A Test and Implementation Framework (TIF-Tool) for Climate Adaptation Innovations: Tool Guidance (Version 1.3; January 2019)

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1. Introduction

This document is intended to guide climate adaptation innovators through interpreting the results to their self-assessment of the performance of their innovations using the BRIGAID Test and Implementation Framework (TIF) Tool. The TIF-Tool consists of nineteen (19) questions related to technical design, twenty-one (21) questions related to environmental impacts, twenty-five (25) questions related to sectoral impacts, and twenty-two (22) questions related to societal acceptance. These question must be answered with yes, no, a specification, or n.a. (not applicable) and the answers are converted to a score. The Tool is designed to help innovators identify possible technical, environmental, sectoral, and societal concerns that their innovations may raise early on – and iteratively throughout the development – so that they may modify their designs and not become locked into those that are less likely to appeal to end users. The results and recommendations are summarized in a chart (Figure 1).

Many assessment question may serve as 'food for thought', or as topics to discuss with stakeholders or end-users. The TIF Tool does NOT provide a definitive assessment: it is a 'checklist' designed to help identify potential concerns so that innovators can then choose how - or whether - to respond to them.

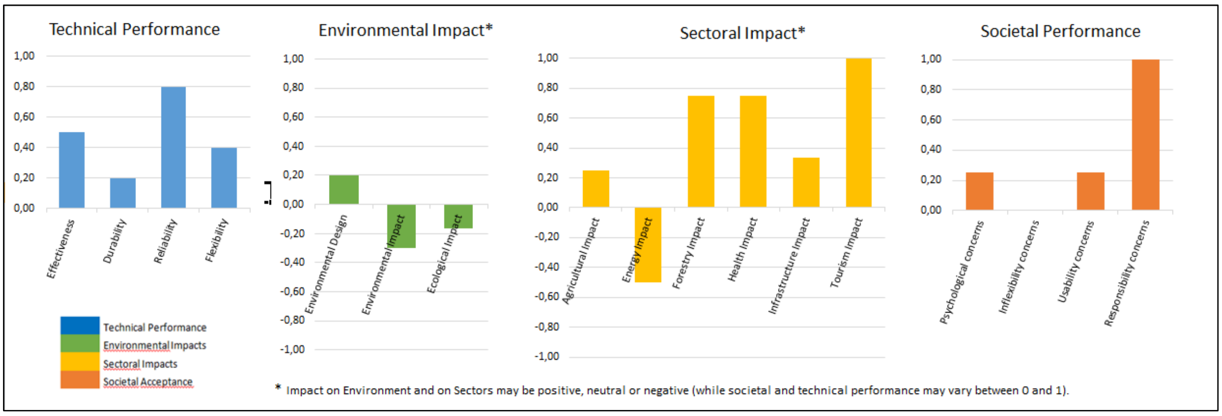


Figure 1: Summary of the results of the TIF-Tool

The Tool is meant to be applied by innovators at three 'stage-gates' – critical points in development at which innovators should pause to identify and address technical, environmental, sectoral and social, concerns. These 'stage-gates' refer to Technology Readiness Levels (TRLs) in the testing framework (see p. 10 and the TIF method document).

'Soft stage-gates' at which to apply the TIF Tool

Stage-gate 1: Apply the TIF Tool prior to validation in a laboratory setting

Stage-gate 2: Apply the TIF Tool prior to testing in an operational setting

Stage-gate 3: Apply the TIF Tool prior to deployment in the real world

The TIF Tool is an Excel spreadsheet with 7 tabs:

1. Navigation/Welcome
2. General information on the innovation's typology
3. Technical performance assessment
4. Environmental impacts assessment
5. Sectoral impacts assessment
6. Societal acceptance assessment
7. Summary of results

The initial navigation page introduces climate adaptation innovators to the layout of the TIF Tool before then presenting them with an innovation typology. This typology will help innovators to clearly identify the types of hazards their innovation is designed to protect against (be it directly or indirectly) and the type of adaptation their innovation is. Some environmental impacts assessment questions may not be applicable to 'social' forms of adaptation. However all technical performance, sectoral impact assessment, and societal acceptance questions are applicable to all adaptations. Some (informational) innovations need to be combined with an additional measure that may have an impact (e.g. prescribed burning). Then the TIF Tool should be applied separately for this structural measure.

Note that the impact of an innovation on the environment and economic sectors can be positive, neutral or negative.

The TIF Tool and this TIF Tool Guidance document are accompaniments to the more detailed TIF Methodology document. Readers who are interested in the theoretical and methodological underpinnings of the Tool and Guidance should refer to the Methodology.

This document proceeds in the following sections by guiding innovators through the process of interpreting the results to their self-assessments of technical performance, environmental impacts, sectoral impacts, and societal acceptance.

2. Technical performance assessment

After completing the technical screening questions (Figure 2), innovators can refer to the interpretations provided in Table 1 below. Using the answers to the questions in the Excel (and the associated scores (range 0 to 1) per indicator), innovators should be able to determine whether adjustments to their design are needed or warranted.

1	**Technical Performance Assessment** NB: all questions are applicable for all type of innovations (please fill in an answer for each question)!	
	Answer the following questions by writing Yes or No in the corresponding cells.	**Yes or No?**
1	Does the innovation provide significant technical advantage(s) relative to traditional/conventional measures?	No
2	Does your innovation physically prevent a hazard from occurring?	No
3	Does your innovation require combination with other interventions and/or activities in order to reduce risk (e.g, flood warning system in combination with a flood barrier or a fire warning system in combination with controlled burning)?	No
4	Will the innovation require additional testing and/or substantial upgrades when considering future hazard conditions (i.e., considering climate change)?	No
5	Is the lifetime of the innovation limited by climate change? (i.e., will climate change affect the estimated life(time) of the innovation?)	Yes
6	Does the innovation require frequent inspection and maintainence to reach its intended lifetime?	No
7	Are the materials or software needed for maintanence and/or repair easily obtained and can they be integrated by the end-user?	No
8	Is the innovation designed to be used repetitively or continuously operated over its lifetime?	No
9	Can the innovation be operated without repair and/or replacement of components during a hazard event?	No
10	Does the innovation exhibit vulnerabilities during testing and/or demonstration (e.g., structural: sliding or rotation, or technological: errors)?	No
11	Is there a critical component in the innovation's structural or technological design that could lead to catastrophic failure?	No
12	Does your innovation rely on the delivery of services or materials (e.g., structural components, data) outside of your control to be successfully operated during a hazard event?	Yes
13	Does your innovation require the execution of tasks by humans to be successfully operated during a hazard event?	No
14	Can the vulnerability of your innovation to human error be easily reduced through improvements in operational protocols and/or end-user training?	Yes
15	Is the innovation modular (opposite: monolithic) and can it be easily installed or applied at different sites across Europe without adjustment?	No
16	Does the innovation require additional testing and/or substantial upgrades (e.g., new components) if used at different sites across Europe?	Yes
17	Will the size of the market for the innovation (in Europe) will significantly decrease (>50%) due to future hazard conditions (i.e., considering climate change)?	No
18	Have relevant end-users have been identified and involved in formulating design specifications?	Yes
19	Does the design of the innovation deliberately aim for advantages derived from multi-functionality (e.g., reduction of carbon emissions or enhanced recreational activities)?	No

