

Geoenvironmental Disaster Reduction

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# Citizens' Observatories on Geohazards

Lessons from Five Pilots

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*QR codes'*

*AGEO Citizens' Observatory: <https://ageoplatform.eu/>*



*AGEO Citizens' Observatory, users' manual: <https://ageo-manual.web.app/>*



*AGEO Mobile app (iOS)*



*AGEO Mobile app (android)*



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# Empowering Citizen Science Through Stakeholder Engagement

# 3

Vitor Correia , José Romão   
and Pavlos Tyrologou 

## 3.1 Introduction

According to the National Geographic Society (2020), ‘citizen science is the practice of public participation and collaboration in scientific research to increase scientific knowledge’. Projects that involve citizen scientists are expanding, particularly in ecology and the environmental sciences, although the origins of citizen science have at least two centuries (Silvertown, 2009).

Perhaps the oldest example of citizen science is the survey that engaged a large number of clergymen throughout Portugal after the 1755 earthquake of Lisbon, ordered by the Marquis of Pombal, chief minister of the Portuguese King, to collect information about the degree

of intensity and type of damage caused by the earthquake throughout the country.<sup>1</sup> Another well-known example of a citizen science project that is running for more than 100 years is the Christmas Bird Count sponsored by the National Audubon Society (National Geographic, 2020); since 1900, the organisation has sponsored a bird count that runs from December 14 through January 5 each year. An experienced birder leads a group (called a circle) of volunteers as they collect information about local populations of birds, and more than 2,000 such circles operate today across the United States and Canada.

Silvertown (2009) advances two main reasons for the expansion of citizen science: (a) scientists cannot always collect large amounts of data or cover big geographic areas for both data collection and documentation because of restricted time and limited monetary resources; and (b) to increase citizens’ awareness of problems related to their immediate environment. This second reason is particularly relevant for AGEO, since the project aims to raise people’s awareness of geohazards and risks, and to engage citizens in disaster prevention, preparedness, mitigation and warning.

Identifying and engaging relevant stakeholders is a crucial but demanding step in the

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<sup>1</sup> Interestingly, probably the oldest example of citizen science was designed to collect information related to a geohazard.

development and implementation of citizen science projects. The following are some of the common challenges:

1. Reaching a diverse audience, citizen science projects often require the participation of a diverse range of stakeholders, including scientists, community leaders, educators, policy makers, and the general public. Reaching and engaging this diverse audience can be challenging, especially in underrepresented communities.
2. Building trust, many stakeholders may be sceptical of citizen science projects, particularly if they have limited understanding of the scientific process. Building trust and credibility with stakeholders is crucial for the success of a citizen science project.
3. Balancing scientific accuracy and community involvement, citizen science projects must strike a balance between scientific accuracy and community involvement. On one hand, the data collected by citizens must be of high quality, i.e., reliable and marked by rigorous observation to ensure that it can be used for scientific purposes. On the other hand, the data acquisition process must be accessible and engaging to encourage widespread participation.
4. Sustaining participation, maintaining stakeholder involvement over time can be challenging, especially if the process is time-consuming or if the results are not immediately apparent.
5. Managing data, citizen science projects often generate large amounts of data, which must be managed and analysed effectively. Ensuring that the data is secure, accessible, and usable can be a challenge, especially if the data is collected by a large number of volunteers.

Overcoming these challenges requires a collaborative, participatory approach that engages stakeholders at every stage of the project, from planning and design to data collection and analysis. Effective communication and transparency are also crucial for building trust and sustaining participation over time.

### 3.2 Engaging Stakeholders in Citizen Science

The field of citizen science has expanded rapidly with the development of smartphones in the last few years, allowing more information to be shared through digital media. By using phones that have built-in GPS receivers, volunteers can readily provide geo-location information about events in real time, and this is supporting the popularisation of science around the new concept of citizens' observatories. The term "citizens' observatories" was first used in 2014 in the EU FP7 Topic ENV.2012.6.5–1: 'Developing community-based environmental monitoring and information systems using innovative and novel earth observation applications' applied to a framework that combined participatory community monitoring with monitoring by policymakers, scientists and other stakeholders.

In practice, citizens' observatories typically share a similar model (Liu et al., 2017), that includes engaging the participation of citizens in data collection, data interpretation and information delivery. The model (Fig. 3.1.) normally combines (i) sequential aspects, (ii) interaction with citizens and other stakeholders, (iii) data collection tools, and (iv) an ICT infrastructure that underlies the citizens' observatories framework and supports effective citizen participation.

The ICT infrastructure (represented in the oval at the top of Fig. 3.1) is an essential part of the citizens' observatories model, and it normally encompasses boundary services with sensors and apps, data management and data storage support (Liu et al., 2017). In the case of AGEO, the ICT infrastructure (including the AGEO mobile app) enables a two-way communication between citizens and other stakeholders, fostering co-design and collaborative management processes. Moreover, the AGEO ICT infrastructure was designed to facilitate replication and the setting up of new citizens' observatories focused in geohazards across the European Atlantic region.

