



IMPRESSIONS socio-economic scenarios

Deliverable D2.2

September 2016

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Prepared under contract from the European Commission

Contract n° 603416
Collaborative project
FP7 Environment

Project acronym: **IMPRESSIONS**
Project full title: **Impacts and Risks from High-end Scenarios: Strategies for Innovative Solutions**
Start of the project: 01 November 2013
Duration: 60 months
Project coordinator: NERC Centre for Ecology and Hydrology
Project website: www.impressions-project.eu

Deliverable title: IMPRESSIONS socio-economic scenarios for all case studies
Deliverable n°: D2.2
Nature of the deliverable: Report
Dissemination level: Public

WP responsible: WP2
Lead beneficiary: WU

Citation: Kok, K. & Pedde, S. (2016). *IMPRESSIONS socio-economic scenarios*. EU FP7 IMPRESSIONS Project Deliverable D2.2.

Due date of deliverable: Month 35
Actual submission date: Month 35

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Preface

In this Deliverable the socio-economic scenarios developed for IMPRESSIONS are presented. The selection procedure was described in Deliverable D2.1 ‘Evaluation of existing climate and socio-economic scenarios including a detailed description of the final selection’. The present deliverable reports on activities related to Task 2.2: Socio-economic scenarios: Design, methods and development of multi-scale participatory scenarios. The IMPRESSIONS climate scenarios are described separately in Deliverable 2.3.

This Deliverable has been produced through the contributions of many researchers in IMPRESSIONS, as well as a large number of other stakeholders across Europe. It reports on the qualitative socio-economic scenarios developed during a series of workshops and engagement activities taking place between workshops. We have chosen to list only two authors as the persons that assembled the text of the narratives of the various case studies and as writers of the other sections of the Deliverable. However, we want to explicitly acknowledge the work of the IMPRESSIONS team contributing to the discussion of the concepts and methods of scenario development, facilitating the workshops, and documenting the results.

Summary

This Deliverable documents the socio-economic scenarios that were developed for all IMPRESSIONS case studies: Europe, Scotland, Iberia, Hungary and Central Asia; the latter as part of the ‘indirect impacts (EUx)’ case study. Participatory methods formed the foundation of all scenario development processes through a series of stakeholder workshops and further engagement activities that took place in each case study. In all case studies, four scenarios were developed based on downscaling and extending four of the global Shared Socio-economic Pathways (SSPs): SSP1, SSP3, SSP4 and SSP5. The scenario elements were developed using two overarching scenario uncertainties (inequality and carbon intensity/GDP). Additional elements to the scenarios, such as other key uncertainties, narratives, quantitative projections and key trends of model variables were developed with both stakeholders (using participatory bottom-up approaches) and using existing models (largely top-down downscaling). The narratives and tables of key trends in uncertainties are provided for all scenarios and all case studies.

The sets of scenarios have also been analysed and a number of initial cross-scale observations are provided. It is essential to stress that these findings are preliminary and need to be discussed and checked with case study leaders and where possible a selection of stakeholders. In its present state, they should only be used as general indications of similarities and differences between SSPs and between case studies. Although findings are preliminary, results of the analysis seem to indicate that we have successfully married a top-down (downscaling of the global SSPs) and bottom-up (stakeholder-determined narratives) approach. In the very least, the sets of scenarios offer sufficient similarities (to enable comparison and integration) and differences (to make the effort worthwhile) to undertake a full cross-scale analysis (in Deliverable 2.4) and a final multi-scale workshop (in March 2018) within which findings will be discussed with stakeholders.

1. Introduction: Multi-scale socio-economic scenarios in five case studies

The overall objective of WP2 is to develop multi-scale, integrated climate and socio-economic scenarios for five case studies: Europe, Scotland, Iberia and Hungary and EUx (Central Asia). Deliverable 2.1 reported on the choice of the shared socio-economic pathways (SSPs) and representative concentration pathways (RCPs) as the starting point for scenario development in the case studies. This Deliverable reports on the activities related to Task 2.2 and includes the methods to develop socio-economic scenarios in each of the case study areas. The Deliverable serves three purposes; first and foremost, it documents the socio-economic scenarios that were developed for all IMPRESSIONS case studies. The regional SSPs have been used both to parameterise models and as context for (stakeholder) discussions on mitigation and adaptation actions, strategies and pathways. It is of utmost importance that the actual scenario products that were developed are properly documented. Second, it provides a short overview of the overall methodology that was followed. It is beyond the scope of this Deliverable to present the details of the methods followed for each case study. However, the stakeholder workshop process has been documented in Deliverable 6A.2. Finally, it presents an initial analysis of the sets of scenarios and a number of cross-scale observations from comparing and contrasting the scenarios across the different case studies.

For each case study, we include all the important elements of the socio-economic scenarios that were produced:

- A narrative;
- A table with key (story) elements;
- A table with trends for key (model) variables and Fuzzy Sets;
- A table with additional elements to connect scenarios to pathways (see Annex).

In general terms, the five sets of socio-economic scenarios (SSPs) for Europe, Scotland, Iberia, Hungary and Central Asia are based on the outcomes of a first series of facilitated scenario workshops (WS1) and follow-up questionnaires which were implemented between the first and second workshop series. In some cases, additional information was obtained during the second series of facilitated stakeholder workshops (WS2).

In chapter 2 we describe the participatory methods that formed the foundation of all scenario development processes. Chapter 3 reports on the elements which make up the socio-economic scenarios: narratives, summary of key narrative elements and quantifications. In chapter 4 we analyse the cross-scale framework of the scenarios in all five case studies and how they are interrelated. The annex contains a table with an extension of the socio-economic scenarios to provide contextual elements to the mitigation and adaptation pathways.

2. Methods

2.1. General overview

It is important to understand that the qualitative SSPs used as starting points are in fact not scenarios, but descriptions of the situation “in the 21st Century” with some indication as to which developments and key events have led to each situation (O’Neill et al., 2015). As such, the qualitative global SSPs are more like ‘proto-scenarios’. The socio-economic products documented here are full scenarios and therefore they rely as much on the information provided by the SSPs as on additional information

added by experts, existing scenarios, and stakeholders. The IMPRESSIONS process was designed to combine and balance downscaling the global SSPs with bottom-up participatory approaches.

There was a marked difference in developing scenarios between those case studies that were based on a continuation of an earlier project, CLIMSAVE, and those that were new additions. Because of the level of detail of the CLIMSAVE scenarios, and the availability in IMPRESSIONS of experts previously involved in the CLIMSAVE project, the IMPRESSIONS socio-economic scenarios for Europe and Scotland have been developed in an expert workshop, using the CLIMSAVE scenarios as an important source of information. For the other three case studies – Iberia, Hungary, and EUx (Central Asia) – scenarios were developed during a series of stakeholder workshops. Two out of three of the full workshop series (WS1 and WS2) have been held for Iberian, Hungarian and Central Asian scenarios (Table 1a; see Deliverable 6A.2 for further information on the stakeholder workshops).

Table 1: Process to produce (a) and elements belonging to (b) high-end socio-economic scenarios in the five IMPRESSIONS case studies: Europe, Scotland, Iberia, Hungary and Central Asia. The methodologies reflect the different scales, audiences and use of the scenarios.

(a) Case study/ Process	Europe	Scotland	Iberia	Hungary	Central Asia
Workshop 1	Experts	Experts	Stakeholders	Stakeholders	Stakeholders
In-between WS1 and WS2	None	Mini- workshop	Questionnaire	Mini- Workshop	Questionnaire
Workshop 2	Stakeholders	Stakeholders	Stakeholders	Stakeholders	Stakeholders, with extension to Russia and China
(b) Case study/ Scenario element	Europe	Scotland	Iberia	Hungary	Central Asia
Scenario axes	From global SSPs	From global SSPs	From global SSPs	From global SSPs	From global SSPs
Other key Uncertainties	From global SSPs and CLIMSAVE	From global SSPs and CLIMSAVE	Stakeholder- determined	Stakeholder- determined	Stakeholder- determined
Narratives	From global SSPs and CLIMSAVE	From global SSPs and CLIMSAVE	Stakeholder- determined	Stakeholder- determined	Stakeholder- determined
Quantitative projection on GDP and population	SSP database	Stakeholder- determined	SSP database	SSP database	Stakeholder- determined
Key trends for model variables and Fuzzy Sets	Expert opinion	Expert opinion	Stakeholder- determined	Stakeholder- determined	Stakeholder- determined

In all case studies, the scenario elements have been developed using two overarching scenario uncertainties which, in turn, are based on scenario archetypes (Table 1b; see Section 2.2). The subsequent elements, such as all other key uncertainties, narratives, quantitative projections and key trends of model variables are developed with both stakeholders (participatory bottom-up approaches) and existing models (largely top-down downscaling) to reflect the different scales in the case studies. Table 1 presents some of the aspects of the scenarios and main methods used to develop elements of the socio-economic scenarios in the five case studies.

2.2. Overall method

2.2.1. Multi-scale consistency

In Deliverable D2.1, we documented the assessment of existing climate and socio-economic scenarios at multiple scales and the selection procedure for the starting set of scenarios. The scenarios selected were the global scenarios consisting of Representative Concentration Pathways (RCPs) and Shared Socio-economic Pathways (SSPs). The socio-economic scenarios in all case studies are based on the SSP logic described in O'Neill et al. (2015) and Deliverable D2.1, with a different degree of matching as described below.

For Europe, the match with SSPs was decided to be 'equivalent', i.e. where outcomes can directly be transferred across scales (Kok et al, in prep; Zurek & Henrichs 2007). This allows for the use of the global SSP database as a source of information to parameterise models. It also increases the potential usefulness of the Eur-SSPs and their potential for further downscaling or extension. The equivalent matching had three important consequences:

1. **Stakeholder participation needed to be limited** because we decided to match SSPs with existing CLIMSAVE scenarios (see Deliverable 2.1 for the method). To ensure equivalence, we organised an expert meeting using the same methods as in the participatory workshops, but exclusively involving scientific experts as participants. The other case study scenarios were developed during participatory workshops with about 20-25 stakeholders representing a broad spectrum of sectors and organisations (see Deliverable D6A.1 for criteria for stakeholder selection in the workshops). Such scenarios are stakeholder determined and thus cannot be guaranteed to be equivalent to the global SSPs.
2. **The global SSPs were leading** because the global scenarios needed to take precedence over the existing European CLIMSAVE scenarios in case of inconsistencies between the two sets. As a result, the existing European scenarios could only be consistent or sometimes coherent with the new Eur-SSPs.
3. **Eur-SSPs were constructed to be general.** Equivalence, based on higher-level scenarios can most easily be achieved when aiming for a scenario product without much spatial or sectoral detail (Figure 1).

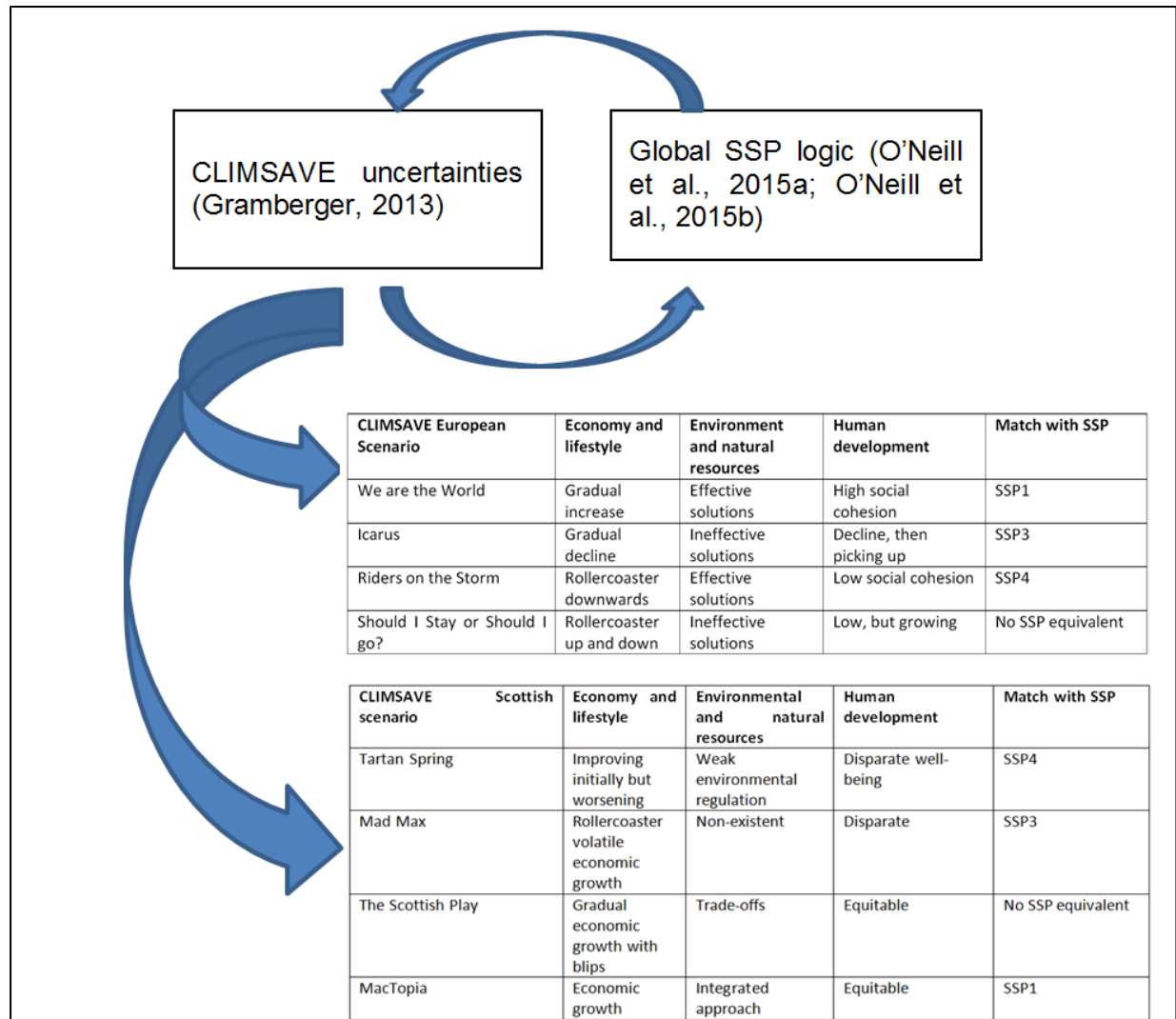


Figure 1: Match of SSP logic with CLIMSAVE European and Scottish socio-economic scenario uncertainties. The basic global SSP elements are ‘Economy and lifestyle’, ‘Environment and natural resources’ and ‘Human development’.