Figure 2: Tab Technical Performance

The questions are intended to assess sets of issues related to the indicators described in the TIF method document: effectiveness, durability, reliability, and exploitability. Depending on how the innovator responds to these questions, their innovation may be more marketable and have a more effective technical design or a design associated with some technical concerns. The table includes information and recommendations on how to alleviate those concerns and improve the performance of their innovation and its technical readiness.

Table 1: Responding to specific areas of technical concern (the numbers refer to the questions in the tab Technical Performance)

1	If your innovation does not provide significant technical advantage(s) relative to conventional measures, then it is likely to raise concerns about its technical design. Innovators should strive to generate designs which fill an existing gap or fulfil a perceived public (or private) need.
2	If your innovation does not prevent the probability or consequences of a hazard, it may not be able to fully mitigate risk (by itself). Based on the definition of technical effectiveness used by BRIGAID, an innovation which completely reduces risk will always score higher in terms of its technical effectiveness. In these cases, it may be prudent to compare your innovation against similar or conventional technologies to determine whether it provides significant advantages in terms of risk reduction.

3 If your innovation must be implemented or operated in combination with other interventions to reduce risk, it may raise some technical concerns. Innovations which are not stand-alone require that the end-user already have access to other services/processes or the ability to purchase them in combination with your innovation. Furthermore, the ability of your innovation to reduce risk will be dependent on the successful operation and effectiveness of both interventions/processes (see reliability concerns below).

4 If you have not considered future hazard conditions or anticipate that your innovation may require additional testing and/or substantial upgrades to be effective under future climate conditions, this may raise technical concerns. Innovators can refer to the current and future hazard maps provided in the TIF methods document and should consider future conditions in the design of their innovation. Note that some innovations may only be designed to mitigate the intermediate impacts of climate change, in which case the innovation's lifetime will be determined by the time at which the impacts of climate change on the hazard surpass the technical design of the innovation (e.g., when the return probability of a flood exceeds the design height of a structure) (see lifetime concerns below).

5 If the life of your innovation is determined by climate change, this may raise some technical concerns. An innovator should consider the implementation context of their innovation; if an innovation is designed to be a permanent solution, the innovator should strive to design their innovation to withstand the effects of climate change on the relevant hazard.

6 If your innovation requires frequent inspection and maintenance to reach its lifetime, it may raise concerns about the innovation's durability. Frequent inspection and maintenance is typically associated with higher costs over the innovations' lifetime and thus will lower its cost-benefit. It may also raise potential concerns about the innovation's reliability during an event.

7 If the materials or software needed for maintenance or repair of your innovation are difficult to obtain, this is likely to raise durability concerns. Innovators should consider incorporating materials that can be easily (and cost-effectively) obtained in case of emergency maintenance or repair.

8 If your innovation is not designed to be used repetitively and is only single-use, this may raise durability concerns. Innovations which can be used repetitively (or continuously) over their lifetime can be expected to have a higher cost-benefit over their lifetime. Innovators should strive to design innovations which are not single-use (and do not generate waste, see environmental concerns).

9 If your innovation requires repair or replacement of components during the hazard event, this may raise some technical concerns. Innovations which are designed to fully withstand the hazard without replacement will score higher.

10 If your innovation exhibits vulnerabilities during testing, this could lead to very low technical reliability. The innovation should be designed to withstand the hazard and the innovator should provide a level of safety (e.g., in the form of probability of failure or a safety factor) associated with the innovation.

11 If there is a critical component in the design of the innovation that could lead to catastrophic failure, this will raise reliability concerns. Innovators should consider how to minimize or remove the potential for catastrophic failure by optimizing the design of the innovation.

12 If your innovation relies on the delivery of services or materials to be successfully operated during a hazard event, this may raise reliability concerns. Innovators should consider this in the design of their innovation and work with end-users to reduce such vulnerabilities.

13 If your innovation requires on the execution of tasks by humans to be successfully operated during a hazard event, this may raise reliability concerns. Innovators should strive to minimize the potential for failure due to human error (e.g., by optimizing the operation and maintenance protocols or requiring execution by trained experts).

14 If the innovation's vulnerability to human error cannot be easily reduced, this may raise reliability concerns. Innovators should consider how to remove potential for human error in the design of their innovation (for example, by automating processes or removing human decision points).

15 A monolithic innovation raises some concerns as it may be difficult to deploy/build in other locations throughout Europe. Innovations which are modular can more easily be distributed/marketed at all locations where the hazard is present. Furthermore, as in the case of some mobile innovations, some modular innovations can be used by a single end-user at multiple locations during different hazard events, making them more attractive (and flexible) than monolithic innovations.

16 An innovation's exploitability will increase, the more easily it can be adapted to different implementation contexts. If your innovation requires additional testing or substantial upgrades to be marketed or used at different sites in Europe, this may negatively affect its exploitability.

17 If the size of the market for your innovation will be substantially reduced by climate change, this may raise some exploitability concerns. Innovators should consider the impacts of climate change on the size of their market in the design of their innovations.

18 If relevant end-users or implementation contexts have not yet been identified, this may raise some exploitability concerns. Involvement of end-users in formulating design specifications will aid implementation. Therefore, innovators should strive to identify implementation contexts and develop contact to potential end-users during the early stages of the design of their innovation.