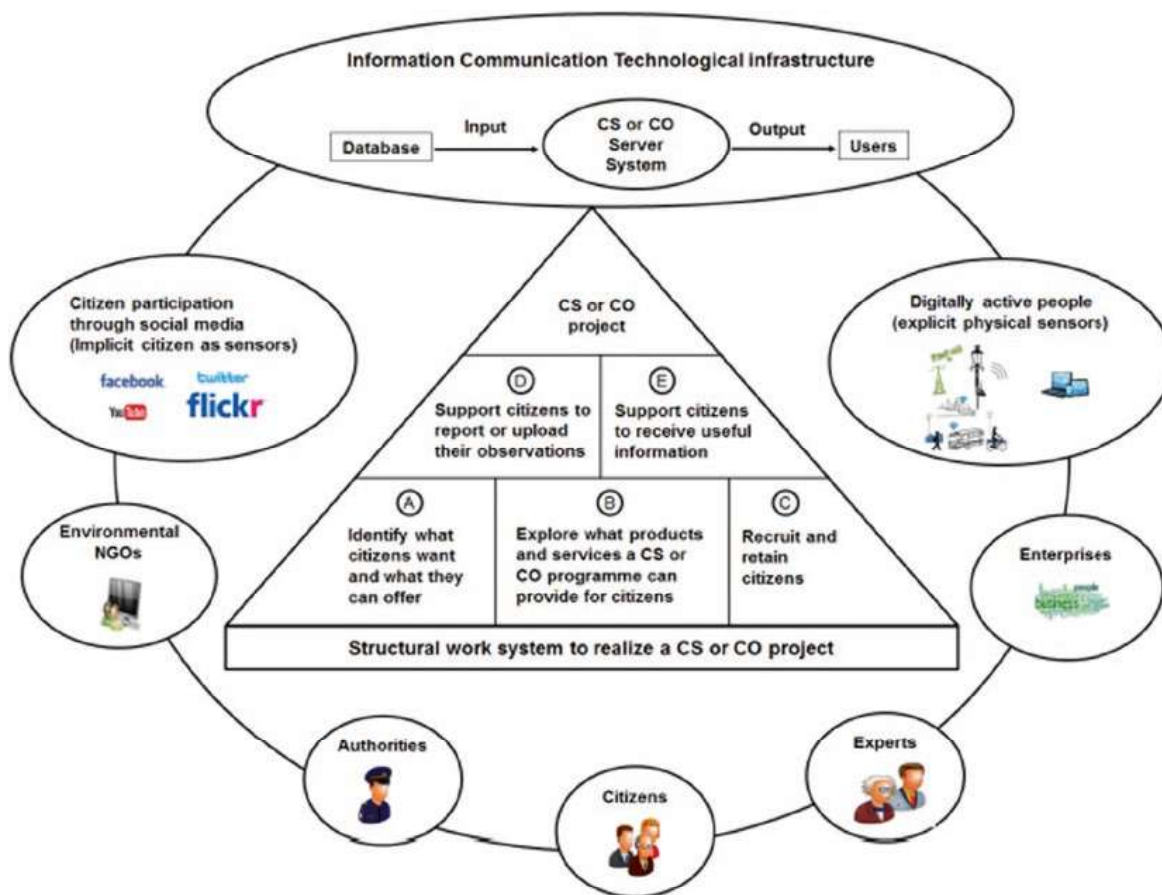


Fig. 3.1 A common model for citizens’ observatories programmes in practice. Source Liu et al. (2017)

### 3.2.1 The AGEO Vision

In the vision of AGEO, local communities will have the ability to organise in Citizens Observatories and actively engage with local authorities for better risk assessment, preparedness, prevention and mitigation, using available data and data infrastructures (e.g., European spatial data infrastructures, such as Copernicus), hence becoming more resilient and capable of responding flexibly and adaptatively to climate change.

To advance this vision AGEO developed and implemented five Citizen Observatories pilots in France, Northern Ireland, Portugal and Spain, focused on the monitoring of particular geohazard risks (according to regional priorities—see Table 3.1).

Table 3.1 AGEO citizen pilots and lead organisations

Citizens’ observatory pilot, focus	Responsible
Brittany, coastal risks	Université de Bretagne Occidentale
Canary Islands, rock falls	Instituto Geológico y Minero de España
Causeway Coast, complex landslides	Geological Survey of Northern Ireland
Lisbon city, multihazards	Câmara Municipal de Lisboa
Madeira, flash floods and landslides	Universidade da Madeira

Engaging stakeholders in AGEO’s Citizen Observatories required a systematic approach, further detailed, encompassing four steps:

**Table 3.2** Types of stakeholders relevant for AGEO

Systems	Groups of stakeholders
Political	1. Policymakers, as they can use AGEO outcomes to align broader policy goals and priorities, and to inform decision-making (e.g., government bodies, regional councils, municipalities, civil protection/disaster response agencies)
Economic	2. Industries and services, impacted by natural hazards or having assets that could be affected (e.g., insurance companies, energy providers, port operators)
Knowledge	3. Scientists and researchers, seeking to leverage the expertise, knowledge, and resources of citizens to address scientific questions and solve real-world problems
Socio-cultural	4. Educators, who could play a crucial role in citizen science projects by helping to raise awareness and engage students, teachers, and other members of the education community 5. The general public, as they are often the primary contributors of data and the ultimate beneficiaries of project's outcomes

1. Identifying stakeholders, identification of all potential stakeholders that could be impacted by AGEO.
2. Understanding their probable level of engagement, in particular the influence and potential interest of stakeholder groups in AGEO, vital to manage outreach and communication activities.
3. Assessing their interests and needs, once the stakeholders have been identified, it was necessary to assess their interests and needs through focus groups and interviews.
4. Engaging stakeholders, this involved the development of outreach and communication activities, the establishment of partnerships, and the provision of opportunities for hands-on involvement.

### 3.2.2 Stakeholders Identification

Citizen science projects can have a wide range of impacts, both positive and negative, on a variety of stakeholders. Determining who is affected by the project, and how, can be challenging and requires a systematic approach to stakeholder identification.

In the initial screening of stakeholders likely to be interested in AGEO outputs, it was possible to identify five relevant groups (Table 3.2), organised around four basic societal systems: political, economic, knowledge and socio-cultural.

In a subsequent step, and considering the diverse geographies, context and aims of the five

AGEO pilots, the organisations working in the different pilots were asked to identify the stakeholders that were more relevant for them. The list produced was more specific than the general groups named in Table 3.2, and included the following stakeholders' groups:

1. Local authorities (e.g. local governments, municipalities).
2. Local communities (e.g. parishes, neighbours associations, recreational non-profit groups).
3. Landowners (e.g., farmers and tenant farmers).
4. Tourists (national and international visitors).
5. First responders (e.g., firefighters, medical emergency teams).
6. Public research institutes/universities (e.g., geological surveys, national laboratories, research departments and institutions).
7. Private agents (e.g., civil works companies, utilities' providers and consultants).
8. Professional associations (e.g., engineers, geographers, geologists professional and scientific associations).
9. Media (local, regional and national radio and newspapers).
10. Insurance companies (insurers of infrastructures and individuals).
11. Schools (from first grade to secondary, professional and tertiary levels).
12. Energy or utility providers/strategic infrastructures (e.g., electricity and gas providers, road authorities).