For all the other case studies, the match with the SSPs was designed to be more flexible or ‘coherent’ at the case study scale (Kok et al in prep.) in that the scenarios combine stakeholder-led narratives and key elements from the SSPs. These scenarios can therefore partly ‘mismatch’ with the global SSPs. Due to the different priorities and scales in the case studies, the scenario development process was designed according to the ‘controlled divergence of approaches’ principle. According to this principle, the overall coherence with the SSPs is maintained while each scenario set starts at different points with different stakeholders (see Deliverables D2.1 and D6A.2).

A series of workshops was designed for all case studies where scenarios had to be developed ‘from scratch’ (see Deliverables D2.1 and D6A.2).

2.2.2. First workshop series: the production of case study specific SSPs

For Iberia, Hungary and Central Asia, the first workshop’s main objective was to have stakeholders develop their own scenarios while contextualising them within a set of higher-level existing SSPs (either European or global). For the Scottish case study, a mini-workshop was organised instead of a

full WS1 because existing CLIMSAVE scenarios were used to produce a first draft of Scottish SSPs. The mini-workshop was designed to increase legitimacy and buy-in of stakeholders for three well-matching scenarios (SSP1, SSP3, and SSP4), and to develop 'from scratch' the Scottish version of SSP5. More specifically, the first workshop series (Deliverable D6A.2) was designed to yield the input for scenario narratives, uncertainty tables and quantifications.

Each workshop started with a discussion on the main factors that influenced the case study. These main factors were grouped into similar clusters. Stakeholders then voted on the importance and degree of uncertainty of each cluster to determine the two main uncertainties to be selected as the main factors that should shape the development of the socio-economic scenarios. These were then compared to the four SSPs. In all cases, there was a good match between selected uncertainties and the four SSPs. The main uncertainties were used to build simple conceptual models that showed the connections between factors and their mutual changes.

Narratives were developed by first familiarising all stakeholders with all SSPs, and subsequently subdividing the entire group into four sub-groups that further developed one of the SSPs, based on the location-specific uncertainties and a short summary of the SSPs.

As a last step, trends in key variables were quantified using Fuzzy Sets (Pedde et al., 2016). During most of the workshop, stakeholders discussed scenarios for their case study in three time slices (2010-2040, 2040-2070, 2070-2100). Stakeholders were asked to quantify some variables for these three time slices for the region of the case study. The stakeholders could provide ancillary information to explain trends for each of the variables, if deemed useful to understand the trends themselves. The variables were selected based on two criteria. Firstly, the variables mirrored the expertise of most of the invited stakeholders and fitted the key issues for the case study. Secondly, they provide guidance on the quantification of a much wider range of socio-economic variables used within the IMPRESSIONS impact models (Pedde et al., 2016). In addition to these model variables, stakeholders also quantified four capitals (human, social, manufactured and natural). Capital metrics are useful indicators of overall wealth in a society, the vulnerability of the system and the ability of the society to cope with, or adapt to, changing circumstances (Tinch et al., 2015).

2.2.3. Stakeholder engagement between workshops: iteration of narratives

The scenario development methodology was structured according to the Story and Simulation approach (Alcamo 2008), which entails iteration between stakeholders and scientists to revise narratives and climate change impact model simulations until their consistency is maximised (Van Vliet 2011). For this reason, the narratives and quantifications, elaborated from the WS1 series, were revised with stakeholders. Several forms of stakeholder interaction were employed across the case studies, including smaller-sized mini-workshops and using questionnaires (see Table 1). Mini-workshops took place for Hungary and Scotland. In Scotland, a workshop was needed to develop a Scottish version of SSP5 that could not be constructed based on the CLIMSAVE scenarios. In Hungary, the limited geographic extent of the case study was suitable for the organisation of a mini-workshop within the timeframe allocated for the engagement between the WS1 and WS2 series. For both Iberia and Central Asia, an additional intermediate workshop was deemed useful but would have been too difficult to organise with time and resource constraints, and a stakeholder questionnaire was circulated instead to revise narratives and quantifications, as well as providing ancillary information for impact modelling. For Europe, the purposefully low degree of stakeholder involvement in the equivalent Eur-SSPs was continued and there was no iteration with stakeholders prior to the second workshop.

2.2.4. Second workshop series: second iteration and extension

The revised narratives were presented in the second workshop series (WS2) as part of the 'integrated scenario context' that was needed for stakeholders to develop adaptation and mitigation strategies towards sustainability. The case study specific SSPs were presented together with climate change scenarios (see Deliverable D2.3) and modelled climate change impacts (Deliverables D3.1, D3A.1, D3B.1 and D3C.1) to provide the full context for identifying adaptation and mitigation responses.

During WS2, stakeholders had a final opportunity to revise minor elements of the socio-economic scenarios and to add specific responses that would help to contextualise adaptation and mitigation strategies. Those specific responses, however, are not presented here as they are only the context for the response strategies and not a formal part of the scenarios (they will be presented within Deliverable D4.2 due in January 2017). In many ways, the scenarios as developed prior to WS2 and as used to parameterise models were considered as final, allowing for changes but not encouraging them. In all cases, stakeholders by and large accepted the socio-economic context and focused discussions on the impacts rather than underlying assumptions.

2.3. Case study specific methods

An overview of the methods to develop case study SSPs is given in Table 1 and Figure 2. Figure 2 also lists some of the main outcomes in the narratives to illustrate case study specific issues.

2.3.1. European scenarios

European scenarios have been developed by matching SSP leading assumptions with CLIMSAVE scenarios. Because the European scenarios have been designed to be equivalent to global SSPs, the main issues identified in the case study reflect the macro global SSP as described in O'Neill et al. (2015). These issues are generic: population growth, economic development (GDP growth), technological efficiency and effective governance and international cooperation. The match of the categories (a), (b), (d) and (e) in Figure 2 between the global and European SSPs illustrates the equivalence of both products. The generic nature of the key issues in the European case study is also in line with the intent of the global SSPs, which is to provide boundary conditions to regional case studies.

2.3.2. National and local case studies (Scotland, Iberia, Hungary)

During the WS1 series, case study leaders and stakeholders identified different key/vulnerable sectors and issues within their case study, which are summarised in Figure 2. These issues are selected to define the socio-economic back-bone of the scenarios. They also represent the scales of each case study. Some of the key issues discussed by the stakeholders can be quantified with impact models. For example, transboundary river management in Iberia has been defined qualitatively and quantitatively by stakeholders, and was modelled and presented during the WS2 series. For the Scottish case study, the key issues were derived from the SSP-CLIMSAVE narrative match and from the input of the mini-workshop.

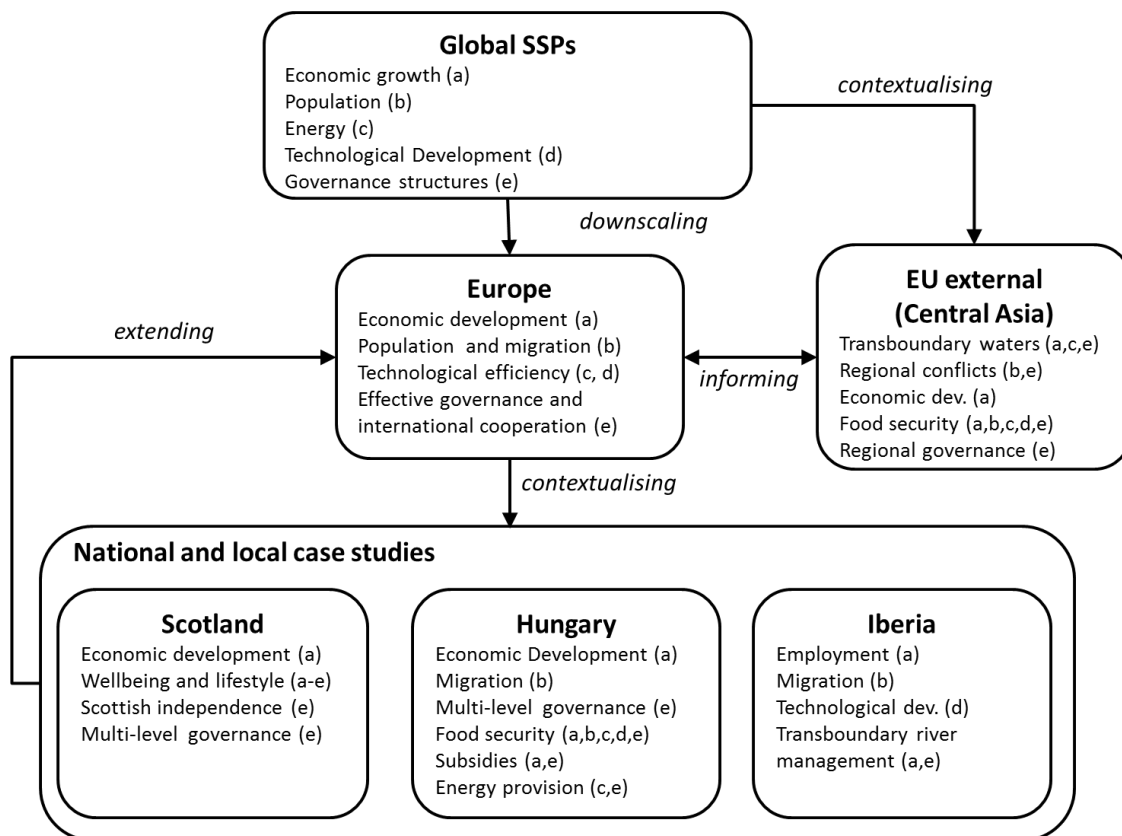


Figure 2: Multi-scale representation of the scenarios with key issues for each case study. The letters in brackets show the match with the key issue categories from the global SSP.

2.3.3. EUx (Central Asia)

The indirect impacts case study (EUx) is a special case and its overall method was somewhat dissimilar to the other regional case studies. WS1 was, however, very similar in set-up and execution and yielded scenarios for Central Asia which were later complemented with information on China and Russia, and the perspective of Central Asian countries on the role of Russia and China (see Annex 1). The key issues for Central Asia are rather generic but present the complexity and the cross-scale aspects of the national and local case studies (Figure 2, single issues in Central Asia often represent several global SSP categories). This is because, like Europe, the case study covers a vast and heterogeneous socio-geographic scope. However, unlike Europe, the case study is less well understood and studied, though its key issues can be easily connected in a conceptual model of the Central Asian system which aided the development of the scenarios.

For EUx, the stakeholder-led quantifications and assumptions prevail, as for the national and local case studies. This is also true in the case of conflicting assumptions with global Integrated Assessment Models, such as the trends for GDP and population growth for Central Asia.

The relation between the European and EUx case study, from a scenario perspective, is therefore strongly determined by the availability of information. Because very limited studies were available for Central Asia in the scientific literature, this case study is strongly led by the information provided by stakeholders.

3. Results: Socio-economic scenarios

3.1. European socio-economic scenarios

3.1.1. Narratives

European SSP1 'We are the World'

From 2010 to 2040: The financial crisis continues to have strong repercussions and EU leaders are forced towards further integration of European financial and fiscal policies. The interplay of financial, environmental, and economic crises fuel the feeling that behaviour has to change away from an unregulated market-driven economy to a sustainable development path. This puts governments under pressure to take ambitious measures, including stimulating an energy transition towards renewables and facilitating innovative research, accompanied by investments in health, education, and social support. These investments are at the expense of somewhat slower economic growth and initially meet with some resistance. Eventually, a system of national accounts is in place that essentially adopts a basket of well-being based performance measures instead of GDP. The resulting higher quality of life and a growing feeling of security and safety are eventually embraced. In Europe and worldwide, trade wars and other economic crises are addressed increasingly effectively by multi-level governance configurations. Investment in green technologies and geo-engineering increases rapidly, focusing on renewables and energy efficiency. By 2040, efforts to transform Europe to a sustainable society are now starting to pay their dividends, reinforced by gradually changing lifestyles.

From 2040 to 2070: A decrease in conflicts in Europe's southern and eastern border regions leads to higher political stability and moderate but steady economic growth in an increasingly equitable Europe, which allows for the middle class to grow stronger. The European Union expands further and participates in new global governance initiatives. The larger EU takes responsibility for addressing its environmental impacts in the border regions and leads investments that help pursuing sustainable development goals in those regions. As a result, migration towards Europe starts to decline for the first time this century. There is a substantial shift in the European political agenda with a greater focus on well-being than economic growth, driven by human losses associated with climate change combined with positive improvements in accessible education and lifestyle. Advances in green technologies are further stimulated by international competition leading to a CO₂ neutral society by 2050.

From 2070 to 2100: Worldwide, consumption is now oriented toward low material growth and low resource and energy intensity. This results from the development of new technologies with radically reduced resource consumption and a strong increase in the use of renewable energy sources, facilitated by new flexible global, regional and national institutions that enhance international cooperation. Supported by a continued steady economic development and the strong middle class, economic and social inequality further decrease. By 2100, Europe is characterised by a high level of sustainability oriented political and societal awareness, focusing on renewable energy and low material growth in a strongly regulated but effective multi-level governance structure. International cooperation is strong, particularly with Asia.