19 Multi-functional innovations have arguably more exploitation potential. For example, innovations which have co- or secondary-benefits (e.g., innovations which increase energy production or decrease an end-user's reliance on fossil fuels) or perform a secondary function during non-hazard times (e.g., have recreational value or boost tourism) have higher exploitation potential than those which only perform a single function.

While not all of these issues require the innovator to take action (and some may not be relevant for a given implementation context), they are intended to help increase the innovator's awareness of potential technical concerns. By scoring themselves against conventional measures and other innovations which promise the same or similar benefits, the innovator will gain perspective of how their innovation may perform in the European market in the context of its technical design.

Technical Readiness Level (TRL) scales

Based on the answers to the questions listed in Table 1 above, an innovator may choose to make changes to the original design of the innovation. An adjusted TRL Scale which lists key tasks related to the readiness of climate adaptation innovations has been included in a separate spreadsheet to help guide innovators through R&D. When testing, an innovator should refer to the checklist to assess the technical readiness of their innovation. Note that this TRL Scale assumes that when entering BRIGAID an innovator is at or has already achieved TRL 4 (prototype) and is striving to reach TRL 8 (demonstration) (see Figure 3).

Significant changes to the original design of the innovation, based on the answers to the societal, technical, or environmental questions, or because significant negative impacts are foreseen based on the questions related to sectoral impacts, may require that the innovator returns to TRL 1-3 or an earlier testing phase (e.g., laboratory testing). An innovator should be weary of proceeding too far in the TRL Scale and becoming entrenched before screening their innovation using the TIF Toolbox.

For more detailed guidance related to testing in each phase, innovators are encouraged to refer to the methods document and references included therein.

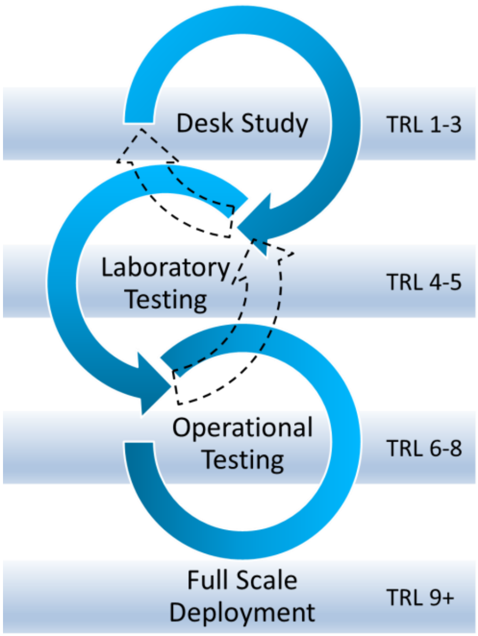


Figure 3: Conceptual model showing the four testing phases based on TRL definitions (see TIF method document).

3. Environmental impacts assessment

Climate adaptation innovations are designed to mitigate safety risks (for people, properties or infrastructure), but can also affect their environment (including nature and ecosystems). A positive impact of an innovation on the environment (such as an increase in nature area, or reduced energy demand) may lead to support for the development, speed up the market uptake and the implementation of your innovation. It may even help to find funding to further develop your innovation. In order to get insight in the potential impact of an innovation, the foreseen impacts has to be compared with the present situation (i.e., reference situation, which may already be altered by previous adaptation measures) and to the business as usual approach over the short and long-term. It is important to note that the effect of climate change and the local, regional, and national impact(s) of an innovation will be highly dependent on the geographic location.
Because adaptations may have negative trade-offs on the environment, the environmental impacts are scored on a scale from -1 to 1.

Direct impacts are those caused by the preparation, construction, or operation of an innovation at a particular location. Indirect impacts are those that occur away from the location of the innovation (in space or in time) as a consequence of the implementation or operation of an innovation. The construction or the operation of an innovation may result in a temporary (short or long term) disturbance of the environment. Some impacts may be reversible with additional efforts when the innovation would be removed. Other impacts on the environment may be permanent (e.g. when some species disappear from a location, they may never return).

If on forehand is clear that an innovation will have significant effects on the environment (e.g. the construction of a dike or a water retention area), or that implementation of innovation will need substantial space (that is for instance, currently designated as nature area), than there is likely a legal requirement for an Environmental Impact Assessment (EIA). For an EIA more advanced analyses than the TIF-Tool is needed. In an EIA the impact of the plan or project must be compared with some alternative solutions. An EIA normally requires a substantial amount of detailed information on several topics (amongst other on species and habitats), supplied and analysed by experts. Information on EU's laws on Environmental Impact Assessment of major projects and of public plans and programs together with other related information can be found on www.ec.europa.eu/environment/eia. Furthermore each EU country provides its own information on national EIA obligations (see national websites on Environmental Impact Assessment).

Regarding the impact on the environment, sustainability forms an important ambition for climate change innovation. Sustainable innovations are not harmful to the environment nor depleting natural resources, and support long-term ecological balance. Sustainability can be described as the endurance of systems and processes. Healthy ecosystems and environments are necessary to the survival of humans and other organisms.

After completing the environmental screening questions (Figure 4), innovators can refer to the interpretations provided in the next section.