13. Federal/national government (e.g., ministries responsible for policy making, emergency preparedness and land use).

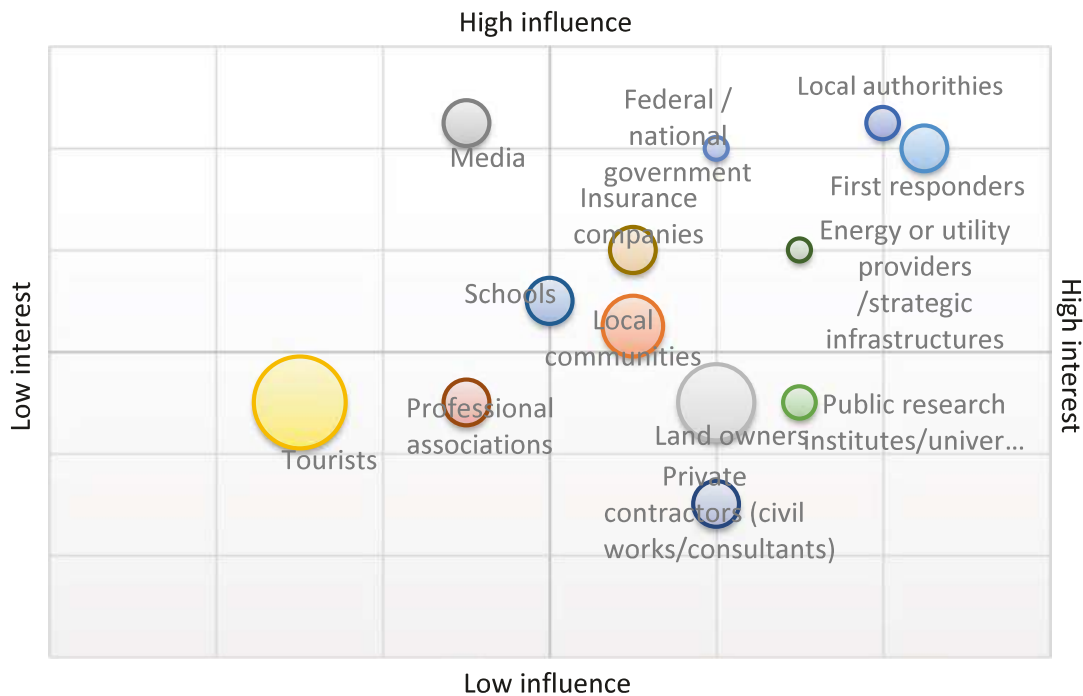
### 3.2.3 Stakeholders Classification

Assessing the level of interest and engagement among stakeholders can be difficult and requires a nuanced understanding of their motivations and expectations. To screen the potential engagement of the 13 stakeholders' groups in AGEO, the organisations in the Consortium directly linked to each of the five pilot Observatories classified the 13 groups using the Mendelow (1991) power-interest matrix, that considers two dimensions: (1) stakeholders power (or influence); and (2) and stakeholders interest (in the pilots or in the AGEO project). The perceptual map below (Fig. 3.2) represents the outcome of the general classification exercise. The size of the circles in the image represents the normalised number of individuals/entities in each group.

The perceptual map and the classification outlined are relevant to manage stakeholder

groups. The management prescriptions arising from the classification (Mendelow, 1991) is represented in Fig. 3.3. According to this matrix, there are four possible positions/prescriptions:

1. High power, highly interested groups (prescription *Manage Closely*): stakeholders in this position should be fully engaged, and meeting their needs should be a main concern;
2. High power, less interested groups (prescription *Keep Satisfied*): these stakeholders should be kept satisfied, but it is essential to avoid excessive interactions;
3. Low power, highly interested groups (prescription *Keep Informed*): this group of stakeholders should be adequately informed and engaged to ensure that no significant issues are raised. People in this category can easily be willing and helpful in implementation activities;
4. Low power, less interested groups (prescription *Monitor*): This group should be monitored, and excessive communication should be avoided.



**Fig. 3.2** Generic classification of relevant stakeholders for AGEO's pilots, according to their influence and interest

It must be emphasised that the generic perceptual map of stakeholders in Fig. 3.2 was later refined to each pilot. This adjustment was paramount to avoid simplifications that would mask over-representation or biases, and to consider existing stakeholder relationships, relevant to identify potential allies and influencers who could shore up support and participation. An evident example of the importance of the local refinement comes from the pilot on the Causeway Coast (Northern Ireland), where touristic activity is incredibly significant and where tourists would play a central role in the Citizens Observatory pilot (placing them in the “high interest” areas of the matrix). The adjustment to the specific features and groups of stakeholders pertinent to each pilot was made by the corresponding pilot leader.

### 3.2.4 Assessing Stakeholders’ Interests and Needs

A fundamental challenge for AGEO was to engage citizens in activities and dialogues with scientists and risk management authorities, hence setting the foundations for resilient, long-lasting Citizens Observatories. Instrumental to address this challenge was the development of compelling value propositions of AGEO and the Citizens Observatories’ aligned with the interests and needs of the most relevant groups of stakeholders.