European SSP3 'Icarus'

From 2010 to 2040: With the economy gradually picking up, the demand for resources increases, which turns out to be a tipping point for the state of the environment with severe ecosystem failures. At the same time, the world economy does not perform as expected with new crises across the European Union that stress the structural differences across and within Member States. Populist

movements become increasingly mainstream and are further fuelled by increasing riots in multicultural neighbourhoods. The persistence of conflicts and decline in trade also substantially increases energy and food prices, while initiating a massive build-up of the defence sector, which is resource hungry but not resource efficient. Extreme weather events become more frequent and further increase the costs of resources, damage control and defensive measures; this causes the economy in Europe to start to stagnate. This, in turn, increases unemployment rates and leads to the phasing out of the social security system. In light of increasingly scarce public resources, long-term policy planning becomes rare with hardly any money for education, research or innovation. Eventually the EU breaks down.

From 2040 to 2070: Continuing negative social, environmental, and economic developments widen the gap between the poorer countries and regions particularly in the periphery of Europe and the richer, larger, countries that maintain a decent level of social, economic, and political stability. With the disintegration of social fabric, Europeans in the poorer regions increasingly migrate in search of jobs, and are employed in countries that are somewhat better off, for relatively low wages. Most migration is within Europe. Eventually, new regional blocs are formed in the north and in the south of Europe, while new alliances with other countries are forged to ensure sufficient energy supply. By 2070, social counter-movements appear with some signs of a slight economic recovery and increased social cohesion. Yet, these signs are temporary and do not take root in a fragmented and divided Europe with strong regional rivalry and conflict. The general lack of economic resources and therefore of means to afford new technologies, coupled with weak institutions and governance structure, leads to an increasing resource intensity and fossil fuel use.

From 2070 to 2100: In the absence of strong (inter)national institutions, criminal organisations and corruption take hold, in the aftermath of failed counter movements. Europe has lost its leading position, reinforced by difficulties to re-establish effective collaborations. The far-reaching fragmentation and cultural diversity have triggered a brain drain with the well-educated migrating to regions outside Europe that offer (slightly) better possibilities. Eventually, Europe is not worse off than the rest of the world, but struggles not to become the world's backwater as new clean technologies are increasingly developed elsewhere and affordable only for the richer Member States. These ensure clean water, clean energy and health for those countries. However, the majority accept political instability and social injustice and learn to live with less.

European SSP4 'Riders on the Storm'

From 2010 to 2040: Sparked by the economic crisis and extreme weather events, the EU increases commitment to find innovative solutions to the depletion of natural resources and climate change. In combination with current relatively high levels of social cohesion, energy efficiency and environmental policy-making this initiates a shift towards a high-tech green Europe. This transformation is strongly supported by large businesses that successfully seek collaboration with the increasingly powerful European government. Eventually, average wealth starts to increase as crises are successfully combatted. At the same time, the centralised public-private partnerships and related policies result in increased social disparities within countries.

From 2040 to 2070: Technology development is strong in the high-tech economy and sectors. Energy companies hedge against price fluctuations through diversifying their energy sources, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. New high-tech sectors are growing in importance and gradually become the backbone of an economically strong Europe. At the same time, however, inequalities are rising because of a number of simultaneously acting factors. These include skill-based technology development, highly unequal investments in education, and less affluent groups having increasingly weak political power

and limited access to credit. Together, these increasing disparities in economic opportunities and political power lead to increasing inequalities and stratification both across and within countries. The traditionally strong middle class decreases in influence but only slightly in numbers. By 2070, there is a large and widening gap between an internationally connected society that is well educated and contributes to knowledge-intensive and capital-intensive sectors of the global economy, and a more fragmented collection of lower income societies that work in a labour intensive, low-tech economy, mostly in the service sector for the benefit of the elite. Despite a strong EU, power becomes increasingly concentrated in a relatively small political and business elite, while vulnerable groups have decreasing representation and influence. Among others, this results in increased conflicts in poorer regions of Europe and migration flows to safer areas, which become protected and clean 'islands'. Migration flows into Europe are highly controlled by the elite, but Europe increasingly attracts illegal immigrants competing for decreasingly available low-skilled jobs.

From 2070 to 2100: Europe has become a market leader in (green) technologies, because of long-term under-investment in new resources in many other regions of the world related to uncertainty in fossil fuel markets. Protected by a strong elite, the small "connected" upper class benefits with high-skilled workers moving easily across countries to tap into new business opportunities. The elite becomes increasingly separated from other social classes, importantly from the now quickly dwindling middle class. A large share of the population, however, does not benefit from technological breakthroughs and does not profit from alliances between big business and the political elite. This results in deepening inequalities within and among countries across Europe. With decreasing public funding, good education is only accessible to those who can afford it. Technological development has not resulted in reduced energy prices, but has instead established an oligarchy of green business developers that control energy supply and reduce resource availability for the majority. As a governing body, the European Union is strong with strong ties with the lobbying industry. Social cohesion, however, is now low and stratified, while human health has decreased for most. By 2100, Europe is an important player in a world full of tensions, but with growing inequalities across and within European countries.

European SSP5 'Fossil-fueled Development'

From 2010 to 2040: Global markets are increasingly integrated, with interventions focused on removing institutional barriers to the participation of disadvantaged population groups. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources. In the aftermath of the economic crises in Europe, there is a slow shift towards market deregulation, resulting in a strong labour market and increased purchasing power. This results in a decrease in political unrest. Of particular importance for Europe is the large-scale extraction of shale gas, which further stimulates economic wealth, part of which is used to stimulate the development of (green) technologies. Europe regains its leading position in the global economy, which further contributes towards a focus on economic growth and export markets rather than environmental policies. Nuclear energy is slowly phased out everywhere in Europe, while investments in biofuels are low, in favour of cheaper and more readily available fossil fuels.

From 2040 to 2070: Because of decreased energy price volatility and stabilising economies, public trust in political decision-making increases which facilitates strategies related to further exploitation of natural resources. Faith is strong in the ability to effectively manage social and ecological systems, including by geo-engineering. High and low skilled immigration and mobility remain high as European economies flourish. Job availability across all market sectors is high and contributes towards a reduction of inequalities and competition. Population across all societal classes, and the strengthening middle class in particular, adopts a very energy intensive lifestyle. Where environmental problems

occur, these are tackled locally and reactively with technological solutions. The environment degrades, but the majority of the population is unaware because of successful technological innovation in e.g. food and water production, vaccination availability and climate adaptation, which decrease the dependency on ecosystem services.

From 2070 to 2100: In general, Europe continues on its path towards economic and social sustainability through competitive markets; investments in education and health; innovation and a strong focus on technological solutions fuelled by an (over)exploitation of fossil fuel resources, with an ever stronger pressure on natural resources. The continuous high stability of the energy market and economies have changed European policy-making, now predominantly focusing on and investing in policies related to human and social capital, rather than environmental protection. National governments have less political power, which enhances free circulation of services, goods and people. Population continues to grow with many European cities having become economic hubs with efficient transportation means. Towards 2100, the environment is locally seriously degraded as non-renewables are further exploited, which eventually results in a slow re-emergence of investments in renewables, deemed necessary as prices of fossil fuels rise.

3.1.2. Key (story) elements

An overview of key elements for the four European SSPs is given in Table 2. The list of elements is based on the set of key uncertainties that is part of the CLIMSAVE scenarios (Gramberger et al., 2013) and the tables with key elements as presented in O'Neill et al. (2015) describing the global SSPs. The final list was drafted during the expert workshop in Wageningen, in January 2015. Note that there is a good match for most key elements.

Table 2: Key elements of the European SSPs with an indication of corresponding key element in the global SSPs, and trends until 2100 for each European SSP. WATW = We are the world, ROTS = Riders on the Storm, FFD = Fossil-fuelled Development.

European SSP element	Global SSP element	SSP1-WATW	SSP3-Icarus	SSP4-ROTS	SSP5-FFD
<i>Decision-making level</i>	<i>Institutions</i>	International/EU leader more than MS	National/Local+ fragmentation	International / Europe leader on the global scale	International/EU not a leader on the global scale
<i>Geopolitical stability</i>	<i>Combination of institutions and international cooperation</i>	High	Low	High	High
<i>International cooperation -</i>	<i>International cooperation</i>	Strong, EU important player	Weak	Strong, EU important player	Strong (trade)
<i>Social respect</i>	<i>Societal participation</i>	High	Low between countries	Low respect between societies	High
<i>Net migration - low in-migration</i>	<i>Population growth/migration</i>	Low immigration	Outmigration	Selected immigration	High to cities and from poorer countries
<i>Economic development</i>	<i>Economic growth</i>	Gradual (with hiccups at the beginning)	Low	High	High
<i>Mobility</i>	<i>Migration</i>	No barriers, but movements are limited	Low	High	High
<i>Globalisation</i>	<i>Globalisation</i>	Unconstrained	Constrained	Uncontrolled (only controlled in parts)	Unconstrained

European SSP element	Global SSP element	SSP1-WATW	SSP3-Icarus	SSP4-ROTS	SSP5-FFD
<i>Choice</i>	<i>Policies</i>	Free, but strong regulation on land use	Restricted	Free for elites	Free
<i>Social cohesion</i>	<i>Social cohesion</i>	High	Low EU\higher within countries	Low	High
<i>Technology development</i>	<i>Technology development</i>	High, but not pervasive	Low	High in some areas; low in labour intensive areas	Strong and crucial
<i>Quality of Governance</i>	<i>Policy orientation</i>	High – focus on sustainability	Low and ineffective	High and effective	High – focus on businesses
<i>Human health investments</i>	<i>Health investments</i>	High	Low	High for elites	High
<i>Education investments</i>	<i>Education</i>	High	Low	High for elites	High
<i>Environmental respect</i>	<i>Environmental policy</i>	High	Low	High in pockets	Low, but high NIMBY*

* NIMBY = Not In My Back Yard.

3.1.3. Trends for key (model) variables and their quantification using fuzzy sets

Trends in a number of model variables were generated for key parameters for the European version of the CLIMSAVE Integrated Assessment Platform (IAP; Harrison et al., 2015). The IAP is a spatially-explicit multi-sector modelling platform which includes models of agriculture, forestry, urban growth, land use, water resources, flooding and biodiversity. Experts in the workshop were asked to provide semi-quantitative trends (increase, decrease, no change) for the three time periods (2010-2040, 2040-2070 and 2070-2100) that were consistent with the scenario narratives (Table 3). Experts were also asked to provide these trends for four capitals (human, social, manufactured and financial) (Table 3).

The experts were then asked to provide an indication of the numerical ranges of changes that they associated with the categories of increase and decrease for each variable and the fuzzy sets methodology was applied to derive the quantitative changes required by the IAP (Table 4; see Kok et al., 2015 and Pedde et al., 2016 for further details). The IAP requires changes for a default value (median) and for a credible and absolute maximum and minimum value to reflect uncertainty in the scenario quantification. All the fuzzy set scenario quantifications were checked by model experts. In addition, as time was limited in the expert workshop, the model experts derived quantifications for other model parameters needed by the IAP based on the scenario narratives, key elements and trends.

Table 3: Qualitative information on input parameters for European scenarios derived from the expert workshop. Increase (+), decrease (-) or no change (0) compared to 2010 are indicated in the brackets for the three time slices.

Parameter	SSP1/ We are the world	SSP3/Icarus	SSP4/Riders on the Storm	SSP5/Fossil-fuelled Development
Water savings due to behavioural change	Strong increase (0, +, ++)	No change (0, 0, 0)	No change (0, 0, 0)	Stable, then decrease (0, 0, -)
Meat consumption	Strong decrease (0, --, --)	No change (0, 0, -)	No change (0, 0, -)	Strong increase (+, ++, ++)
Household externalities	Strong decrease (0, -, --)	Strong decrease (0, -, --) No change in northern Europe	Decrease (0, -, -) Stable northern Europe and (western Europe until 2050)	Strong decrease (0, -, --)
Water savings due to technological change	Strong increase (0, +, ++)	Increase and then decrease (0, +, 0)	Increase (0, +, +)	Increase (+, +, +)
Set aside land	Strong increase (0, +, ++)	Stable, then decrease (0, 0, -)	Increase (0, +, +)	Strong decrease (-, --, --) until none left
Attractiveness of the coast	Strong decrease (0, -, --)	First increase, then abandoned (0, +, -)	Decrease and then increase (0, -, 0) (Elites limit access, but due to social pressure there are concessions)	Strong increase (0, +, ++)
Human capital	Strong increase (0, +, ++)	Decrease (0, -, -)	Decrease and then increase (0, -, 0). Middle class re-emerges	Strong increase (+, 1½+, ++)
Social capital	Strong increase (0, +, ++)	Increase, then decrease (0, +, 0). Increase because group of people cluster against others	Decrease and then increase (0, -, 0).	Strong increase (+, 1½+, ++)
Manufactured capital	Steady increase (0, ½+, +)	Decrease (0, -, -)	Increase (0, +, +). Depends on sector	Strong increase (½+, +, ++)
Financial capital	Steady increase (0, ½+, +)	Strong decrease (-, -, --)	Strong increase (0, ++, ++) with saturation after 2050.	Strong increase (½+, +, ++)

Table 3: Quantitative information for the input parameters of the IAP model for the European SSPs. WATW = We are the world, ROTS = Riders on the Storm, FFD = Fossil-fuelled Development.