1	**Environmental Design**	
1.1	Does the innovation deliberately use ecosystems and their services, or mimic or preserve natural processes? (A) Yes (B) No, and the innovation may hinder natural processes or services provided by ecosystems, (C) No, but the innovation does not affect the ecosystems present nor natural processes	A
1.2	How does the change in footprint (area) required for implementation on-site compare to conventional measures or the present situation? (A) Increase space required (B) Decrease space required (C) No Impact on space required	A
1.3	How does the construction or operation of the innovation affect the quantity of greenhouse gases in the environment (e.g., as CO_2 or CH_4)? (A) Increase (B) Decrease (C) No Impact	A
1.4	Is the innovation made from recycled or recycable materials? (A) Yes (B) No, it is made of non-recyclable materials (C) Partly	A
1.5	Does the innovation include specific design features or components which preserve or enhance ecosystem services? (A) Yes (B) No, and the innovation may hinder natural processes or services provided by ecosystems (C) No, but the innovation does not affect the ecosystems present nor natural processes	A
2	**Environmental Impact**	
2.1	How does the innovation impact the quality of surface water? (A) Improve (B) Worsen (C) No Impact	A
2.2	How does the innovation impact the quantity of available surface water? (A) Increase (B) Decrease (C) No Impact	C
2.3	How does the innovation impact the quality of ground water? (A) Improve (B) Worsen (C) No Impact	A
2.4	How does the innovation impact the quantity of available ground water? (A) Increase (B) Decrease (C) No Impact	B
2.5	How does the innovation impact the quality of the sea water? (A) Improve (B) Worsen (C) No Impact	B
2.6	How does the innovation impact soil quality? (A) Improve (B) Worsen (C) No Impact	B
2.7	How does the innovation impact air quality? (A) Improve (B) Worsen (C) No Impact	B
2.8	Does the implementation (or construction) of the innovation generate debris? (A) Yes (B) Debris can even be stored or captured by the innovation (C) No	A
2.9	Does the implementation (or construction) of the innovation generate noise or vibration? (A) Yes (B) It even dampens noise (C) No	A
2.10	How does the innovation impact landscape quality? (A) Improve (B) Worsen (C) No Impact	A
3	**Ecological Impact**	
3.1	How does the innovation impact the spatial extent of protected nature area? (A) Increase (B) Decrease (C) No Impact	B
3.2	How does the innovation impact the quality of protected habitats? (A) Improve (B) Worsen (C) No Impact	A
3.3	How does the innovation impact the number protected species (e.g., birds, vegetation, fish, mammals)? (A) Increase (B) Decrease (C) No Impact	A
3.4	How does the innovation impact the spatial extent of non-protected nature area? (A) Increase (B) Decrease (C) No Impact	B
3.5	How does the innovation impact the quality of non-protected habitats? (A) Improve (B) Worsen (C) No Impact	B
3.6	How does the innovation impact the number non-protected species (e.g., birds, vegetation, fish, mammals)? (A) Increase (B) Decrease (C) No Impact	C

Figure 4: Tab Environmental Impact

Explanation questions on environmental impacts

1 Environmental Design

1.1 Nature-based Solutions: A special type of innovative adaptation measures (with an increasing interest of e.g. the European Commission) are Nature-based Solutions. They deliberately use ecosystems and the services they provide, and/or natural processes (like water retention, water storage, buffering of floods, wave damping, changing wildfire conditions (e.g. by removing burnable material), changing soil conditions, providing shade etc.) to address societal challenges such as climate change or natural disasters. Nature-based Solutions are often used in conjunction with other types of interventions.

1.2 Areal Footprint: the physical implementation of the innovation may require space at its implementation location that is currently used for other purposes. This may result in resistance.

1.3 Carbon Footprint: the construction, transportation to its implementation location, and/or application of the innovation may result in additional CO2 emissions compared with the current situation. The use of local materials may reduce transportation, and subsequently the amount of carbon dioxide released. Implementation may be favoured if an innovations forms a sink for carbon dioxide (e.g. because the innovation increases permanent vegetation development that could store carbon dioxide).

1.4 Resource Footprint: recycling and recyclability fits in the Circular Economy concept and in the Cradle to Cradle concept. A Circular Economy is a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling. Cradle to Cradle pertains a "closed loop" approach to production processes, where waste forms a resource for production. The innovation is made of recyclable materials.

1.5 Footprint on the Services provided by the natural Ecosystem: The natural environment offers besides its intrinsic value, a broad range of benefits for human beings, such as the provision of products (e.g. food, fibres, wood, fresh water, medicines), regulation of temperature, nutrients, waste, water, and greenhouse gasses, supporting services, such as nutrient cycles and crop pollinations, and providing cultural and amenity values (e.g. recreation, tourism, inspiration, spiritual). These benefits are called ecosystem services. An innovation may affect these ecosystem services provided by the natural environment.

2 Environmental Impact

Environmental quality is a set of properties and characteristics of the environment (water, soil and air). It forms a measure of the condition of the environment. In the EU the environmental quality is protected from pollution by several EU and national regulations and standards and it is monitored by governmental agencies. Pollution can be defined as the addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form.

2.1 Surface Water Quality: the construction, implementation, and/or application of the innovation may affect aquatic ecosystems, drink water production, health situation, availability of water for irrigation, fish production, tourism, etc. by producing pollutants like nutrients, oil spilling, chemicals, salt, plastics, or an increase in water temperature, etc.

2.2 Surface Water Quantity: the construction, implementation, and/or application of the innovation may also affect the water quantity by using water, streamlining extreme discharges, buffer and/or store extreme discharges.

2.3 Ground Water Quality: an innovation may affect ground water quality by producing pollutants like nutrients, oil spilling, chemicals, salt, etc.

2.4 Ground Water Quantity: an innovation may also affect ground water quantity by using water, affecting the ground water level, retention of freshwater, etc.

2.5 Sea Water Quality: the construction, implementation, and application of an innovation may affect sea water quality by releasing pollutants like nutrients, oil spilling, chemicals, plastics, which in return may result in an impact on marine ecosystems, fish production, tourism, health situation, etc.

2.6 Soil Quality: an innovation may affect soil properties such as nutrient status, salinity, and water holding capacity. These are important for terrestrial ecosystems, agricultural and forestry production, health situation, etc. Furthermore, soil support buildings and roads.

2.7 Air Quality: air quality is important for the health situation, and air pollution can result in diseases, allergic reactions and even deaths. Furthermore, air pollution may affect buildings. An innovation may (temporarily or permanently) produce air pollutants like chemicals, particulates (e.g. dust), biological molecules, etc. (NB Carbon Dioxide is already included in the Carbon Footprint question).

2.8 Debris: an innovation may result in debris. Some debris is easily recyclable, while other debris may need further processing or must be stored.

2.9 Noise: during construction or implementation, the innovation may result in temporarily noise. However, some innovations may result in permanent noise during application.

2.10 Landscape Quality: An innovation may affect the visible features (like hydrological or ecological aspects, settlement patterns, cultural history, scenic characteristics, or land use patterns) of an area of land, its landforms, and how they integrate with natural or other man-made features.