The definition of the appropriate value propositions followed a standardised method, that included:

- The selection of the most relevant stakeholders’ groups, detailing their background, influence, specific needs and expectations;
- Definition of the value map for each relevant group, using Osterwalder’s (2014) value proposition canvas (see Fig. 3.3);
- Development of compelling value propositions for each stakeholders group, supported by AGEO’s features and the benefits for the pilot Citizens Observatories;
- Test and refinement of the value propositions (with the support of stakeholders



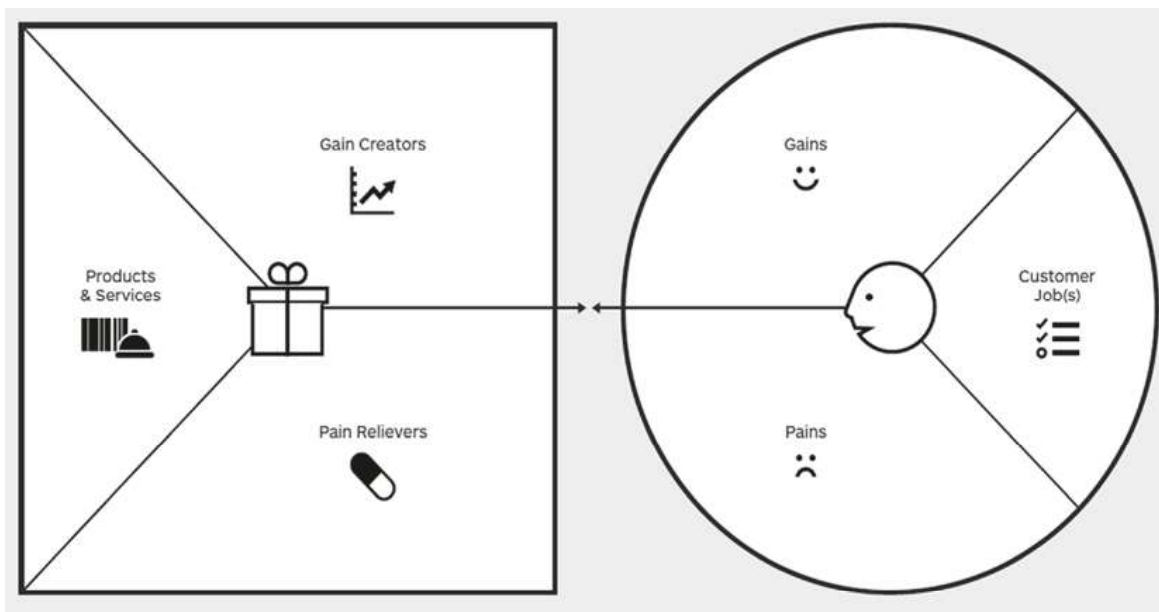
**Fig. 3.3** Power/Interest (influence) grid for stakeholder prioritisation (adapted from Mindtools.com)

classified in the low power, high interested quadrant of Mendelow’s (1991) power-interest matrix);

- Fitting use of the tailored value propositions for each pilot to foster local engagement and boost the capitalisation and uptake of AGEO’s results.

The value proposition canvas (Fig. 3.4) developed by Osterwalder (2014) was used to outline the value propositions for the most relevant groups of stakeholders, following three steps:

1. Analysis of stakeholders’ jobs, pains, and gains; definition of what these stakeholders are trying to achieve (their jobs), what problems they are trying to solve (their pains), and what benefits they are looking for (their gains).
2. Definition of AGEO’s value proposition; using the information about AGEO’s features, identifying a unique value proposition, that matches some of the features, solve stakeholders’ problems and meet their needs.
3. Test and refinement of AGEO value propositions; by gathering feedback from representatives of each stakeholders group and fine tuning the proposition to ensure that it effectively addresses specific needs.



**Fig. 3.4** Value proposition canvas to be used to define value for relevant stakeholder groups within each pilot (Osterwalder, 2014)

The development of value propositions was made in a workshop held with all Consortium members, and some of the generic value propositions canvas produced are shown below (Figs. 3.5, 3.6, 3.7, 3.8 and 3.9).

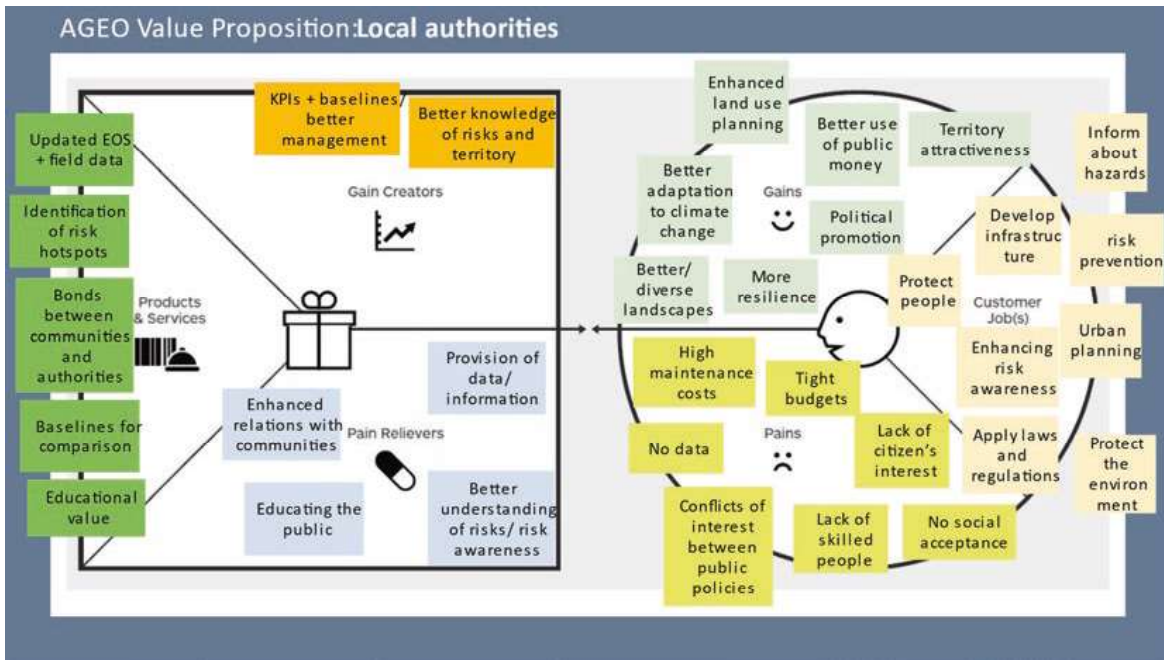
The value proposition outlined for local authorities says *AGEO reinforces regional and local authorities (e.g., regional councils, county councils, municipalities, cities) capacity to design and implement better land use planning, civil protection and response to crisis requirements*. This value proposition took in consideration the resources (financial and human) constraints that most local authorities have, as a result of tight budgeting, and the vital role local authorities play in land-use planning, civil protection and response to crisis.