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Change in energy price (% of 2010)							
SSP1 (WATW)							
	2025	0	41.5	46.4	100.0	153.6	158.5
	2055	+	103.9	107.4	162.3	241.3	247.7
	2100	+	103.9	107.4	162.3	241.3	247.7
SSP3 (Icarus)							
	2025	+	103.9	107.4	162.3	241.3	247.7
	2055	++	111.1	120.7	266.7	460.0	476.0
	2100	+++	145.8	158.4	350.0	603.7	624.7
SSP4 (ROTS)							
	2025	++	111.1	120.7	266.7	460.0	476.0
	2055	++	111.1	120.7	266.7	460.0	476.0
	2100	++	111.1	120.7	266.7	460.0	476.0
SSP5 (FFD)							
	2025	-	42.6	45.1	74.7	96.9	98.3
	2055	-	42.6	45.1	74.7	96.9	98.3
	2100	-	42.6	45.1	74.7	96.9	98.3

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Increase in arable land used for biofuel production (% change from 2010)							
SSP1 (WATW)							
	2025	0	-8.7	-8.0	0.0	8.0	8.7
	2055	+	13.2	360.5	145.0	360.5	376.7
	2100	+	13.2	360.5	145.0	360.5	376.7
SSP3 (Icarus)							
	2025	0	-8.7	-8.0	0.0	8.0	8.7
	2055	0	-8.7	-8.0	0.0	8.0	8.7
	2100	0	-8.7	-8.0	0.0	8.0	8.7
SSP4 (ROTS)							
	2025	0	-8.7	-8.0	0.0	8.0	8.7
	2055	+	13.2	360.5	145.0	360.5	376.7
	2100	+	13.2	360.5	145.0	360.5	376.7
SSP5 (FFD)							
	2025	-	-70.7	-68.0	-36.7	-9.5	-7.5
	2055	-	-70.7	-68.0	-36.7	-9.5	-7.5
	2100	-	-70.7	-68.0	-36.7	-9.5	-7.5

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Food imports (% change from 2010)							
SSP1 (WATW)							
	2025	+	6.0	6.9	21.7	45.5	47.3
	2055	-	-47.2	-45.5	-26.7	-8.7	-7.2
	2100	--	-95.3	-92.5	-62.5	-32.5	-29.7
SSP3 (Icarus)							
	2025	0			0.0		
	2055	-	-47.2	-45.5	-26.7	-8.7	-7.2
	2100	-	-47.2	-45.5	-26.7	-8.7	-7.2
SSP4 (ROTS)							
	2025	+	6.0	6.9	21.7	45.5	47.3
	2055	+	6.0	6.9	21.7	45.5	47.3
	2100	+	6.0	6.9	21.7	45.5	47.3
SSP5 (FFD)							
	2025	½+			10.8		
	2055	+	6.0	6.9	21.7	45.5	47.3
	2100	++	24.1	28.0	88.3	182.0	189.3

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Water savings due to technological change (% change from current)							
SSP1 (WATW)							
	2025	0	-10.0	-3.0	0.0	3.0	10.0
	2055	+	17.4	21.0	29.1	40.0	45.5
	2100	++	27.1	32.6	45.2	62.1	70.6
SSP3 (Icarus)							
	2025	0	-10.0	-3.0	0.0	3.0	10.0
	2055	+	17.4	21.0	29.1	40.0	45.5
	2100	0	-10.0	-3.0	0.0	3.0	10.0
SSP4 (ROTS)							
	2025	0	-10.0	-3.0	0.0	3.0	10.0
	2055	+	17.4	21.0	29.1	40.0	45.5
	2100	+	17.4	21.0	29.1	40.0	45.5
SSP5 (FFD)							
	2025	+	17.4	21.0	29.1	40.0	45.5
	2055	+	17.4	21.0	29.1	40.0	45.5
	2100	+	17.4	21.0	29.1	40.0	45.5

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Household externalities (categorical variable)							
SSP1 (WATW)							
	2025	0	1	1	2	3	4
	2055	-	1	1	2	3	4
	2100	--	1	1	1	2	3
Comments: Society/individuals seeking green space as a lifestyle choice							
SSP3 (Icarus)							
	2025	0	1	1	3	4	5
	2055	-	1	1	2	3	4
	2100	--	1	1	1	2	3
Comments: Disparate society; some stay in cities, some move to countryside							
SSP4 (ROTS)							
	2025	0	1	2	4	4	5
	2055	-	1	2	3	4	5
	2100	-	1	1	2	3	4
Comments: Disparate society with high poverty leading to more people in cities							
SSP5 (FFD)							
	2025	0	1	1	2	3	4
	2055	-	1	1	1	2	3
	2100	--	1	1	1	2	3
Comments: Individualistic, rich people move to the countryside							

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Attractiveness of the coast (categorical variable)							
SSP1 (WATW)							
	2025	0	Low	Low	Med	High	High
	2055	-	Low	Low	Low	Med	High
	2100	--	Low	Low	Low	Med	High
Comments: Environmentally friendly population does not put pressure on coast. Also afraid of sea-level rise							
SSP3 (Icarus)							
	2025	0	Low	Low	Med	High	High
	2055	+	Low	Med	High	High	High
	2100	-	Low	Low	Low	Med	High
Comments: Decreasing wealth leads to a move away from the coast							
SSP4 (ROTS)							
	2025	0	Low	Low	Med	High	High
	2055	-	Low	Low	Low	Med	High
	2100	0	Low	Low	Med	High	High
Comments: Decrease and then increase (Elite limit access, but due to social pressures there are concessions)							
SSP5 (FFD)							
	2025	0	Low	Low	Med	High	High
	2055	+	Low	Med	High	High	High
	2100	++	Low	Med	High	High	High
Comments: Individualistic society lives where it wants							

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Change in agricultural yields (%change of current)							
SSP1 (WATW)							
	2025		-10	-5	-2	0	5
	2055		-33	-18	-10	0	22
	2100		-57	-35	-19	0	53
Comments: The underlying model of increasing technical performance is one of compounded improvements, i.e. exponential growth at varying speeds. However, land degradation, due to the accumulation of phytotoxins in the soil will work the other way. Transition to organic and extensive systems also implies moving to lower curves. Assumption that net growth can be negative.							
SSP3 (Icarus)							
	2025		-18	-10	-5	0	10
	2055		-55	-33	-18	0	49
	2100		-82	-57	-35	0	133
Comments: The underlying model of increasing technical performance is one of compounded improvements, i.e. exponential growth at varying speeds. However, land degradation, due to the accumulation of phytotoxins in the soil will work the other way. Assumption that net growth can be negative.							
SSP4 (ROTS)							
	2025		0	7	10	14	22
	2055		0	30	49	70	121
	2100		0	76	133	208	438
Comments: The underlying model of increasing technical performance is one of compounded improvements, i.e. exponential growth at varying speeds.							
SSP5 (FFD)							
	2025		0	10	16	18	22
	2055		0	49	81	94	121
	2100		0	133	254	308	438
Comments: The underlying model of increasing technical performance is one of compounded improvements, i.e. exponential growth at varying speeds.							

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Change in agricultural mechanisation (% change from current)							
SSP1 (WATW)		Increase					
	2025		0	7	10	14	22
	2055		0	30	49	70	121
	2100		0	76	133	208	438
Comments: as per changes in irrigation technical efficiency but the scale has a difference sense. Exponential model for increases.							
SSP3 (Icarus)		Decrease					
	2025		-10	-6	-5	-3	0
	2055		-33	-23	-18	-13	0
	2100		-57	-43	-35	-25	0
SSP4 (ROTS)		Increase					
	2025		0	7	10	14	22
	2055		0	30	49	70	121
	2100		0	76	133	208	438
SSP5 (FFD)		Decrease					
	2025		0	7	10	14	22
	2055		0	30	49	70	121
	2100		0	76	133	208	438

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Change in irrigation efficiency (% change of current): -50% = water halved per unit food							
SSP1 (WATW)		Increase (technological change due to awareness)					
	2025		-18	-12	-9	-6	0
	2055		-55	-41	-33	-23	0
	2100		-81	-68	-57	-43	0
Comments: The underlying model of increasing technical performance is one of compounded improvements, i.e. exponential growth at varying speeds.							
SSP3 (Icarus)		Decrease					
	2025		0	3	5	7	11
	2055		0	14	22	31	49
	2100		0	33	53	77	135
Comments: As SSP1 (WATW), but is negative growth justifiable or does that imply going back in time to retro technologies.							
SSP4 (ROTS)		Increase (less water available, but higher technology)					
	2025		-18	-12	-9	-6	0
	2055		-55	-41	-33	-23	0
	2100		-81	-68	-57	-43	0
Comments: As SSP1 (WATW)							
SSP5 (FFD)		Increase (tech. investment due to higher food demand)					
	2025		-18	-12	-9	-6	0
	2055		-55	-41	-33	-23	0
	2100		-81	-68	-57	-43	0
Comments: As SSP1 (WATW)							

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Reducing diffuse source pollution from agriculture by reduced crop inputs of fertilisers and pesticides -factor where higher value mean less inputs and by implication less diffuse pollution (-% change from current)							
SSP1 (WATW)		Decreased pollution					
	2025		18	32	52	83	117
	2055		68	113	170	241	300
	2100		130	203	277	344	379
Comments: The basic model assumed of exponential decay making each additional increment of input reduction harder to obtain. Varying assumptions about the rate of decline.							
SSP3 (Icarus)		Increased pollution					
	2025		-11	-7	-5	2	5
	2055		-38	-26	-18	7	22
	2100		-64	-47	-35	15	53
Comments: Exponential growth with varying rates of pollution growth							
SSP4 (ROTS)		Increased pollution (but not around rich neighbourhoods).					
	2025		-10	-6	-4	2	5
	2055		-33	-21	-15	8	22
	2100		-57	-40	-29	19	53
Comments: Exponential growth with varying rates of pollution growth. Diffuse pollution is by nature intangible and thus nimbys is very weak. More so with point source pollution unless, say the nimbys can impose NVZs based on postcode rather than hydrology.							
SSP5 (FFD)		Increased pollution (but NIMBY)					
	2025		-10	-6	-4	2	5
	2055		-33	-21	-15	8	22
	2100		-57	-40	-29	19	53
Comments: As in SSP4 (ROTS).							

		Trend	Absolute Min	Credible Min	Default	Credible Max	Absolute Max
Importance of wood for fuel (% change from current)							
SSP1 (WATW)		Low					
	2025		-40	-23	-13	-7	5
	2055		-87	-65	-42	-26	22
	2100		-99	-89	-69	-47	53
Comments: The basic model for wood fuel is slow exponential decline with possible renaissance as exponential growth. Any asymptotes are outside the current time periods. Various rates of negative/positive growth assumed.							
SSP3 (Icarus)		High → Less available resources					
	2025		0	5	8	16	34
	2055		0	22	35	81	226
	2100		0	53	89	254	1134
Comments: As SS1 (WATW) but very little is currently used for charcoal and direct combustion so it could increase dramatically under some conditions.							
SSP4 (ROTS)		Low					
	2025		-40	-22	-12	-6	5
	2055		-87	-64	-40	-23	22
	2100		-99	-88	-66	-43	53
Comments: As SS1 (WATW)							
SSP5 (FFD)		Medium					
	2025		-22	-13	-7	0	16
	2055		-64	-42	-26	0	81
	2100		-88	-68	-47	0	254
Comments: As SS1 (WATW)							

3.2. Scottish socio-economic scenarios

3.2.1. Narratives

Scottish SSP1 'MacTopia'

From 2010 to 2040: Recent developments in social debates following election results, and the migration triggered by the outcomes of the COP debates drive Scotland towards more equitable and far-reaching decision making. At the *Inverness Conversations*, which gather representatives from all layers of society, it is decided that oil will be slowly phased out as an energy source in Scotland in favour of renewable energy sources such as wind and hydropower. The focus is on trade-offs which lead to balanced decisions. For example, by slowly adopting a circular economy, zero waste and resource efficiency, there is less need for food imports. Another example of such focus is the plan to provide all Scottish residents with broadband internet. This plan recognises community empowerment and more bottom-up decision making. It also makes teleworking possible and increases the levels of access to information for all residents of Scotland. Many of the transitions towards an equitable and sustainable society require effective regulation from the government. The presence of the government increases at all levels, but does not become centralised. Efficient use of resources, circular economy and economy at the local level contribute to a sustainable, environmentally aware economy. The economy is diversified (diversified business environment) and attracts businesses. By the same token, harsh penalties are dealt out to those households not switching to renewable energy sources. Some pockets of the population do not agree with the increased government presence, but most primarily see the advantages of strong government

policies. The number of poor people decreases slowly and a large and solid middle class is the driver of the economy. Even though taxes are higher, most rich people choose to stay because they are more socially and environmentally aware; and increased peer pressure among the richest actually perpetrates the trend for the super-rich to re-invest and to behave philanthropically.

From 2040 to 2070: The greater public expenditures and investments of previous years result in a slow but steady economic growth and more stabilised economy. This evolution towards a more socially and environmentally sustainable Scotland comes at the backdrop of somewhat slower economic development and a further political separation from the UK. Scottish people want to be different from the rest of the UK. Strong devolution from the UK gives Scotland the autonomy it needs to make the transition towards an equitable society possible. The legal system becomes more European over time. This leads to councilors/developers no longer allowing people to build houses in flood risk zones in Scotland, since the planner developers can be sued if a newly built house gets flooded. This additional personal liability is extended to all levels of society, including Ministers. Social justice has become a key term in law in the same way that accountability has become a key term in government. Scotland also puts the payment of flood risk subsidies to London on hold. Scotland remains strongly linked with the European Union, while strengthening its connection with other like-minded countries both within and outside the EU. Best practices are exchanged between the different countries which have similar economies and a similar philosophy concerning equality. Additional income is generated by the Scottish government from the selling of resources such as water, of which Scotland has a surplus, and also from the reduced need for imports (including food imports) because of the shift towards a circular economy. Because of its comparative advantage over others in the field of water, it can obtain good trade agreements with other countries on innovative resources such as information technology. Trade agreements are made between Scotland and BRICS countries without British interference. Fossil fuels are still sold to a pocket of developing countries lagging behind in the transition to alternative sources of energy. For small and medium businesses, costs tend to increase, but these are more than outweighed by the benefits of a resource surplus and positive externalities. More and more ethical companies relocate to Scotland due to its diversified and dynamic business environment. Since the Scottish economy is one of the healthiest in the world and innovative companies have made Scotland their stomping ground, highly educated Scots no longer emigrate. On the contrary, many Scottish expats return to their home country. Industry is focused on innovation and technology. There is government support for research, development and innovation. The long-term investments in education are also paying off and Scotland becomes a frontrunner in trading resources as well as the associated intellectual property. The export of water and other products increases the global role of Scotland. Part of the profits from the sale of surplus resources is invested in a Sovereign Scotland fund. This fund gives Scotland both the ability to ensure the well-being of its population, regardless of their social status, and also the resources to invest in innovation and other sustainable investments. These include a reforestation programme, a very extensive railway network, and research programs to boost innovation in the field of renewable energy and IT. Scotland begins to play an important role in service provision worldwide, diversifying away from natural resources to ensure stability if and when those resources are depleted. Significantly increased amounts of government funding are invested in education and innovation to secure a stable economy for the decades to come. There is also a boom in small and medium sized enterprises. Scotland becomes a frontrunner in IT, life sciences, green technology and finance. The benefits of the resource abundance reignite the positive arguments for independence – namely economic growth – and result in a landslide victory in the polls. Scotland introduces its own currency, which is linked to a stronger currency. At this point Scotland has developed strong independent links with many other countries. It bids to play an important role in decision-making on the European level and provides key personnel for the different EU bodies. One of its biggest achievements in the political arena is the EU Environmental Framework Directive, which was advocated for by Scotland to ensure an integrated regulatory system for land and water management. All new buildings have to be energy neutral and all households have to be on smart