3 Ecological Impact

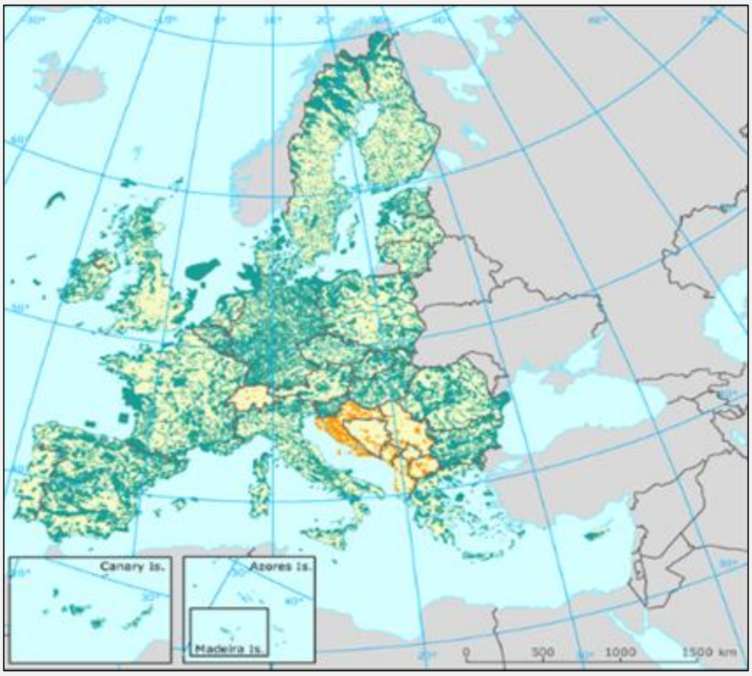
The conservation of biodiversity, restoration of nature, and greening the economy and the society as a whole to make them more sustainable are important ambitions of the EU. 'Green' aspects will certainly favour implementation of the innovation.

3.1 Nature Conservation: innovations may result in an impact on the size of protected nature area. Such an innovation will certainly encounter legal resistance, and probably lead to the requirement of detailed ecological analysis and the obligation to compensate the affected nature values by developing a new nature area.

Due to its physical geography and the long history of cultural development, Europe harbours a broad variety in ecosystems (e.g. Cropland and grassland, Woodland and forest, Heathland and shrub, Sparsely vegetated land, Wetlands, Rivers and lakes, Marine, Urban, Mountains, Islands, see http://biodiversity.europa.eu/topics/ecosystems-and-habitats/grasslands).

Several of these areas are designated as EU Natura 2000 sites. Natura 2000 is an EU-wide network of nature protection areas established under the Habitats Directive and Birds Directive. The aim of the network is to ensure the long-term survival of Europe's most valuable and threatened species and habitats. It is comprised of Special Areas of Conservation (SAC) designated by Member States under the Habitats Directive and Birds Directive. Water quality is protected by EU's Water Framework Directive. Furthermore, on a national scale areas are designated as nature area, nature reserve, national park, or protected landscape.

Maps and information available on e.g. http://natura2000.eea.europa.eu/# provide a first impression of the nature values present.



3.2 Nature Conservation: innovations may result in an impact on the quality of habitats in the protected nature area, and cause a shift from one habitat towards another habitat.

3.3 Protected species: Many European wildlife species (birds, vegetation, fish, mammals, other animals) are increasingly in danger. Therefore, the EU aims to protect all species facing particular threats by e.g. the EU Habitats (Habitats Directive 92/43/EEC) and Birds Directive (Directive 2009/147/EC), in which over 1.000 animal and plant species are mentioned. NB: Because of the diversity and complexity of ecosystems, the help of experts may be needed to identify if and which protected species are present at a certain location, and to assess how the innovation may affect these species.

3.4 Non-protected nature (size): Not all nature in Europe is protected by international (Natura 2000 area) or national legislation (e.g.as designated nature area, nature reserve, national park, or protected landscape). Implementation of innovations in these areas may expect no legal hurdles forthcoming from nature conservation agreement and less resistance than in protected nature areas. If an innovation would result in an increase of nature, then it will probably meet societal support.

3.5 Quality of the non-protected habitats: Ex-ante identified positive co-benefits of the innovations for non-protected habitats could result in a swift implementation of the innovation.

3.6 Impact on the number of non-protected species: an increase in the number or the variety of species could result in support from the general public and the government.

4. Sectoral impacts assessment

Climate Adaptation Innovations are designed to directly offset the effects of climate change in socio-economic sectors like agriculture, energy, forestry, health, infrastructure or tourism. However, they may also have (unintended or unforeseen) co-benefits or trade-offs in others. All impacts must be compared with the present situation (i.e., reference situation) and to the business as usual approach over the short and long-term. Because adaptations may have negative trade-offs, the sectoral impacts are scored on a scale from -1 to 1.

> Direct impacts are those caused by the preparation, construction, or operation of an innovation at a particular location. Indirect impacts are those that occur away from the location of the innovation (in space or in time) as a consequence of the implementation or operation of an innovation. The construction or the operation of an innovation may result in a temporary (short or long term) disturbance of socio-economic sector. Some impacts may be reversible with additional efforts when the innovation would be removed, while other impacts may be permanent.

It is important to note that the effect of climate change and the local, regional, and national impact(s) of an innovation on the different socio-economic sectors will be highly dependent on the implementation of the innovation at a specific geographic location. Its impact will also depend on the duration and severity of a hazard event together with the exposure, vulnerability and resilience of the socio-economic sector(s) and their components.