The value proposition outlined for civil protection agencies says *Citizens' Observatories increase knowledge and stimulate cooperation between civil protection/disaster response agencies and citizens*. This value proposition builds on the importance of coordination between agencies and other disaster response players, and on the importance of public awareness to counter the lack of interest of the general public on risk prevention and mitigation.

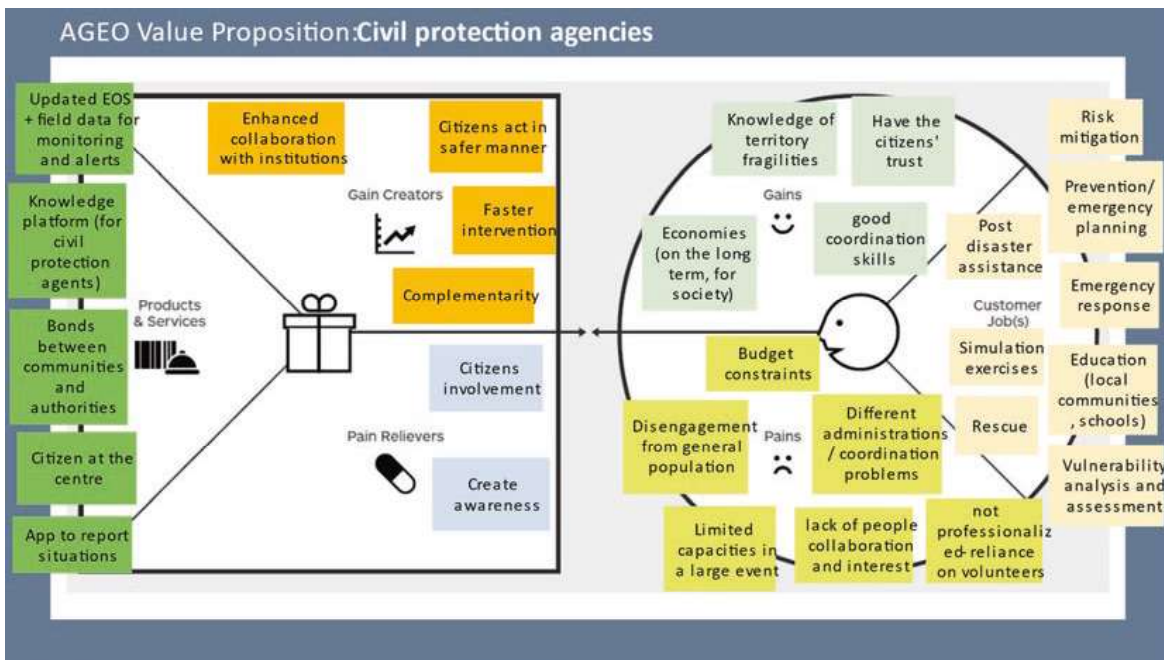
The value proposition outlined for local communities says *Citizens' Observatories contribute to better adaptation and enhanced resilience of local communities to climate change*. This proposition builds on the increasing awareness of the effects of climate change (and the rollout of more frequent extreme climatic events) and on the public perception that is crucial to improve the resilience against the effects of climate change.

The value proposition outlined for landowners says *AGEO supports coalitions and networks for better risk assessment, preparedness, mitigation and prevention*. This value proposition underlines the importance of partnerships between scientists and local networks (such as associations of landowners) in defining and implementing actions that would limit the risks of natural hazards and the mitigation of their impact.

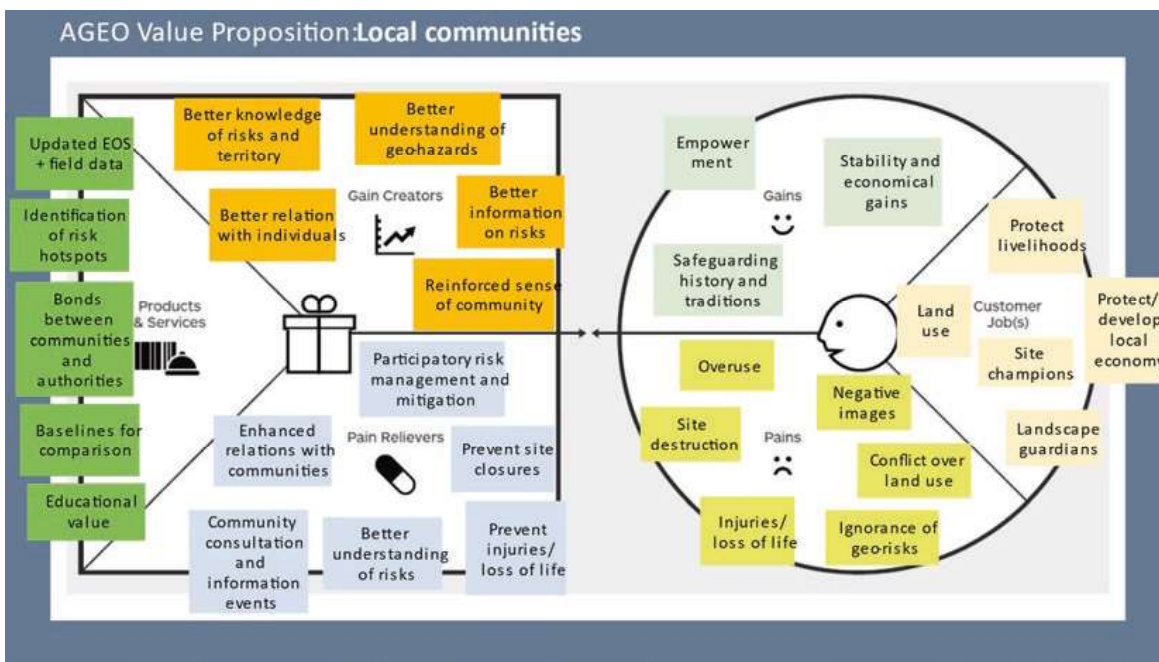
The value proposition outlined for tourists says *AGEO stimulates the active participation of tourists and groups of citizens in the prevention and response to natural hazards*. This value proposition points out the important role tourists and groups of citizens play in risk monitoring and response.