grids. This green push does have some disadvantages. Scotland has become highly dependent on renewable energy and transmission systems, since oil and gas are phased out as an energy source and nuclear power is also largely abandoned. This makes Scotland vulnerable, particularly economically, and solar storms are feared. Tax evasion also increases in a heavily taxed Scotland, as do illegal activities such as the smuggling of water outside of Scotland to other parts of the world. In spite of these small recurring hiccups, the Scottish economy still grows. The new economy and multilevel governance now bear fruit, by buffering downturns in the national and global economy. The strong economy and equitable lifestyle in Scotland attracts even larger numbers of immigrants. They are encouraged to settle in the west and in rural locations to provide cheap labour. This has a positive effect on the economies of small towns, but the influx also puts pressure on local communities, resulting in a growth in nationalistic attitudes. Strong assimilation measures are put in place for immigrants. In some parts of Scotland Gaelic language courses are compulsory in school, as well as for immigrants. They are not forced to speak Gaelic, but they are educated in the Scottish traditions. Scotland and the other Nordic Council countries work together to obtain exceptions from the EU Freedom of Movement Act. A minority of Scots feel threatened by this wave of immigration and the media reports on nationalist terrorists attacking immigrants. The – often highly educated – immigrants do not always receive a warm welcome, but they prove to be extremely valuable. They help to reinvigorate the communities in which they live in West and Central Scotland. This fuels further development and enhances the health of the local population. Due to this influx in rural areas, many villages become larger rural towns over time and gain more facilities. The local communities are so strong that a new type of governance is adopted: Communitarianism. The Scots identify strongly with their local community. They expect much from it, but also give back to it.

From 2070 to 2100: In 2070, Scotland is shocked when a Scottish water tanker is hijacked on its way to the Mediterranean to deliver drinking water. This and similar events prompts Scotland to rethink its national security strategy. The strategy aims to protect all the resources of Scotland; not just commodities, but also its biodiversity. Because Scotland is firmly attached to values such as equality and solidarity it does not establish an inwardly protective attitude to achieve the protection of its resources. Instead it establishes healthy trade relationships with rich countries, as well as helping with the (economic) development of poor countries to enable those countries to develop their own sufficient resources and thus to keep them at bay. This protective stance has a number of unintended effects. Some remote communities do not buy into this way of life. Some Scots dislike the fact that they are no longer able to live their hedonistic lifestyles. Satellite communities of hedonistic Scots move to the wide-open spaces and forestland of Eastern Europe, where they can enjoy their alternative lifestyles in peace. Some trade-off conflicts continue to exist. For example, the trade-off between the need for timber as an eco-building material and sustainable forest management (including also reforestation). A few tax exiles also move to London or other major European cities. These super rich are, however, a very small minority because the extensive development of more socially oriented enterprises has reduced the disparities in income. Most rich investors still reside in Scotland. Although there is some discontent in the populace, these events are all occurring on the fringes of Scottish society. The Scottish population continues to increase, but homelessness hits zero. The rich may have become slightly less rich, but poverty is almost eradicated and a powerful middle class now takes the lead in Scotland.

Scottish SSP3 'Mad Max'

From 2010 to 2040: On-going conflicts and political instability in the world are affecting global systems. Demographic issues in other countries include male dominance, population control, conflicts over resources and international resource grabs. All these external factors drive resource issues and migration to Scotland. Increased pressure on resource exploitation leads investors and companies to buy up land and access to water. This creates volatile financial, energy and land markets, with the

energy market being the most volatile. Commodity speculation takes place, notably on water, natural resources, food, land and housing. The price of a patch of land increases substantially, which forces landowners to engage in intensive land cultivation. This has an upward effect on the wheat price. Increasingly more people have problems buying food and water. A hunger march is organised in Edinburgh and a few days later there is a riot in a local market over the cost of potatoes as farmers abandon the price control agreement. These commodity speculations and riots demonstrate that the social contract has deteriorated to a situation of “every person for themselves”. Because of the financial volatility, increased social tensions and difficult economic conditions, solidarity with others is not a priority. The aim for most people is to safeguard their lifestyles at the expense of others in society during these torrid times. The cooperative system collapses, which illustrates the new self-centred paradigm of Scottish society. Some characterise this as a return to the feudal system. The steady increase in the use of private cars over public transportation reinforces this paradigm. Energy becomes an increasingly valuable resource. In order to maximise such resources the Scottish Government sells energy to the highest bidder. As such, multinationals and SMEs with less stringent ethics increase their grip on society. They own large portions of land, control the scarce water and food supplies and determine the consistently high pricing of essential goods and commodities. These companies do not respect labour laws and they abolish trade unions; but the government does not respond. These ruthless companies are the only ones that keep the remainder of the Scottish economy going. With them gone, unemployment rates would soar even more. The self-centred, profit-driven system leads to a disparity between the Haves and the Have-nots, the rich and the poor. The Haves have access to drinking water, health care services, energy and are able to buy patches of land, while the Have-nots are deprived of most essential services. The Have-nots start squatting in order to find shelter and poaching increases due to a lack of access to food. Fragmentation of society leads to more sectarianism. Conflicts between Catholics and Protestants are rampant, especially in the small mining communities in the Highlands. The whole European Union suffers from social unrest and an economic and energy crisis. The resource deficit and disparity in society are not only Scottish issues. Independence is no longer an issue in Scottish society, because there are other priorities now. Moreover, a Scotland that has to rely solely on its own economy and resources is destined to deteriorate even more.

From 2040 to 2070: By 2040, the Have-nots organise themselves in communities of interest. They attempt to voice their grievances and hope to find protection among people facing the same challenges and suffering the same fate. Black markets for food, water, clothes and jobs are sprouting up all over Scotland and cheap labour is the only sort of employment to be found. By 2050, people are looting the limited water supplies. The whole system is now characterised by short-term thinking. People are afraid that things could change for the worse overnight, so do not see the point in investing in long-term solutions. A survival from day-to-day, “getting the sandbags out” type of mentality prevails over a long-term structural approach, especially for the have-nots. The haves on the other hand are preoccupied with securing their fortunes and the few remaining resources.

The Scottish government also applies this “just-in-time” approach for its policymaking. This results in the government being more of a crisis management team than a stable regulatory force with a long-term vision for the future of Scotland. A lack of long-term (public) investment also makes this society vulnerable to new shocks, such as energy blackouts. The health care system that was built on the principles of solidarity experiences a crisis. This is not just a Scottish problem, but a European one. Only the emerging economies, such as India and China, seem to be doing better; mostly since they have a large, cheap and eager labour force. The few remaining multinationals in this globally regionalising world take hold of much of Scotland’s remaining resources. These multinationals do not see the benefits of being sustainable; when resources run out, they just move on and exploit the next town or county. The rich are the most resilient to shocks as they have the financial resources to adapt to the crises. As a result they increase their grip on society. The rich have private health care and protest against the introduction of a national publicly financed health service. But even the rich cannot

escape the volatility of Scottish society completely. Asset stripping becomes common practice amongst those on the management boards of major multinationals. In the meantime, the pressure on the poor increases further as rising house prices force some of them to live on houseboats. Ghettos of poor people living on boats emerge just off the Scottish coast. Initially, the social cohesion in these ghettos is low, but over time religion, faith and spiritualism bring the poorer Scots closer together. Poor people also leave the central belts and move to the Highlands. They look for the scarce resources so they can be self-sufficient, or they move to the areas owned by the “Haves” and the multinationals, which have reinstated a feudal system reminiscent of the Middle Ages. Multinationals own all the land suitable for mining, agriculture or forestry. Their forests and gated communities are guarded by security personnel that do not shy away from violence to keep out the desperate Have-nots. Decision-making is in the hands of multinationals and landowners, since governance remains weak. The poor have to pay or work for the landowners to safeguard their water supply. But at least they can get access to some clean water. The poor that are left behind in the decayed cities are worse off. The network of water distribution does not exist anymore and potable water is scarce. There is also an increased resistance to allowing people to move into the region. Immigration is strongly discouraged. Both the Haves and Have-nots realise they have to organise themselves: the Haves to protect themselves and their property, the Have-nots to survive. These unions originate out of necessity. However, conflict within these groups is also common. The Have-nots for example are also subdivided into different strata. The more the situation deteriorates, the worse this sectarianism based on culture, religion and dialect becomes. ‘Clans’ are ruling Scotland again, just like they did in historic times. Some of these clans go into organised crime and as a result the black market thrives. The image of a split country is reported to the rest of the world and causes a crisis in the tourism sector. Tourists are afraid of being robbed and so they stay away. Scotland is also facing external pressure to restore its budget deficit and to ensure a proper functioning parliamentary democracy, which does not solely serve the short-term interests of multinationals. As of 2055, both the Haves and Have-nots get used to this system and learn to live with instability, albeit both in very different ways. The Haves and Have-nots organise themselves internally. Within each strata of society the overall situation starts to improve as the cooperatives are reinstated and a sufficient degree of innovation ensures survival. By the same token, Scotland remains inequitable and real fundamental problems between the different strata continue to exist. There is no, or very limited contact between the different strata. The poorer Scots work for the richer Scots, but that is the only interaction between them.

In 2065, a small part of the Scottish social elite comes to realise that Scotland can no longer continue to live like this. A small movement of the Scottish social elite reconsiders the historic concept of “sustainability”. The movement advocates for a sustainable society in which poor and rich can live in harmony with one another. However, most Haves are determined to sustain their position. That is why a decrease in the gap between both groups remains implausible. The multinationals adopt a Victorian approach to eliminate social unrest. They provide their work force with a better quality of life, simply because a happy workforce tends to work harder.

From 2070 to 2100: By 2070, the Scottish economy and society have somewhat stabilised. The “Have-Nots” are creative and earn a living by providing services to the Haves. There is a strong demand for security guards and lawnmowers. Have-nots shop on the black market and bartering becomes popular. Decision-making happens on two levels: on the corporate level and on the local/clan level. The national level is still very weak and the First Minister of Scotland has almost become a ceremonial function.

Scottish SSP4 ‘Tartan Spring’ (or ‘Tartan Unrest’ or ‘Jacobite Uprising’)

From 2010 to 2040: Scotland continues to be a prosperous country with a strong socio-economic middle class. All layers of the Scottish society enjoy the benefits of a strong government-led

management of its (natural) resources, of which it has a large surplus. This surplus fosters prosperity in the short term and also boosts technological innovation, which ensures prosperity over the long term. Technological innovation leads to more efficient use of resources, the exploration of new stocks, and the chance to turn previously low value resources into valuable ones. The thriving engines behind this technological development are accessible education and science centres on the one hand, and the private sector on the other hand. A whole new generation of highly educated young people takes the lead. Because of this high degree of prosperity, Scotland is increasingly seen as a good place to live. Young and wealthy people immigrate to Scotland and the domestic birth rate goes up, as does life expectancy. But wealthy elderly people also migrate to Scotland for their retirement because of the good services on offer. This causes an overall ageing population. The new flock of retirees cannot join the workforce, but puts a strain on public finances. Through innovation, there is a massive increase in recycling activities and the use of natural resources is optimised. Hydrogen fuel cells are also being developed successfully. Moreover, a major gas find in the Atlantic helps to secure growth in Scotland for the years to come. To capture the full potential of all of these technological developments the Scottish government decides to open resource access to the private sector and to establish liberal market structures. As a result, by 2040 the influence of the private sector in Scotland has become very strong. Scotland can export part of its resource surplus. Electricity is exported to Europe, while China is mainly interested in the minerals hidden under Scottish soils, such as uranium from the Shetlands. The ties with neighbouring countries that are also rich in resources are strengthened and Scotland has formal contracts with the Scandinavian countries and North America. Private companies are equally driven by cooperation. The whole Scottish economy is essentially resource based and has a low dependence on financial resources. Human capital has reached very high levels, and apart from its resources Scotland also exports knowledge. Multinationals invest strongly in Scotland, which is beneficial for the economy. But on the other side of the coin, however, the Scottish government no longer has control of its resources. The multinationals have slowly become the controlling force. Following the first immigration wave of highly-skilled professionals comes a wave of lower-skilled labourers. They strengthen the workforce and become an essential part of the Scottish economy. Scotland becomes a stronger economic player, being less and less dependent on developments within the United Kingdom and EU. Economic growth becomes the pillar supporting Scottish nationalism and the Scottish people believe independence is the best way to safeguard their wealth. Resource security fosters independence. However, Scottish independence does not happen overnight. The outcome of the 2030 referendum sets in motion an incremental process leading to full independence by 2040.