1	Agriculture	
1.1	How does the innovation impact the total area available for agricultural production? (A) Increase (B) Decrease (C) No Impact	A
1.2	How does the innovation impact agricultural production conditions (e.g., by increasing soil quality or water availability)? (A) Improve (B) Worsen (C) No Impact	A
1.3	How does the innovation impact the variety of agricultural products (e.g., crops, dairy, meat, fruit, fish, aquaculture) that can be produced or are available? (A) Increase (B) Decrease (C) No Impact	B
1.4	How does the innovation impact the total yield of one or more agricultural products? (A) Increase (B) Decrease (C) No Impact	C
2	Energy	
2.1	How does the innovation impact the energy production capacity (e.g., by generating energy or increasing energy distribution)? (A) Increase (B) Decrease (C) No Impact	B
2.2	How does the innovation impact the reliability of energy production (e.g. by improving cooling water conditions for energy plants)? (A) Increase (B) Decrease (C) No Impact	B
2.3	How does the innovation impact the efficiency of energy production? (A) Increase (B) Decrease (C) No Impact	B
2.4	How does the innovation impact the carbon footprint of the end-user? (A) Increase (B) Decrease (C) No Impact	B
3	Forestry	
3.1	How does the innovation impact the total area available for wood production (including timber and biomass)? (A) Increase (B) Decrease (C) No Impact	A
3.2	How does the innovation impact wood production conditions (e.g., by increasing forest resilience or water availability)? (A) Improve (B) Worsen (C) No Impact	A
3.3	How does the innovation impact the total area available for non-wood production (including cork, fruit, honey, mushrooms, pastures, game and fishing)? (A) Increase (B) Decrease (C) No Impact	A
3.4	How does the innovation impact non-wood production conditions (e.g., by increasing forest resilience or water availability)? (A) Improve (B) Worsen (C) No Impact	C
4	Health	
4.1	How does the innovation impact the number of fatalities in the area exposed to the hazard? (A) Increase (B) Decrease (C) No Impact	B
4.2	How does the innovation impact the number of people affected by the hazard in their physical health (i.e., number of people injured)? (A) Increase (B) Decrease (C) No Impact	B
4.3	How does the innovation impact the number of people affected by the hazard in their mental/psycho-social health? (A) Increase (B) Decrease (C) No Impact	B
4.4	Does the innovation emit or release chemicals or products that are harmful to humans? (A) Yes (B) It can even capture harmful substances (like small particles) (C) No impact on concentration of chemicals or harmful products	C
5	Infrastructure	
5.1	How does the innovation impact the quality of the built environment (I.e., residential, commercial, and industrial)? (A) Improve (B) Worsen (C) No Impact	B
5.2	How does the innovation impact the total area available for urban development? (A) Increase (B) Decrease (C) No Impact	A
5.3	How does the innovation impact the capacity of existing transportation systems (e.g., roads, railways, waterways, and airports) or create new capacities? (A) Increase (B) Decrease (C) No Impact	A
5.4	How does the innovation impact the reliability of existing transportation systems (e.g., roads, railways, waterways, and airports)? (A) Increase (B) Decrease (C) No Impact	B
5.5	How does the innovation impact the transport capacity of critical infrastructure networks (e.g., power, water, waste management)? (A) Increase (B) Decrease (C) No Impact	A
5.6	How does the innovation impact the reliability of critical infrastructure networks (e.g., power, water, waste management)? (A) Increase (B) Decrease (C) No Impact	A
6	Tourism	
6.1	How does the innovation impact the total area available for recreational activities? (A) Increase (B) Decrease (C) No Impact	A
6.2	How does the innovation impact the attractiveness of the area for recreational activities? (A) Increase (B) Decrease (C) No Impact	A
6.3	How does the innovation impact the length of the tourist season? (A) Increase (B) Decrease (C) No Impact	A

Figure 5: Tab Sectoral Impact

After completing the sectoral screening questions (Figure 5), innovators can refer to the interpretations provided in the next sections.

1 Agriculture

1.1 If an innovation needs area that is currently used for agricultural production, then its implementation may lead to resistance among farmers, and implementation could lead to an obligation to compensate the affected landowners.

1.2 If your innovation could improve local agricultural production conditions e.g. by increasing freshwater availability, improving the groundwater table, preventing damage by temporal flooding, or increasing the soil quality, then your innovation will probably meet support from farmers.

1.3 If your innovation could lead to an increase in the variety of agricultural products that could be produced, then this may result in interest of farmers or consumers for your innovation. However, when new products do require new expertise or additional investments, such interest may be very modest, or result in a demand for agricultural innovation.

1.4 If your innovation results in increased yield, e.g. by improving local production conditions, or improving harvest conditions or methods, then your innovation probably will meet support from local farmers.

2 Energy

2.1 If your innovation generates energy (e.g. a device that harvest wave energy) or sources for energy production (e.g. biofuel), or offers space for energy production (e.g. wind turbines or solar panels), then it probably meet support from the energy sector, the government, and the general public.

2.2 Research has shown that climate change may affect power generation by decreasing water availability and increasing ambient air and water temperature, which reduces the efficiency in cooling. If your innovation improves cooling water conditions for energy plants, then it will probably meet support from the energy sector and the government.

2.3 If your innovation improves the efficiency of energy production, then it will probably meet support from the energy sector and the government.

2.4 The energy sector is the largest contributor to global GHG emissions. If the innovation results in less greenhouse gas emission by the energy sector than in the current situation, or forms a sink for carbon dioxide, then it probably will be meets societal support and support from the energy sector.

3 Forestry

3.1 If an innovation needs area that is currently used for wood production, then its implementation may lead to concern from the forestry sector, and implementation could lead to an obligation to compensate the affected wood producers.

3.2 If your innovation would lead to improved resilience of a forest against climate change (e.g. by improving surface water management conditions, improving the groundwater table, preventing damage by temporal flooding, or increasing the soil quality) then your innovation probably result in support from the forestry sector.

3.3 If your innovation cost area that is currently in use for non-wood productions such as cork, fruit, hone, mushrooms, pastures, game, or fish, then it will meet concern from forest owners and users, and implementation could lead to an obligation to compensate the affected non-wood producers.

3.4 If your innovation would result in improved production conditions for non-wood products such as cork, fruit, hone, mushrooms, pastures, game, or fish, then your innovation probably result in low resistance or even in support from forest owners and users.

4 Health

4.1 If your innovation could decrease the potential numbers of fatalities of climate change related hazards (e.g. by reducing the risk of drowning during a flood, by a cooling effect during heat waves, by improving air and or water quality during heat waves), then it will probably be supported by the health sector, the government, and the general public.

4.2 If your innovation could reduce the impact of hazards on the physical health of affected people (e.g. by reducing the impacts of floods, by a cooling effect during heat waves, by improving air and or water quality during heat waves), then it will it will probably be supported by the health sector and the general public.

4.3 Climate change related hazard may result in stressful conditions for human beings, such as a high night temperature during heat waves (which may impact sleep). If your innovation could reduce the impact of climate related hazards (e.g. by reducing the urban heat effect due to the cooling effect of vegetation, the urban wind pattern, or water bodies) on the mental/psycho-social health of affected people, then it will it will probably not meet resistance by the health sector or the general public.

4.4 If your innovation emits or release chemicals or products that are harmful, then this may result in resistance, and it is recommended to adjust the design in order to prevent or reduce the emittance of these chemicals.

5 Infrastructure

5.1 If the innovation improves the quality of the built environment (e.g. by a urban design that deliberately uses trees to provide shade, or green roofs or walls to cool buildings or to store rainwater, or to develop green water retention areas), then it will probably meet less resistance, or even support from local residents or the local government.