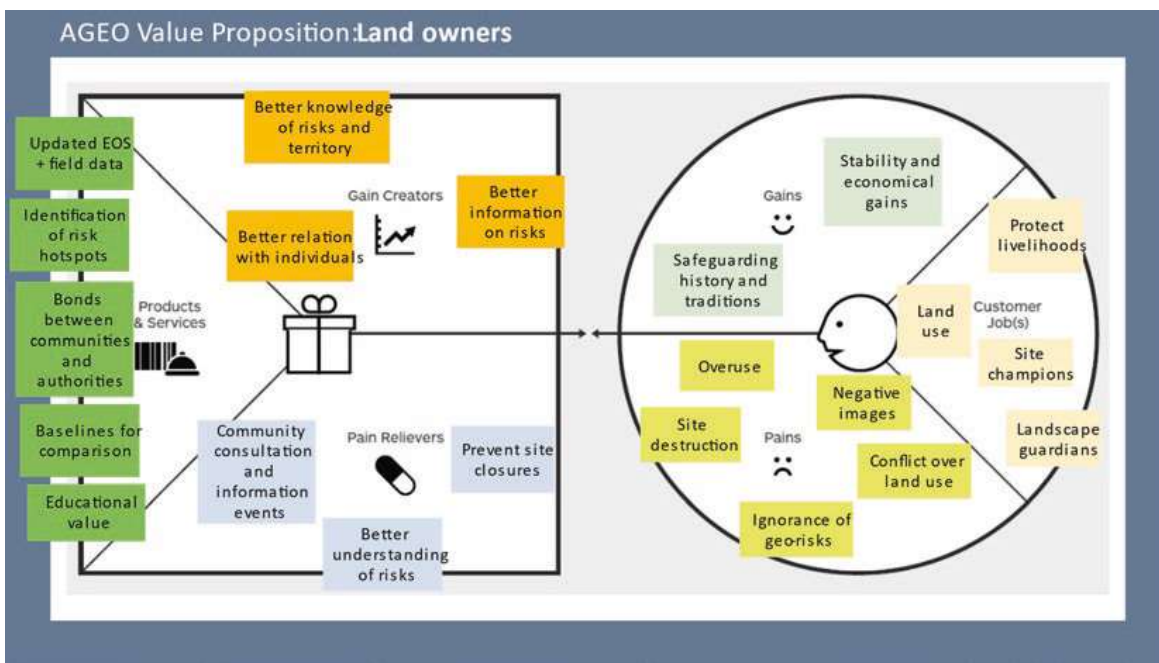
**Fig. 3.5** AGEO’s value proposition canvas used to define the value proposition for Local Authorities (canvas adapted from Osterwalder, 2014)



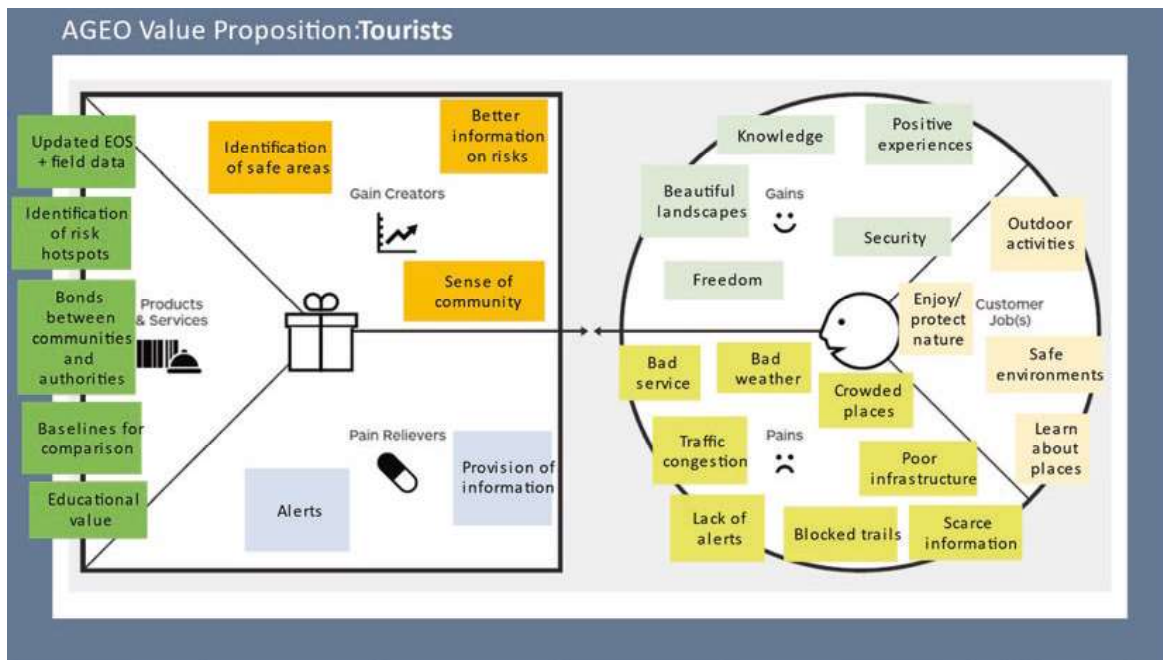
**Fig. 3.6** AGEO’s value proposition canvas used to define the value proposition for Civil Protection Agencies (canvas adapted from Osterwalder, 2014)



**Fig. 3.7** AGEO’s value proposition canvas used to define the value proposition for Local Communities (canvas adapted from Osterwalder, 2014)



**Fig. 3.8** AGEO’s value proposition canvas used to define the value proposition for Landowners (canvas adapted from Osterwalder, 2014)



**Fig. 3.9** AGEO's value proposition canvas used to define the value proposition for Tourists (canvas adapted from Osterwalder, 2014)

### 3.2.5 Engaging Stakeholders

Communication and outreach activities played a crucial role in the development of the participation of diverse groups of stakeholders in the activities of all and every pilot Citizens Observatories, despite the constraints arising from the COVID pandemic that affected social interactions for approximately half of the project duration.

