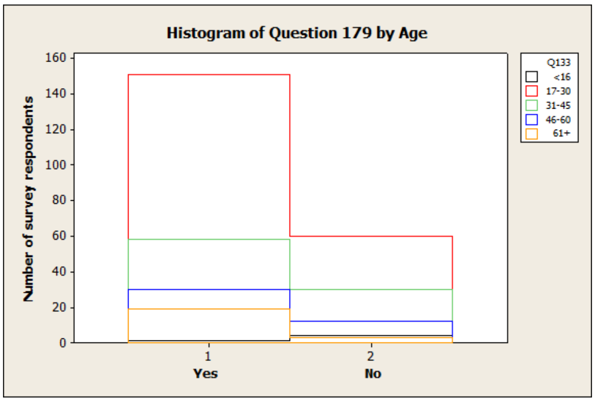

Figure 19: Histogram of Question 179 by Age

Figure 19 shows that the active answers respondents from various age groups answered similarly to the question. Proportionally, age group of 46-60 years old saw it most important to share environmental data on social media. Whether this observation is significant will require further research.

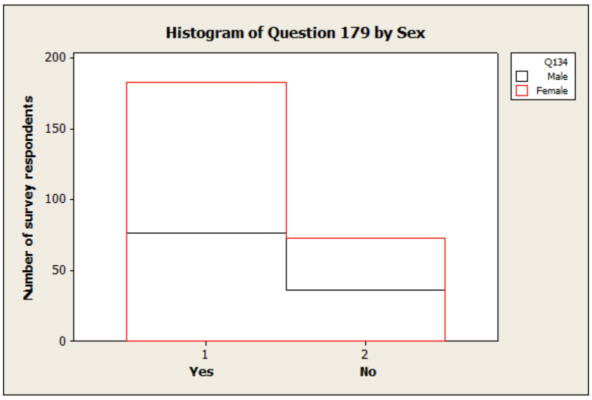

Figure 20: Histogram of Question 179 by Sex

Figure 20 shows that of the active respondents, females and males answered this question quite similarly. A small majority of both males and females find it important to share environmental data on social media.

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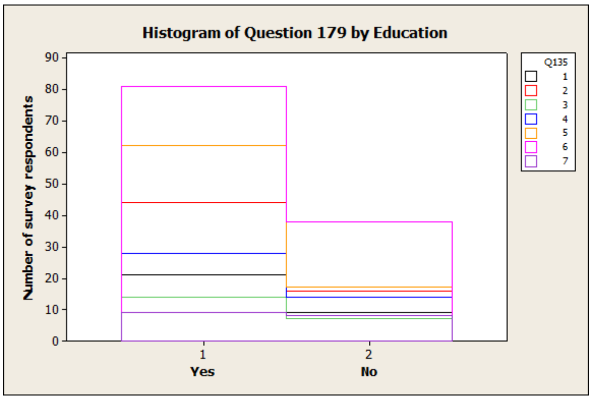

Figure 21: Histogram of Question 179 by Educational level

Figure 21 shows the turnout of the importance of sharing environmental data in social media by educational background. There were no significant differences amongst various educational backgrounds. However, of respondents with Master's degree nearly half found it unimportant to share environmental data on social media.

In conclusion, respondents find it important to share environmental data on social media. That the question was answered by all respondents makes it crucially important since it can be inferred that people have a clear opinion on the issue. Based on the previous answers, the platform and mechanisms of sharing such information could however be seen more case specific.

Conclusion

Based on the survey, a clear majority of the respondents have an account at least for one social media service, Facebook being the most popular. Social media platforms enable people to share information and create content on social media. Respondents were identified to mainly utilize social media for informing their network of their selected personal or public matters. When planning new environmental monitoring programmes and projects, it is seen important to understand what the social media networks are utilised for, and what type of information would be preferred by the active citizens to be shared.

Based on this and more specific questions regarding the usage of social media, people are positively receptive to sharing environmental monitoring data on their accounts in various social media services for their network. Nonetheless, the respondents generally want to strictly control the information they share, e.g. by reviewing the data before publishing. In total, based on this survey analysis, citizens see sensor technology as an attractive and potentially useful way of creating content for social media purposes and via social media networks.

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BALTIC FLOWS

Baltic Flows is a European Commission 7th Framework Programme coordination and support actions project which aims at creating a framework for future research cooperation in the management and monitoring of rainwater flow into Baltic Sea catchment areas by establishing common methods of managing and monitoring water quality and quantity and to have a common goal in protecting the Baltic Sea from further environmental degradation.

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