5.2 If the innovation needs area that is currently in use for urban development, then it will probably meet resistance from the infrastructural sector, and implementation could lead to the appointment of another area for urban development, or an obligation to compensate the affected stakeholders.

5.3 If the innovation does increase existing transportation capacity or create new transportation possibilities (e.g. roads, railways or energy transportation networks integrated in flood defences), then it is likely to meet less resistance, and even receive support from the transportation sector and the government.

5.4 If the innovation results in a higher reliability of the existing transportation systems (e.g. by reducing the time that a road or railway is flooded, or by reducing the potential damage by erosion due to flooding to roads and railways), then it will probably meet few resistance, or even support from the general public and the transportation sector.

5.5 If an innovation results in a decrease in the power, water or waste management infrastructure, then it may not be accepted, and the innovator is advised to adjust the design.

5.6 If an innovation results in a less reliable infrastructure, then the innovator is advised to adjust the design.

4.6 Tourism

6.1 If an innovation needs area that is currently used for recreational activities, then it will probably meet resistance, while an innovation that results in more recreational area (e.g. a green water retention area, or water square in the urban area), will probably meet support.

6.2 If an innovation improves the recreational attractiveness of an area, e.g. by creating nature area or walking paths, then it will probably not lead to public resistance, and could create opportunities to strengthen or to develop the tourist sector.

6.3 If an innovation would lead to an extended tourist season (e.g. by offering new recreation possibilities outside the normal tourist season) then it will probably generate support among the general public and the tourist sector.

5. Societal acceptance assessment

After completing the societal acceptance questions (Figure 6)innovators can use this guidance to interpret their results and identify possible societal acceptance concerns for their innovations. Scores range from 0 to 1.

The questions in the Societal Section 1 are yes or no questions. They test particular issues or sets of issues associated with the themes of issues described in the TIF method document: psychological concerns, inflexibility concerns, usability concerns and responsibility concerns. Depending on how an innovator responds to these questions they will have either given a response associated with higher public concern or a response associated with lower public concern.

	Societal Acceptance assessment NB: all questions are applicable for all type of innovations (please fill in an answer for each question)!	
	Answer the following 16 questions by writing Yes or No in the corresponding cells. These questions apply to ALL types of adaptations.	**Yes or No?**
1	Does your innovation use any materials that might be considered unfamiliar (such as nanomaterials or genetically modified materials)?	Yes
2	Will members of the public affected by your innovation be the ones to decide whether or when to use it?	Yes
3	Does your innovation involve visible infrastructure (such as physical barriers) or visible land use changes (such as woodland removal)?	Yes
4	Could the use/deployment of your innovation disrupt daily activities, for example through road closures?	Yes
5	Does your innovation require large amounts of capital investment relative to other adaptations in the sector?	Yes
6	Does your innovation require a long lead time between users placing an order and it becoming operational?	Yes
7	Does your innovation require new infrastructure or significant changes to existing infrastructure?	Yes
8	Does your innovation involve releasing any materials into the environment (such as sprays or coatings)?	Yes
9	Are your potential users likely to have a single mission, for example to protect ecosystems?	Yes
10	Does your innovation take less time to use/deploy than incumbent alternatives (such as sand bags for floods or fire nozzles for wildfires)?	No
11	Would everyday users of your innovation require special training in how to use it?	No
12	Will your organisation provide help and support to users of your innovation?	No
13	Innovations can either reinforce or change users' existing ways of working. Does your innovation reinforce existing ways of working?	No
14	Are the effects of your innovation directly publicly tangible (such as seeing flood defences working or hearing a warning alert system)?	No
15	Adaptations can either be used/deployed permanently or temporarily. Is your innovation deployed permanently?	No
16	Is any personal data associated with the adaptation shared with others, for example other companies? If your innovation uses no personal data, select 'No'	No
17	Is any personal data associated with the adaptation held securely, for example in an encrypted database? If your innovation uses no personal data, select 'Yes'	No
18	Are members of the general public involved in shaping the research, development, demonstration and deployment of your innovation?	Yes
	Answer the following 4 questions by writing A, B or C in the corresponding cells.	**A, B or C?**
19	What would your innovation primarily protect (either directly or indirectly)? (A) public infrastructure, (B) private properties and assets, or (C) the environment	A
20	Who would pay for your innovation? (A) government authorities, (B) private companies or (C) local communities	B
21	Who would implement your innovation? (A) government authorities, (B) private companies or (C) local communities	A
22	How would compensation be made in the event of your innovation failing? Through (A) government compensation, (B) project insurance or (C) responsible parties	C

Figure 6: Tab Societal Acceptance

Innovators can now explore specific areas of societal concern by consulting the guidance on answers to each question associated with higher public concern given in Table 2 below. The table includes material and organisational recommendations on how to alleviate those concerns and improve the performance of their innovation and its societal readiness.

Table 2: Responding to specific areas of societal concern

1	If your innovation uses unfamiliar materials (such as nanomaterials or genetically modified materials) it is likely to raise societal concerns. Psychological science shows that unfamiliar materials and novel impacts are associated with higher levels of public concern. Innovators should consider using familiar alternatives to lower societal concerns.
2	To the extent that members of the public affected by your innovation will not be the ones to decide whether or when to use it, it may raise public concerns. Psychological science shows that involuntary exposure and a lack of personal control is associated with higher levels of public concern. Innovators should consider recommending an appropriate level of public control over their innovation to those implementing the innovation to lower societal concerns.

3 If your innovation involves visible infrastructure (such as physical barriers) or visible land use changes (such as woodland removal), psychological science shows that it may raise public concerns. Innovators should consider developing unobtrusive infrastructure and avoid making land use changes near human settlements to lower societal concerns.

4 If the deployment of your innovation could disrupt daily activities, psychological science shows that it is likely to raise public concerns. Innovators should consider designs that work around daily activities to lower societal concerns.

5 If your innovation requires large amounts of capital investment, sociological research shows that it is likely to raise public concerns. Innovators should consider designs that do not require large amounts of capital investment to lower societal concerns.

6 If your innovation requires a long lead time between users placing an order and it becoming operational, sociological research shows that it is likely to raise public concerns. Innovators should consider ways of reducing lead times to lower societal concerns.

7 If your innovation requires new infrastructure or significant changes to existing infrastructure, sociological research shows that it may raise public concerns. Innovators should consider using existing infrastructure and minimising any changes to lower societal concerns.