In the initial stages of the project development pilot leaders and local partners used referrals to get in touch with existing community networks, and relied on word of mouth to spread information, facilitated by the access to digital sources describing AGEO (e.g., website and social media). This required the previous identification of existing networks (on the area of influence of each pilot site) that could be interested in receiving information on AGEO.

The approach was typically initiated with a face-to-face or online meeting with managers/responsible from the relevant stakeholders' groups (e.g., recreational non-profit groups, landowners' associations, fire squad/police stations and local/regional schools), where the

goals of AGEO were explained, and digital/printed materials provided. The follow up on the initial contacts typically included a request to respond to a survey (in the local language) addressing natural hazards and generic community concerns. These surveys included questions such as "What are your concerns relating to natural hazards?", "How would you like the Citizens Observatory to be?", "Would you like to be involved?" and created the favourable conditions for further engagement.

The next step was the organisation of enjoyable and social events within each group of stakeholders, to boost people's participation. These were linked to the observatory topic, conveyed scientific-based information, and used formats tailored to the audiences. Examples of such events include guided tours, open discussion/workshop sessions and visits to and from schools.

The experience with AGEO has confirmed that the five crucial factors that drive stakeholder engagement are:

1. Relevance, citizens are more likely to engage in a citizen science project if they feel that the project is relevant to their interests and

- concerns. Relevance can be enhanced by involving stakeholders in the design and implementation of the project and by clearly communicating the goals and benefits of the project.
2. Accessibility, citizen science projects must be designed to be accessible to all stakeholders, regardless of their level of scientific expertise or technology skills. This may involve providing training and support, developing user-friendly interfaces, and ensuring that the project is culturally and linguistically appropriate.
  3. Trust, trust is a critical factor in stakeholder engagement, particularly for underrepresented communities. Building trust requires transparent communication, the use of reliable and trustworthy sources of information, and ensuring that the data collected is secure and protected.
  4. Recognition and incentives, these play an important role in motivating citizens to participate in a citizen science project. This may involve providing opportunities for hands-on involvement, recognising contributions and achievements, and offering tangible benefits such as access to training and resources.
  5. Sustainability, Maintaining stakeholder engagement over time can be challenging, especially if the process is time-consuming or if the results are not immediately apparent. Ensuring the sustainability of the project requires continuous engagement and communication, and providing ongoing opportunities for participation.

### 3.3 Sustaining the Participation of Stakeholders in Ageo

Broadly speaking, the likelihood of sustaining a citizen science project depends on: (1) initial project design; (2) project implementation; and (3) community support.

#### 3.3.1 Initial Design

The AGEO project design considered, since its start, four assets (outcomes) that would be relevant to the uptake of project results:

- (1) The AGEO Information and Communication Technology (ICT) infrastructure, including a mobile app, data management and information services, and data storage support, to be uptaken by civil protection entities and used by citizens and civil protection agents;
- (2) Recommendations and examples of application of European spatial data infrastructures (such as Copernicus services and solutions) for a range of geohazards including landslides, floods, tsunamis, earthquakes, volcanic activity, cascading events that may include other types of natural hazards (such as wildfires) and human-induced geohazards (e.g., induced seismicity or surface subsidence);
- (3) Recommendations to policymakers to increase the resilience of society against natural hazards by enhancing risk management structures and capacity in disaster risk reduction (DRR) via public engagement and better integration of Copernicus products and services;
- (4) Recommendations for risk authorities on citizen engagement to enhancing geohazard risk preparedness in the Atlantic region through educational/capacity-building and communication tools and activities.

The development and fine-tuning of AGEO assets were made as the project progressed, with the active contribution of all consortium partners, and one can assert that these outcomes were fully achieved.

Also, at the start of AGEO, a group of sustainability factors were identified and further detailed into sustainability objectives (see Table 3.3), to harness the exploitation and replication potential of the five Citizen Science Observatories after the end of the project funding period.

#### 3.3.2 AGEO's Implementation

During the project implementation, two supporting factors became very relevant to boost the uptake of AGEO results: (1) the perception

**Table 3.3** AGEO's sustainability factors and objectives

Sustainability factors	Sustainability objectives
Project design and implementation	Define the value-added of AGEO Define what are the aspects of the Citizens' Observatories that are most effective Prioritise what to sustain from experience with the Citizens Observatories pilots Identify goals and action steps for long-term (after the AGEO funding period) sustainability
Project monitoring and evaluation	Define what activities result in a significant positive impact Design and implement a monitoring dashboard to assess the impact and outcomes of Citizens' Observatories
Financial resources	Define which Citizens' Observatories components can be sustained with minimal financial resources Evaluate the feasibility of different sources of funding Establish budget/resources needed Develop fundraising activities
Organisational structure	Define which Citizens' Observatories components can be sustained with minimal human resources Provide staff and community stakeholders training in creative and flexible problem solving to consolidate and expand the Citizens' Observatories Recruit and engage volunteers
Project Champions	Recruit, train and engage community champions who facilitate community activities Uphold the endorsement and support of project champions
Managerial support and flexibility	Disseminate AGEO impacts to leaders of Citizens' Observatories and educate them on the importance of adapting to external changes and using opportunities to meet AGEO's goals Define which aspects of AGEO can be integrated into other existing/ongoing programs or partnerships
Community support for the project	Define the aspects of AGEO that are highly respected or supported by the broader community Hold regular dissemination meetings with the stakeholder community and professional conferences to disseminate the results of the project and build recognition for success

of climatic extremes and the increasing risk of geohazards; and (2) the launch of the European Ground Motion Service (EGMS) as part of the Copernicus Programme.