From 2010 to 2040: In the period after the referendum and before full independence, the private sector further increases its grip on society. As the private sector is already very large, it is a small step for private enterprises to offer health care plans for employees. However, the privatisation process is poorly regulated and thus safeguards are not put in place for those not able to benefit from such privately organised schemes. With the new private healthcare system not everybody is able to access or afford health care. However, the Scottish middle class favours new policies which further deregulate the system. These changes occur along with decisive cuts in public expenses, which in turn are spearheaded by the steady economic growth and the focus on GDP growth of the previous decades. An unwanted consequence is that the welfare state ceases to exist and Scotland is now run by ten private enterprises controlling the main assets of the country. Because increasingly more people depend on the private sector and the services of major international companies, the social fabric erodes and the influence of the local, community level decreases. With independence in 2040, a new government also comes to power. From this moment onwards the full effects of developments since the vote for independence start to pan out. The power of the private sector, together with Scotland's independence, now makes it possible for Scotland to become a major player on the global market. Scotland signs trade agreements with China on the use of critical minerals and becomes the world's major producer of uranium. It also exports water to southeast England. By 2060, Scotland spends 30% of its GDP on overseas conflicts to secure ownership of access to resources; meanwhile

less and less belongs to the people. On a global level, the scarcity of resources leads to an energy crisis. Prices for energy become high worldwide. In spite of growing national income, the purchasing power of the middle class decreases partly due to the decrease in welfare spending which has resulted in increased inequality. The first symptoms of social unrest by a growing lower working class emerge. The government of Scotland attempts to face these unintended, negative consequences by establishing trade liaisons with other resource rich countries, such as Canada, Norway, Iceland and even Russia, in a bid to increase income from exports. However, increased income does not translate into increased access to income for the middle class, but, rather, strengthens the power of the rich Scots. The disparity between the poor and the wealthy in Scotland is more pronounced. The progressive decrease in welfare support, combined with the elimination of jobs and manpower due to technological innovation results in growing social unrest. Those that have a job still benefit from privately organised health care schemes, but a large part of the workforce services the super-rich and has only limited social security, barely enough for a decent life. In addition to this, the prosperity of Scotland attracts refugees and job-seekers, further increasing the divide. For every job there are hundreds of candidates, so salaries tend to be low. Some commentators speak of a modern slave economy. As such, most people cannot sustain their standard of living. Standards in education and science cannot be sustained either. Unemployment rates increase, while social welfare decreases rapidly as there is no social safety net for those that are unemployed. A class of poor citizens emerges.

From 2070 to 2100: The wealthy move into eco-communities and the top 10% of Scottish multi-millionaires start living in multi-millionaire ghettos. Scotland also becomes a new tax haven. The poor start to feel the burden of no longer being able to benefit from the welfare state. The government (unsuccessfully) tries to regain a grip on society, but fails to do so because long lasting contracts and agreements on tax cuts for the private sector are deemed to be legally binding. The private sector threatens to relocate, also winning a political battle on low tax revenue. The poorly regulated privatisation operation in the 2040s has left the Scottish treasury empty, and there are very few public resources available. Only the wealthy can still afford to travel and access certain services. This also stimulates a large black market, run by the Scottish mafia. People are unhappy and at each election a landslide victory takes place. But, the Scottish Government fails to make an impact on what is happening in society. By this point, business districts with labour housing have been created by the multinationals. Nevertheless there is still pressure on the housing market, because Scotland continues to attract migrants due its resource surplus. Therefore the unemployed and new immigrants are forced to move to overcrowded housing surrounding the cities and main towns. Although the country has an enormous resource surplus, there is a scarcity of food. The worldwide energy crisis has led to increasing food prices. Scotland does not produce nearly enough food to feed its ever-growing population. Together with financial pressures, social pressures rise to previously unseen levels. The multinationals and government react by promoting agriculture. The poor are urged to move to the countryside to build up new rural communities. A record number of Scottish families live below the poverty line and as a result the life expectancy of the bottom 50% of Scots is around 50 years. Scottish society is characterised by an increasing wave of migration and increasing birth and mortality rates. People die from diseases that were thought to be extinct. The ratio of poor to rich Scots is 80:20, where at the beginning of the century it was 20:80. A Scottish middle-class is non-existent. Initially, the poor were not upset because they were told, and proud that, they lived in a very successful country, regardless of their personal level of prosperity. But this changes when continuous strikes and protests by the dispossessed paralyse the country. The population is seriously disappointed by the lack of sustainability and the lack of accountability of governance. In the private sector strikes and uprisings are also prevalent. The underpaid workforce is more than fed up with the dictatorship of the multinationals. Insecurity results in a “Tartan spring” revolution. The Scottish government is overthrown by the dispossessed. Scotland enters turbulent times.

Scottish SSP5 'MacMordor'

From 2010 to 2040: A stabilisation of the fossil fuel price has allowed for an increased tax on fossil fuels. Because of a concomitant increase of immigrants from outside the EU, the Scottish government invests extra income in health services, social housing and education. The government also invests in the establishment of for-profit publically owned energy companies, such as Statoil and the Scotland Energy Corporation (SEC), and in regulation being devolved to regional, local and community entities. At the central level, SEC investment fund has a large stake in fossil fuels and can invest in public services. This means that the profits stay in Scotland with SEC paying its dividends, just like the Alberta Tar Sands. Each Scottish resident receives £1000/year. The Longannet and Cockerhills power stations reopen, with the government acting as guarantor for carbon capture and storage operators. The areas also serve as hubs for international trade, because Scotland has international trade agreements both inside and outside the EU (including with the BRICS). The dynamism of the energy and technology sectors driving economic growth is reflected in university funding. The education push is primarily aimed at science, engineering and technology, at the expenses of the humanities. Scottish Universities are in the top UK R&D league (Research Excellence Framework <http://www.ref.ac.uk/>). Examples of technological advances that are developed and widespread before 2040 include: medical advances for the ageing population; water treatments at local sites; floating houses (based on the Dutch model) for flood prone areas; distillery by-products being turned into salmon feed protein; cheap coal gasification; and peppers being grown in the Shire of Sutherland, using heat from a peat power station.

From 2040 to 2070: Technological advances also shape the Scottish political arena. Citizen participation in politics is facilitated by internet referenda. Locally, 'Clantons' have slowly developed from the devolution policies of the earlier decades. Thanks to these advances, referenda have become more popular both at national and 'Clanton' level and democratic participation is at its highest. Environmental degradation, however, continues, with most Scottish people living in urban areas and thus being further separated from the natural environment. Because of high profit returns (including the 'Clanton' dividends from fossil fuels) and unemployment being at its lowest, most Scottish people are unaware of the severity of environmental degradation. However, some discontent starts to rise among pockets of the population, driven by issues such as 'the last bumblebee in Scotland'. This is initially partly overshadowed by steady economic growth, including in Western Scotland, and the widespread existence of major processing plants, even in remote areas. SEC opens a second university and innovation centre and a car industry is created in Central Scotland. A high speed train link to Aberdeen opens, and bridges to Ireland and France are also built.

From 2070 to 2100: Thanks to technological advances, GM oats can grow on fracking water and SEC gets rid of midges and ticks. In spite of increasing migration and a growing population overall, energy and food demands are met and surpassed. Trade agreements and low tariffs contribute to keeping the basic commodities affordable. On the other hand, environmental degradation reaches a tipping point. Larger shares of the population realise the high costs of geo-engineering, and the increasing economic inefficiency of fossil fuels. As a result, unhappiness about environmental degradation spreads. Due to this increased awareness and the public demand for regulations on technology, several referenda are organised. However, a 'referenda fatigue' starts to occur because of the increased need to have a more central political approach. Eventually the outcome of the referenda highlights the concerns that the Scottish people hold about the future. As a result, SEC undertakes a major clean-up of the environment. Because technology and the economy are just perceived as generating fuel, a change towards renewables triggers a change towards a whole new energy system. The change is, however, a technological, rather than a philosophical one. SEC investments in renewables slowly increase, matching those in fossil fuels by the end of the century. New hydropower schemes are put in place from Cairngorms. Examples of headlines in the Scottish news are 'Off-world/moon travels as planet implodes', 'Cure for Alzheimer found!', 'Person found in Scotland who

can remember trees'. 'Extra height on welly boots'. Camping in the concrete garden has become a common holiday trip.

3.2.2. Key (story) elements

An overview of key elements for the four Scottish SSPs is given in Table 5.

Table 5: Key elements of the Scottish SSPs with an indication of its trend until 2100.

	SSP1 MacTopia	SSP3 Mad Max	SSP4 Tartan Spring	SSP5 MacMordor
Decision-making level	International, Strong government at multiple levels	Multinationals	Multinationals	SEC (de facto), Clantons
Geopolitical stability	High	Low	High (in Europe). High in Scotland, but then Tartan Spring in the end.	High
International Cooperation	Strong	Low	Stratified	Medium; cooperation
Social respect	High	Stratified	Low	Medium; individualistic society; the success of the economy limits social responsibility
Net migration	Stability, no one wants to migrate out of Scotland	Out-migration	In-migration	In-migration
Economic development	Steady growth, with small hiccups.	Low, Rollercoaster	Slow Increase	Fast growth
Mobility	Low; because of sustainability	Within Scotland: have nots forced mobility	Within Scotland: Rich high; majority low	High
Globalisation	Unconstrained	Low	High\medium	Unconstrained
Choice	Partly restricted; policy constraints in terms of environmental protection	Possibly stratified	Possibly stratified	Free
Social cohesion	High	Stratified	Low	High; due to the need for cooperation with the markets
Technology Development	Rapid	Low	High	Rapid development
Quality of Governance	Effective	Low (black markets)	Ineffective (Duality: GDP growth vs social decline)	Effective
Human health investments	High	Stratified [low]	Low-medium	High; – private
Education investments	High	Low	Medium-low private education	High; – public education
Environmental respect	High	Low	High (100% renewable)	Very Low

3.2.3. Trends for key (model) elements

Trends in a number of model variables were generated for key parameters for the Scottish version of the CLIMSAVE Integrated Assessment Platform (IAP; Holman et al., 2015) (Tables 6 and 7). As for the European case study some model parameters were quantified using fuzzy sets (Table 6) and others based on model experts interpretations of the scenario narratives, key elements and trends (Table 7).

Table 6: Qualitative information on input parameters for Scottish scenarios derived from the expert workshop which were then quantified using fuzzy sets. Increase (+), decrease (-) or no change (0) compared to 2010 are indicated in the brackets for the three time slices.

Parameter	SSP1 Mactopia	SSP3 Mad Max	SSP4 Tartan Spring	SSP5 MacMordor
Population growth	Strong increase (+, ++, +++) (linear, up to 50% in 2100	Decrease (-, -, -); decreased fertility, but increased migration (decrease is very small, only -9%)	Increase ($\frac{1}{2}+$, +, +).	Strong increase (+, ++, +++) Steady but lower than present trends
Bioenergy	Stable (0, 0, 0). Arable land for energy production = bad for SSP1. But we want some biomass production from trees	No change (0, 0, 0)	Increase ($\frac{1}{2}+$, +, +). Forests, food waste but not agricultural bioenergy	Decrease (0, -, --). Fossil fuel driven, so no incentive for bioenergy (not economically viable)
Food imports	Strong decrease (-, --, --) thanks to circular economy, but still imports	Steady decrease (-, $1\frac{1}{2}-$, --) possibly damaged land, subsistence	(+, $1\frac{1}{3}+$, $1\frac{1}{2}+$). Food imports – land use – high-value exports	Strong increase (+, ++, +++) Affordable and necessary
GDP growth	Increase ($\frac{1}{4}+$, $\frac{3}{4}+$, $\frac{1}{2}+$) Slow growth until 2060, then some decrease and levelling off	First volatile then collapse ($\frac{1}{2}-$, $\frac{1}{2}+$, $1\frac{1}{2}-$)	Increase ($\frac{1}{2}+$, + and $1\frac{1}{4}+$)	Strong increase (+, ++, +++) Steady and faster than present
Energy price	Decrease (-, --, --). Diversification of energy resources. First investments, then returns	Not given. Too constraining for mitigation options	Same as SSP3	U-curve (0, -, 0). System doesn't change but different energy sources. First fossil fuels, then renewables are more economically viable

Table 7: Qualitative information on input parameters for Scottish scenarios derived from the expert workshop which were then quantified by the model experts. Increase (+), decrease (-) or no change (0) compared to 2010 are indicated in the brackets for the three time slices.

Parameter	SSP1 Mactopia	SSP3 Mad Max	SSP4 Tartan Spring	SSP5 MacMordor
Water savings due to behavioural change	Strong increase (0, ++, ++)	(0, 0, 0) Very small stable decrease. Stratification between have and have not's	Increase ($\frac{1}{2}$ +, +, +). Could change with climate change impacts	Strong decrease (0, --, --)
Meat consumption	Strong decrease (-, --, --)	No change (0, 0, 0) Preferences don't change but changes are forced	No change (0, 0, 0).	Strong increase (0, +, ++)
Household proximity to green places	Strong decrease (-, -, --). People live in countryside, but peri-urbanisation slows down	Strong decrease (-, $1\frac{1}{2}$ -, --). Stratified between have and have nots	Increase (+, +, +)	Strong increase (+, +, ++). Rise of medium-sized peri-urbanisation
Water savings due to technological change	Strong increase (+, ++, +++)	Stable (0, 0, 0)	Increase (+, +, +). Ups and downs after 2050	Strong increase (+, ++, +++)
Set aside	Strong decrease (--, --, --)	Stable, then decrease (-, $1\frac{1}{2}$ -, --)	Very very small steady decrease (0, 0, 0)	No change (0, 0, 0)
Attractiveness of the coast	Strong decrease (--, --, --)	Strong decrease (-, --, --) people move to the coast --> ghettos! --> not attractive	No change (0, 0, 0). Could change with climate change impacts.	Strong increase (+++, ++, ++)
Human capital	Strong increase (+, ++, ++)	Decrease (-, -, -)	Decrease and then increase (+, 0, -).	Increase (0, +, +)
Social capital	Strong increase (+, ++, ++)	Decrease (-, $\frac{1}{2}$ -, $\frac{1}{2}$ -).	Many small up and downs between 2050 and 2100 ($\frac{1}{2}$ +, 0, 0).	Decrease (0, -, -). High human but low social capital
Manufactured capital	Increase (+, +, +)	Decrease ($\frac{1}{2}$ -, -, --)	Increase (+, +, +)	Strong increase (+, ++, ++)
Financial capital	Steady increase (+, +, ++)	Strong decrease (-, $1\frac{1}{2}$ -, -)	Increase then decrease ($\frac{1}{2}$ +, +, 0)	Strong increase (+, ++, +++). Faster growth rate than present

3.3. Iberian socio-economic scenarios

3.3.1. Narratives

Iberian SSP1 'Sustainability'

From 2010 to 2040: In the 2010s social movements intensify participation in social, economic and environmental issues in Spain and Portugal. More precisely, increased initiatives from NGOs, local and regional policymakers lead to the establishment of environmental programmes and enhanced public participation toward a more balanced development model (with less inequalities and social disparities and more environmentally sound). At the same time, outside Iberia, fossil fuel prices increase. Because of the strengthened social participation, new forms of innovation are being promoted, enabling a shift into renewable energies. In addition, reuse of other materials through, for example, bio-construction projects and green building become more important. In Europe, partly because of the change of the political climate towards more socially and environmentally sustainable policy making, a 'European social framework' is established. This ensures a minimum salary, fairer employment regulations and an effective public health system both in Spain and Portugal. Thanks to increased engagement of society, the effects of the 'European social framework' translate to a more democratic governance structures in Iberia where the European, national and local levels collaborate and work more in synergy.