8 If your innovation involves releasing any materials into the environment (such as sprays or coatings) it is likely to raise public concerns. Sociological research shows that unrecoverable releases and irreversible actions are associated with higher levels of public concern. Innovators should consider designs that do not release materials into the environment to lower societal concerns.

9 If your users are likely to have a single mission, for example to protect ecosystems, sociological research shows that they are likely to raise public concerns about your innovation. Innovators should consider targeting their innovation at users with plural missions or joint ventures between single mission users with different missions to lower societal concerns.

10 If your innovation takes as long or more time to deploy than incumbent alternatives (such as sand bags for floods or fire nozzles for wildfires) it is likely to raise public concerns. Management science shows that longer deployment times and delayed effects are associated with higher levels of public concern. Innovators should consider designs that take less time to deploy than incumbent alternatives to lower societal concerns.

11 If the use of your innovation require special training, management science shows that it is likely to raise public concerns. Innovators should consider designs that are less complex to lower societal concerns.

12 If help and support will not be available to users of your innovation, management science shows that it is likely to raise public concerns. Innovators should consider appropriate ways of providing help and support to users after they have procured your innovation to lower societal concerns.

13 If your innovation disrupts rather than reinforces existing ways of working, management science shows that it is likely to raise public concerns. Innovators should consider designs that minimise changes to existing ways of working to lower societal concerns.

14 If the effects of your innovation are not directly publicly tangible (such as seeing flood defences working or hearing a warning system) it is likely to raise public concerns. Management science and psychological research shows that unseen benefits,

unobservable effects and non-awareness of exposure is associated with higher levels of public concern. Innovators should consider designs that make the benefits of their innovation tangible.

15 If your innovation is deployed temporarily, management science shows that it is likely to raise public concerns. Innovators should consider designs that make their innovation a more permanent solution to lower societal concerns.

16 If personal data associated with the adaptation is shared with others, for example other companies, it is likely to raise public concerns. Management science shows that sharing personal data is associated with higher levels of public concern. Innovators should not share personal data with any third parties without first obtaining explicit prior consent.

17 If personal data associated with the adaptation is not held securely, it is likely to raise public concerns. Management science shows that insecurely held personal data is associated with higher levels of public concern. Innovators should hold personal data securely, for example in an encrypted database.

18 If members of the public are not involved in shaping the research, development, demonstration and deployment of your innovation it is likely to raise public concerns. Science studies and sociological research show that exclusion and closure to criticism are associated with higher levels of public concern. Innovators should consider ways of including members of the public and being open to criticism.

The questions in Societal Section 2 are multiple choice questions. They test particular issues associated with the sociocultural theme of issues described in the TIF method document. Depending on how an innovator responds to these questions they will have given a response that indicates their innovation is best suited to ‘technocratic’, ‘techno-optimistic’ or ‘techno-sceptical’ implementation contexts.

Innovators might now locate the intended implementation context of their innovation in a triangular space to help them think about where they are likely to meet societal support and where they are likely to meet societal resistance (see Figure 7).

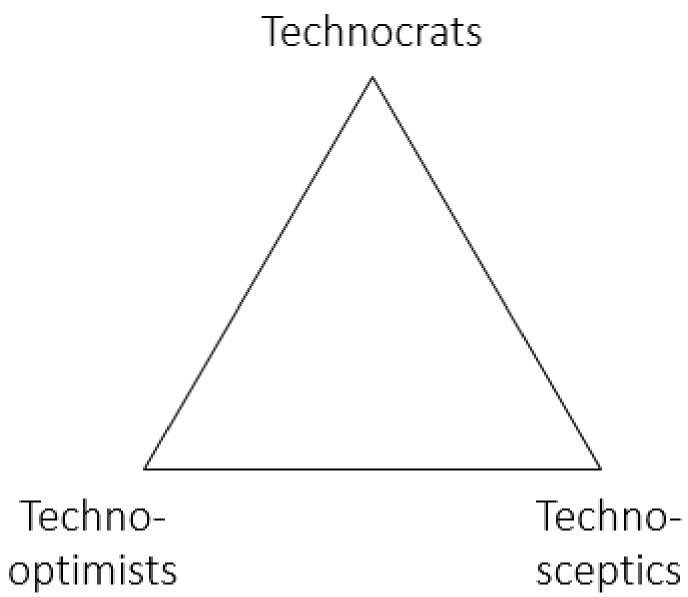


Figure 7: A space for matching technology characteristics with implementation contexts

Technocratic, techno-optimistic and techno-sceptical implementation contexts each hold unique preferences for particular sets of technology characteristics:

- Technocrats tend to prefer long-lasting, tried-and tested and large-scale technologies with a traditional aesthetic.
- Techno-optimists tend to prefer rapidly replaceable, cutting-edge and profit-maximising technologies with a striking aesthetic.
- Techno-sceptics tend to prefer environmentally benign, low-tech and small-scale technologies with a natural aesthetic.

Innovators might now also locate the technology characteristics of their innovation in the triangular preference space to help them think about where they are likely to meet societal acceptance and rejection. The aim of this exercise is to match preferred technologies with preferred implementation contexts:

- Bureaucracy enabling, long-lasting, tried-and tested and large-scale technologies are best used to protect public infrastructure, paid for and implemented by government authorities and held liable through government compensation.
- Individually enabling, rapidly replaceable, cutting-edge and profit-maximising technologies are best used to protect private properties, paid for and implemented by private companies and held liable through project insurance.
- Community enabling, environmentally benign, low-tech and small-scale technologies are best used to protect the environment, paid for and implemented by local communities and held liable through responsibly parties.

If the intended implementation context and set of technology characteristics do not match, innovators are likely to encounter societal resistances. For example, the implementation context may be technocratic, but the technology characteristics are preferred by techno-optimists. Innovators should consider changing either their implementation context or set of technology characteristics to make sure they match. If the implementation context and set of technology characteristics do match, innovators are likely to encounter societal acceptance where they match and resistances where they do not. For example, a technocratic implementation context and technocratic set of technology characteristics is likely to meet societal resistances from techno-optimists and techno-sceptics.

If innovators require a deeper analysis of the societal acceptance issues surrounding their innovation they will need to employ social scientific experts to directly engage the public using one or more established methods for eliciting public perceptions and preferences. A selection of these methods are described in the TIF method document, together with their typical strengths and weaknesses.