On the climatic extremes, and according to the IPCC (2019), 'the scale of recent changes across the climate system as a whole—and the present state of many aspects of the climate system—are unprecedented over many centuries to many thousands of years'. The climate models and projections made by the IPCC (2018) point out to global surface temperature increases until at least mid-century under all greenhouse gas emissions scenarios considered (including CO<sub>2</sub>

emissions declining to net zero around or after 2050). In this context, increases in the frequency and intensity of hot extremes, marine heatwaves, heavy precipitation, agricultural and ecological droughts and even cyclones should be taken as a new reference across the Atlantic region of Europe. The social dimension also needs to be considered, in particular the impact of climate change awareness on behavioural changes. Greta Thunberg and the intense media coverage of the *Fridays For Future* movement she created in 2018 boosted the debate around climate change and sustainability both among the population and in the political arena (Rucht & Sommer, 2019).

Until recently, the monitoring of ground-instability was site-specific and administered by local authorities using conventional means available (e.g., line levelling, electronic distance measuring, GPS) in connection with a particular known local geohazard. This reactive approach changed with the setup of the European Ground Motion Service (EGMS) as part of the Copernicus Programme (source). This service, designed to provide for free consistent, regular, standardised, harmonised and reliable information regarding natural and anthropogenic ground motion phenomena over Europe and across national borders, with millimetre accuracy (Copernicus, 2020), was launched in 2020.

### 3.3.3 Community Support

The uptake and capitalisation of AGEO's results is fundamentally linked to the earliest development of connections and solid partnerships with relevant stakeholders or networks that could build upon project outputs after the funding period. The citizens in the area where a disaster happens and their local governments and voluntary agencies are the first to have to cope with the damage of a disaster; local governments/municipalities normally act as the primary "first provider" of emergency response services, and they often coordinate assistance with public and private organisations and agencies. In this framework, the role that local governments/municipalities and disaster response authorities play in response to a natural disaster in the Atlantic region, including the assessment of risks, the response and the recovery stages, is crucial to minimise impacts and save lives.

An assessment made by the pilot leaders, concluded that the agents vital to sustaining the five Citizen Observatories created, willing to receive training (for capacity building) and lead or support the uptake of the Observatories were<sup>2</sup>:

1. Landowners and citizens with a detailed and all-inclusive knowledge of their territory, who need to feel empowered to participate actively in the prevention and response to natural hazards;
2. Local community leaders who have a strong influence on landowners and citizens' behaviour;
3. Civil protection/disaster response agencies, who need trustable local information from people that have a detailed and all-inclusive knowledge of their territory/area;
4. Regional and local authorities (e.g., regional councils, county councils, municipalities, cities) who have direct responsibility for land regulations, civil protection and response to crisis requirements.

After identifying the four main groups of stakeholders interested in the uptake of the Observatories, the main benefits (for each stakeholder) associated to maintaining and enhancing (i.e., managing) the Citizen Observatories were discussed, and generic performance indicators were outlined (Table 3.4).

Relevant civil protection/disaster response authorities for the capitalisation of AGEO in the European Atlantic region include National Disaster Management Authorities, Environment Agencies, public infrastructure (e.g. highways, railways, water dams) private owners, managers and utility providers (gas, electricity, water). The support of these entities played a crucial role in the project implementation and boosted public participation. This support came in the form of partnerships with community-based organisations, and promotion of the AGEO app, to support decision-making processes. By endorsing AGEO, civil protection and disaster response authorities in the area of the five pilots increased public trust in the project and encouraged greater public participation.

## 3.4 Conclusions

Whatever the range of influences (temperature, rainfall events, snowmelt, frosting, cyclones, etc.), it is certain that climate change effects will

<sup>2</sup>The listing of these groups, identified in the five pilots, does not exclude the possible interest of other stakeholders (such as insurance companies, professional networks and science-based organisations) in the uptake of a specific Citizen Observatory.

**Table 3.4** Learning outcomes tailored to AGEO's agents of change

Stakeholder groups interested in the uptake of the Observatories	Main benefit for the stakeholder	Generic performance indicator to measure the benefit
Landowners and citizens that have a detailed and all-inclusive knowledge of their territory	Greater awareness about disaster's risk and vulnerability and its relevance to prevention and response	Community support for the Observatory Incentives for compliance
Local community leaders	Increased understanding of disaster risk assessment and management	Stakeholders' engagement Transparency of information to stakeholders
Civil protection/disaster response agencies	A better understanding of the needs and concerns of citizens	Stakeholders engagement Transparency of information to stakeholders
Regional and local authorities	Enhanced land use planning and formulation/implementation of regulations	Improved compliance. Better civil protection and response to crisis requirements

impact the type, extent, magnitude and possibility of changes in rock and ground stability conditions, triggering geohazards.

With the advent of new and advanced communication and Earth Observation technologies, the potential for proactive citizen involvement in disaster preparedness, mitigation, and warning has increased, particularly in the context of the ongoing effects of climate change. Citizen science can make a significant contribution by providing a large volume of data that can enhance our understanding of natural hazards and the associated risks. This information can inform decision-making processes related to disaster preparedness and response, ultimately reducing the risk of harm to both communities and ecosystems. Furthermore, citizen science can serve to increase awareness and encourage community engagement in disaster risk reduction efforts, promoting a more active role in protecting both themselves and their communities.

In this vision, technological advances and capacity-building actions would enable integrating risk authorities and citizen communities' viewpoints, combining theoretical and empirical perspectives with real-world, on-the-ground applications, thus creating resilient societies with a shared understanding of risks, roles and responsibilities between risk agencies and risk publics. This change would probably be gradual, starting with information-sharing mechanisms (such as the already adopted emergency

warnings sent to mobile phones within one region) and moving on to collaborative environments where experts and specialists and the lay publics that they serve work together to jointly tackle complex compound-risk scenarios and multi-agent threats.

The identification and engagement of relevant stakeholders is paramount in establishing a successful foundation for citizen participation in disaster preparedness, mitigation, and warning. Overcoming linguistic and cultural barriers and establishing trust and credibility are crucial, yet challenging, aspects of the process, which require a collaborative, participatory approach throughout the design and implementation of the project. Strengthening stakeholder engagement can be achieved through building partnerships and fostering relationships with the most relevant groups of stakeholders, resulting in increased participation, impact, and sustainability.

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