From 2040 to 2070: The new positive synergies become even stronger thanks to multiple 'learning cycles' in many sectors which feed back into decision making hence boosting sustainable development policies. For example, local tourism practices respect of nature and even increase conservation by effectively implementing national and European regulations. Regarding waste and resource efficiency, new policies are implemented on plastics and textile production, as well as on water recycling and reuse. An increased supply of high quality tourism services is thus possible and meets higher demand from (wealthy) retired people. This positive loop also creates more job opportunities. Natural resources are managed from a more local and environmentally friendly perspective in synergy with higher level regulations. In addition, water resources are managed at river basin level, hence also taking into account long-term land-use planning. The consolidated development of other renewable energy sources such as solar, marine and wind energy (of which Portugal and Spain had so far just a great potential) increasingly allow for energy export of Iberia, resulting in even further increasing income and jobs. The greater participation in the national economy and cooperation at regional and European level also strengthens an effective governance in multiple sectors (education, innovation, social care etc). For example, a joint Portuguese-Spanish Agency on environmental protection and natural resource use is established, and it is responsible, among others, for transboundary water planning taking into account sustainability issues. By mid-century, the economies of Spain and Portugal are growing strong. Both countries become increasingly self-sufficient in terms of energy, because of market innovations both in demand and supply. On one hand, increased cooperation between water users results in increased production of new high-value redesigned green goods and services; and on the other hand, the emerging green economy promotes a reduction of water and energy demand which is partly helped by new modes of financial and technological innovations (e.g., including crowdfunding for green products and investments). The impacts of the new policies and other strategies are also evaluated on their social effectiveness and on the degree they generate new cross-sectoral synergies and collaboration. This leads to a boost in demand for green technology-based jobs, which in turn further reduces unemployment rates. Between 2040 and 2050, cities are transformed in such a way that energy and water consumption are reduced substantially, e.g. thanks to new forms of reuse and recycling systems. In addition, people move out of the large cities to the countryside to live in small and more liveable settlements. Population is stable because of low natural growth and a balanced migration. By the 2060s, the European Union institutions are strong and

specially focus on sustainable development, which helped Iberia even to export technology and renewable energy and green quality services further to the other member states.

From 2070 to 2100: In 2100, the joint Portuguese-Spanish Agency has expanded and becomes part of a network of institutions towards a Union of Iberian countries. This 'Union of Iberian Countries' becomes very effective to support cooperation and to deal in an integrated and participatory way with the planning and management of shared natural resources. Such a Union, however, does not entail that local identities are not respected but on the contrary it fully embraces complexity and differences in a more harmonised way, hence fostering local learning, multiple forms of experimentation, and diversity which is beneficial to the whole Union. For each international river basin, a single and participative joint authority has been created which deals not only with water issues but also with other sectoral and cross-cutting issues such as land use, agriculture, energy or public awareness. In particular, strong public participation spans over multiple sectors and also across governance levels. The strong influence of a broad range of stakeholders eventually results in fundamental and lasting changes. A new circular economic model is based on integrating and closing material loops. To support this system, governance institutions also go through constant readjustments and learning processes, based on experimentation. Monitoring what works or does not work in practice help to implement corrective measures and new strategies aligned with sustainable development.

Under the new conditions, globalisation is no longer destroying local human capital or depleting Iberian natural resources but rather become a harmonising force that facilitates the creation of synergies of the new development model within the Iberian Peninsula.

Iberia SSP3 'Regional Rivalry'

From 2010 to 2040: The political system is focused on immediate needs and politicians only promise populist measures in order to re-win elections, but not really to address public needs and the ultimate causes of social disorder. Hence, only end-of-pipe symptoms are being tackled, increasing inequalities and discontent. This leads to an increasing detachment of citizens with their politicians thus reinforcing this developmental trend which further exacerbates social exclusion. In addition, the negative impact of the global market and the financial system also determine this economic orientation which benefits only the few. This creates an unbalanced development model which generates social fragmentation, which in turn negatively affects other pillars of the Iberian development including cultural cohesion and the environment. This unbalanced development model hinders a fair economic distribution of resources. Such a trend adds to historical rivalries between Iberian regions and countries and an increase in the destructive impacts of globalisation which are also affected by uncontrolled migratory movements. The social and economic fabric of Spain and Portugal become increasingly fragmented. In Spain, Catalonia gains independence in 2030 and spearheads autonomist movements across other resource-rich regions in Iberia such as the Basque Country. In spite of environmental degradation, environmental issues are not any more on the agenda and either much of the social issues. This leads to a series of dramatic events of water and resource scarcities. For instance, several Iberian cities start have more frequent and severe water shortages which are just attenuated with water imports. The weakening role of the EU institutions further reinforces economic deterioration and social fragmentation in a vicious circle. The growing divide between Northern and Southern European countries fosters the creation of a 'Club Med' which includes Italy, Spain, Portugal and the Northern African countries. In spite of the internal conflicts, the 'Club Med' is perceived by its members as the only chance to slow down the hegemony of the North.

From 2040 to 2070: Some social and political stability brought by the international cooperation in the 'Cub Med', is counterbalanced by increasing social tensions within Spain and Portugal. Tensions arise among groups with less access to social and economic opportunities, including between long-term

resident immigrants and their families, in some cases materialising into religious expressions. But tensions also increase because of water and resource scarcities. A series of environmental problems hit the Mediterranean. Prolonged heatwaves with temperatures reaching 50 degrees and long-term droughts are increasingly common triggering higher desertification. This, combined with multiple economic crises and the lack of effective political capacities to react and take the sound decisions, social unrest increases. Tourism is also affected negatively because all of these factors, which in turn further deteriorate the economy and the environment. Larger stretches of land are abandoned and conflicts over water use increase tensions in the regions resulting in their independence. By the 2060s four countries have come to exist in Iberia: Portugal, Spain, Catalonia and the Basque Country. But such independence has not solved problems in Iberia because the regions remaining within Spain and Portugal are still in conflict with each other due to resource scarcity, especially water. The lack of resources however prevent an escalation of these conflicts to a war. Growing crime, lack of future prospects and ineffective policies lead to increased numbers of emigrant people leaving Iberia.

From 2070 to 2100: Population flows are mostly leaving Iberia and the remaining Iberian population concentrates more and more in large cities. Because of recurring droughts and growing dependency on scarce fossil fuels the economy drops further and conflicts escalate. Nevertheless a full-fledged war is prevented thanks to some intermediation operated by the 'Club Med' authorities. Economically, little hope is left for those who stay in Iberia whose population is growing older. A common source of income for families are remittances from their relatives abroad, especially young people who never manage to find jobs at home. A way out of this quandary seems difficult, because a desertified and resourceless Iberia, with an economy unable to produce quality goods and services and with a high level of crime, is of no interest to the world. The divide between Northern and Southern countries grows larger than ever before, mostly because of the lack of sound, inclusive integration of the EU. This situation lead to Southern Europe and North Africa sharing the same social, economic and environmental problems. Libya and other African countries (with some fossil fuel resources) lead the Club Med. However, continuous conflicts and social unrest across multiple countries (with a similar disintegration process occurring in other members) limit its potential for international cooperation.

Iberia SSP4 'Inequality'

From 2010 to 2040: Economic challenges in Iberia are exacerbated by the new EU-global crisis related to famine and war in Africa and the Middle East. Additionally, multiple environmental crises and accidents take place in Iberia, such as droughts, increased erosion and reduced water quality and quantity. This leads to increased poverty in the south of Iberia, where people depend on agriculture for subsistence. This leads to lower quality of life and increased conflicts, which escalates with an increased immigration from North Africa because of perceived better conditions in Iberia. Immigration from the Middle East and Asia is also rising. Until 2040, there is a strong and enduring immigration from those regions and particularly Northern Africa not only to Iberia but to the entire EU. In Iberia, unemployment rises to record levels, which leads to additional economic crises, and eventually social unrest and massive protests. Social cohesion is very different within different social groups. Low social cohesion between lower levels of income is due to diverse ethnicities, religions, etc. Within the top classes ("club"), social cohesion is increasingly strong. This leads to strong tensions both between lower and higher social classes and within social classes.

From 2040 to 2070: This unstable social situation escalates further in the 2040s, when continued social tensions, protests and riots lead to a shift in the political system, with the existing governments collapsing in Spain and Portugal, but consequently also leading to dramatic changes at the regional level. New, democratically elected, governments establish an oligarchical system. In this situation of political instability and social conflicts, power and money are gradually centralised in a few companies in collaboration with the new governments. This creates a strong and powerful public-private

partnership which guarantees the position of the existing multinationals and newly elected political powers. By 2060, this alliance controls markets, production and access to goods. In line with EU priorities to diversify energy portfolio and become self-sufficient and because of rising worldwide energy demand, Iberia starts to invest in wind and solar technology through taxes and EU funding. Europe sees also advantages in exploiting those abundant energies. Iberian leaders are also the opportunity to explore solar energy development in neighbouring North Africa. The increased stability of the new regime comes at a drawback. To maintain power, the political system quickly becomes less democratic and more oppressive. To ensure a continued approval and vote from the public, the rulers provide basic needs but ensure relatively low levels of education and health conditions for the masses, restricting access to high-level privatised education and health services to themselves.

From 2070 to 2100: By 2070s Iberia is the “EU leader” in wind and solar niche technology. To increase their benefit, elites monopolise natural heritage, health, education and culture, while privatising the energy resource market. The political and industrial elite successfully continues its strategy to use “subtle” enforcement of inequality through education and keeping people busy on low skilled tasks, with no expectations for education and for increasing their well-being; The motto ‘divide et impera’ is back in Iberian politics: rivalry between social and ethnic groups are maintained and increased by the elite policies. Basic conditions are provided ad-hoc to the poor classes so that order is maintained. The media information is controlled to maintain public order. An increase in renewable energies is very lucrative, because the government can sell energy to Africa. Other businesses, such as energy and food production also contribute to technological transfer in Africa to keep migration under control.

Iberia SSP5 ‘Fossil Fuelled Development’

From 2010 to 2040: The global and European economic crisis severely affects Iberia resulting in both Spain and Portugal defaulting on their debts. To maintain stability in southern Europe, northern European countries agree to provide social aid and subsidies for Iberia. The subsidies are linked to a restructuring of the economy and social system to ensure European access to fossil fuels in North Africa. This is supported by investments in technology to connect electricity networks in Europe which enable better control and distribution of cheap and plentiful fossil fuel-based energy resources. Iberia is strategically placed in this new energy network creating opportunities for further investment in technological development for exploiting fossil fuels as well as education to support this technological focus. In order to increase its economic output and further exploit its natural resources, Iberian countries invest in large-scale intensively managed and mechanised agriculture and commercial forestry. This is supported by subsidies and the widespread access to cheap fossil fuel-based energy. However, the strong push for intensification, particularly in commercial forestry, leads to more forest fires, and fire becomes a regular part of the system. Investments in technological development pay off as they enable local fossil fuel resources within Spain (shale gas) and Portugal (offshore), which were previously difficult to access, to become economically viable to be exploited. A government-subsidised scheme is initiated to fight unemployment by ensuring jobs through internships/trainings, particularly in the expanding technology and fossil-fuel exploitation industries. This strongly decreases unemployment rates, resulting in broad support for the government. At the same time, these corporations also increase their influence on national decision-making.

From 2040 to 2070: In the 2040s, problems start to occur because of increasingly frequent droughts. Technological solutions are sought and found, for example, by building desalination plants on the coastline and prioritising water use in cities and the agricultural sector over the environment. Flooding and drought become more common and more intense, leading to further environmental destruction. By 2050, the natural hydrological system collapses in particularly dry areas of the region, such as central Spain, and some major cities, such as Madrid are gradually abandoned as people migrate towards the coast and wetter parts of the region where water is more plentiful. The majority of

people, however, are unaware of the effects of a lack of investment in environmental protection because of the successful technological solutions to resource availability. People do not complain because there is sufficient food and water supply and, for example, a relatively efficient health system. The large technology corporations are already in control of government decisions. By 2060, Iberia totally depends on technology, fossil fuels, subsidies from the EU and gas from northern Africa, and investments of large corporations. Towards 2070, the peak of the fossil fuel crisis triggers a strong economic crisis leaving many in debt. It serves as an eye-opener to many that problems are overly solved with technological fixes, while much of the power resided in the hand of only a few.

From 2070 to 2100: The consequences of peak oil continue to affect the fossil fuel-based development put in place so far. With a significant decrease in energy tax returns, companies' debts increase which leads to increased investments and further exploitation of off-shore fossil fuel resources. In 2080, this leads to a big oil spill accident which exacerbates marine environmental degradation. At the same time, massive forest fires destroy large commercial forests and droughts plague Iberia and endanger food and water production. These environmental disasters, together with the fossil fuel financial bubble, lead to food shortages. Iberians start to be aware that technology can no longer solve environmental problems or sustain agricultural production. By 2100, people are concentrated in cities where the technology corporations and technological solutions for providing resources are focused. The outlook is uncertain as the fossil-fuel based development model collapses and business opportunities decrease, and large proportions of the population migrate to northern Europe.

3.3.2. Key (story) elements

An overview of key elements for the four Iberian SSPs is given in Table 8.

Table 8: List of trends for five key elements in the storylines for the four Iberia scenarios.

Other key questions/elements	SSP1 'Sustainability'	SSP3 'Regional Rivalry'	SSP4 'Inequality'	SSP5 'Fossil-fuelled Development'
<p>1. <u>Economic growth and job creation opportunities:</u></p> <p>To which extent do you think that high-end scenarios will impinge on economic growth and job creation opportunities in Portugal and Spain in the coming years? If possible specify the effects in different sectors (e.g., tourism, services, technology and energy, industry, construction and agriculture).</p>	<p>There is a strong increase of green jobs, especially in the renewable energy sector. Jobs are also created due to more demand for tourism services for retired people. The boost in demand for technology-based jobs creates jobs and reduces unemployment rates. An increased emphasis in social politics also produces a generalised public health system for all which together with minimum salary and strong and efficient employment and environmental regulation, also creates jobs.</p>	<p>Economic growth opportunities are impaired in all sectors, due to lack of political reaction and decision.</p>	<p>EU-Subsidy based development of green technology in both Spain and Portugal. Main sectors are green energy (wind and solar) development. Few companies, which will control markets, production and access to goods.</p>	<p>Boost in job creation opportunities in agriculture, technology, energy (from fossil fuels).</p>
<p>2. <u>Governance & decision-making coordination and innovation (regional/ national & European):</u></p> <ul style="list-style-type: none"> What are the prospects for policy <i>coordination between both Portuguese and Spanish regions</i> and national authorities to face high-end scenarios? (e.g., main opportunities, strategies and difficulties). And in particular, which are the main options and mechanisms (including information, communication and public participation) to improve/transform existing cooperation <i>between shared river basins</i> (such as the Tajo or the Guadiana and others) in the face of high-end scenarios? What do you think will be the <i>effect of the Implementation of EU</i> 	<p>The crucial element in the new development model is public participation, which should be understood in a very broad way. Overall, the public participation processes affect multiple sectors importantly including the agricultural sector that needs to cooperate and consult with other relevant sectors such as the energy sector for the elaboration of its strategy. The crucial element is public multi-sectoral participation in development of strategies, not in implementation and execution. For each international river basin one joint coordinating authority.</p>	<p>Very loose coordination between 'Club Countries' as EU breaks down. However, increasing rivalry in the region results in effective governance. This leads to disintegration of Spain in to 4 countries. Little opportunities for cooperation between shared river basins.</p>	<p>Very hierarchical system. Both Spain and Portugal are dependent from the EU. Public participation is at its lowest, as education levels will drop for the poor classes.</p>	<p>No shared decision-making process, but institutions work well. Focus is on income. Main opportunities are created at the beginning thanks to EU subsidies to both Spain and Portugal. This scenario is top-down and cooperation between shared river basins is implemented if of interest for companies (water production). Public participation is not a prerogative. Effective Implementation of EU Directives.</p>

<i>Directives</i> (Water Framework Directive, Energy, Climate and Conservation Policies) in such coordination?				
<p>3. <u>Population and migration flows. Urban dynamics derived from HES</u></p> <ul style="list-style-type: none"> How and to what extent will high-end scenarios affect population dynamics and migration flows within Iberia (e.g., rural land abandonment, urbanization, coastal migration, etc.)? How and to what extent will high-end scenarios affect population dynamics and migration flows between Iberia and other countries? How HES will affect urban dynamics and configuration in Iberia? 	There is a 'repopulation' [sic; meaning 'reinhabitation'] of the countryside, hence rural abandonment stops and small liveable cities are created. People move from megacities to live in little towns.	Increased immigration from Africa, poorly managed. As the situation degenerates, increasing outmigration from Iberia. Rural land abandonments.	Immigration to Iberia from Africa, until democratic collapse around 2040s. Population migration flows are stable afterwards. "Colonization" of Africa by the big companies to produce energy and food for the EU and to keep populations in their countries.	Within Iberia, migration to cities, job opportunities in corporations. Migration from Africa to Iberia and rest of Europe. Retired rich Northern people will also move to Iberia. By end of the century, collapse of development model leads to migration away from Iberia towards Northern Europe. To protect Iberia from immigration the budget for military expenditures will be increased, creating a more and more defensive system.
<p>4. <u>Energy production and technology development</u></p> <ul style="list-style-type: none"> How do you think HES will affect energy production structure in Iberia (e.g., hydro and nuclear in shared river basins)? What are the main opportunities and constraints for the development of low-carbon resilient technologies in Portugal and Spain? 	Energy sector would shift from its reliance on hydropower, towards other renewable sources of energy (i.e. solar and wind). A common strategy would be developed for natural resources utilization for both countries to minimize the differences, i.e. collaboration between the two countries. Create a unique administration: Iberia. Iberia exports technology and renewable energy to the EU. The main constraints are of an institutional nature, based on preventing small companies taking up renewable energy and connecting to the grid or creating de-centralised / autonomous energy markets.	Energy production is centred on fossil fuel production, mainly imported from other Club Med countries. Impossible challenges for hydropower production as Iberia remains without water. No investments in alternative resources.	Opportunities, when needed to the elites. For example in the Tajo/Tejo basin, the water quality will first decrease and then increase from 2040; elites will keep many protected areas in good conditions because of the services they provide: tourism; biological agriculture; increased air quality and water quality, etc.	Hydropower, but will be challenged by droughts. Focus on sea water for water production and fossil fuels for energy production. Development model based on fossil fuels and subsidies shifts away from low-carbon technology.

3.3.3. Trends for key (model) variables

Impact modelling in the Iberian case study focuses on the key issues of water management and agro-forestry using the SWIM (Krysanova et al., 2000) and LandClim (Schumacher et al., 2004) models, respectively. Thus, stakeholders were asked to provide trends for variables related to these key issues, as well as the capitals, that were then quantified using the fuzzy sets method (Table 9). In addition, stakeholders were asked about specific assumptions related to domestic water supply (Table 10).

Table 9: List of variable trends for the Tajo/Tejo basin for three time slices (2010 to 2040, 2040 to 2070, 2070 to 2100). Increases (+ or ++ or +++) or decreases (- or -- or ---) or no changes (0) expressed as change compared to the baseline, 2010.

Model parameters and capitals	SSP1 Sustainability	SSP3 Regional Rivalry	SSP4 Inequality	SSP 5 Fossil-fueled Development
Cropland	½+, +, +	½-, --, ---	0, 0, 0	½-, -, --
Water transfer	0, 0, 0	+, ---, ---	-, --, --	½-, -, -
Water storage	0, 0, ½-	0, -, ---	0, 0, 0	0, 0, 0
Human capital	+, +++, +	-, ---, ---	+, -, 1½-	++, +++, ++
Social capital	++, +++, +	-, ---, ---	+, 0, -	+, +, --
Manufactured capital	-, +, ++	--, ---, ---	½+, +, ++	+++, +++, ++
Natural capital	-, ++, +	-, ---, ---	+, ++, ++	-, --, ---

Table 10: Additional assumptions based on storylines for impact modelling (domestic water supply).

Model parameters and capitals	SSP1 Sustainability	SSP3 Regional Rivalry	SSP4 Inequality	SSP5 Fossil-fuelled Development
Urban water supply	Decrease (increase in efficiency)	Increase (more inefficiency)	First increase, then decrease (increase efficiency)	Increase (due to non-environmentally friendly practices, such as desalinisation)
Domestic water demand per capita	Decrease (due to recycling and reuse)	Decrease (people can have access to less)	Decrease (people have less access, only elite will have better access)	Unsustainable increase, and then a decrease because access (costs of environmental sanitation, water scarcity will surpass technology by 2070)

3.4. Hungarian socio-economic scenarios

3.4.1. Narratives

Hungary SSP1 'Roszasim alom' ('Pink dream')

From 2010 to 2040: Because of the inertia of the system, barriers to development emerge. Hungarian national debt remains persistently high because of irresponsible spending and leads to the need for debt restructuring. The economy is characterized by market orientation and overconsumption. Population continues the present trend of decrease and aging. Population distribution is becoming unbalanced; Budapest becomes overpopulated and the rest of the country depopulates. Pressure on population is increasing due to a rising number of immigrants from outside the EU. Public opinion is changing in Hungary and people increasingly speak out in favour of change. Local governments take

initiative to revert these trends by initiating a dialogue with the people. For example, in Veszprém the local government invests in social services from its own pockets to avoid depopulation. The first positive effect of these changes is a growing number of residents choosing locally available education versus elsewhere in Hungary or abroad. Investments in education pay off through an increase in skills and expertise in sustainable technological development and innovation. Veszprém becomes a knowledge centre of green industry that attracts further skilled workers and stimulates accelerated conversion to renewable energy. In agricultural areas, such as Szekszárd, subsidies and grants from earlier EU tenders have been invested in the development of sustainable practices and the local food processing, to increase value added and reduce losses. Such local changes also influence governance at the national level. Hungary maintains and reinforces domestic policies to counteract population decrease (for example family planning subsidies). The Hungarian policy agenda also includes policies to promote the conversion to clean energy, improved education and public health. An aggressive Hungarian renewable energy plan is put in place along with ambitious energy efficiency measures, including a reversal of the decision about expanding Hungary's nuclear energy capacity. Locally, 'sustainable regions' like Szekszárd and Veszprém become role models for good practices, which are replicated throughout the country.

From 2040 to 2070: Thanks to the successful policies, these changes keep the positive direction. New political elites stem from local communities who better represent people's real needs. The new elites understand the importance of the long-term synergy of economic and environmental measures. This means that community participation is intrinsic to policy-making and all levels are interconnected ("hálózatosodás"). The common good is pursued as the primary priority and wealth produced is shared more equally. Local governments develop ambitious climate change adaptation plans. Further measures to increase green economic growth include prudent fiscal policy and effective anti-corruption measures. A positive outcome of the new political reality is that it reflects the will of people as it originates from the will of the communities bottom up. A new emphasis on transparency results in a decrease of corruption and politicians being accountable. People trust the decision-making process and tax morale radically improves. The education system is fully reformed with emphasis on skill development in sync with a green transition. The new generation is not only technically skilled, but also involved in decision-making. Agricultural products are grown locally and food safety improves. However, this doesn't mean that Hungary has closed its borders: the country is more integrated in the EU and has increased its trade relations within and outside the EU (Hungary joined the Eurozone already in the early 2040s). The share of high value-added products made in Hungary increases vs. raw materials and products with low-value assembly. The state of the environment improved: air quality is high, zero-waste communities are the norm and waste water is fully recycled. People use increasingly environmentally friendly public transport and car dependence falls.

From 2070 to 2100: Favourable external conditions further cement the positive socio-economic trends of previous decades. Europe's broader neighbourhood stabilizes and migration pressure falls to insignificant levels, while permanent outmigration of the indigenous population falls to tolerable levels and birth rates stabilize. Increased cooperation with the European Union contributes to increased social and economic opportunities. Unemployment is consistently low. Citizens actively participate in politics and decision-making and change their behaviour. People are conscious of health and favour active lifestyles. The number of health adjusted life years is high and many lifestyle diseases disappear; across all levels of society, education levels are higher and people are able to dynamically respond to new challenges and opportunities. Teaching has become a prestigious profession. Prevention is the preferred form of environmental management, the degradation of local flora and fauna has stopped and there are clear signs of a recovery. Sustainability, responsible finance and health are all an integral part of the curriculum. The use of renewables is widespread, especially solar and wind but also new, presently unknown clean technologies emerge. Security is high, to the extent that wine cellars in Szekszárd can be left unlocked.

Hungary SSP3 'Regional Rivalry'

From 2010 to 2040: The persistent lack of political consensus in Europe and newly skyrocketing energy prices result in European member states arguing over the allocation of remaining resources. Weaker countries with limited domestic sources of fossil energy and bargaining power, such as Hungary, are forced to pay extremely high premiums for energy imported from Russia, the Middle East and the US. In order to sustain economic growth, the Hungarian government reallocates the budget from social services and the environment to sectors such as industry. As a result, GDP continues to grow, but growth is lacklustre and temporary. Due to stalling wages, high inflation and because of decreased social services, tensions among the population increase. Social participation and environmental responsibility decrease as people struggle to meet their day-to-day needs and have to bear costs of what used to be provided through social services. Only the rich have access to higher quality healthcare and education, and those who can, particularly the educated, leave in large numbers. The lack of skilled workers becomes acute, acts as a break on economic growth and contributes to immigration from countries to the East that are even worse off than Hungary. Food production slightly increases then stagnates, as the needs of the population are met, but due to high input costs and economic struggles in potential foreign markets exports flatten. Natural ecosystems, particularly forests are showing increasing signs of vulnerability due to extreme events, droughts and more common heatwaves. Water use falls due to unaffordability, while the government fails to implement large-scale water conservation and watershed management measures. Year by year there is less money for public education and for maintaining social services, leading to growing social tension, particularly among the poor. The political system responds to public discontent by investing in increasingly authoritarian measures and by reducing investment in education and other services, leaving it to society to fill the gap. The process results in further increasing inequality and entrenched structural poverty. Solidarity among European countries is weak and a persistently crippled and over-bureaucratized EU is unable to respond to these challenges and eventually disintegrates.

From 2040 to 2070: As European countries are mired in addressing growing problems on their own, external and internal pressures destabilize the country. Because of the uncertain outlook in Hungarian (and European) economic development and due to social unrest, large German investors leave Hungary and economic turmoil turns into a political fight for power. As earlier during WWI and WWII, Hungary again finds itself in a war zone between competing world and regional powers where common interests and true intentions become difficult to follow. In an attempt to stabilise social tensions and try to reinvigorate again the economy, the government embarks on a major (fossil) energy subsidy scheme to keep prices artificially low. The main energy exporter to Hungary dislikes these type of policies and therefore intervene politically. A fragmented and disoriented Europe has become a theatre where geopolitical interests of the major powers collide. As European reconciliation with Russia and integration within the broader Eurasian region fails and as Europe's other neighbours to the South and East are mired in poverty and conflict, Hungary finds itself in the frontlines, unable to take advantage of its strategic location between East and West. The country is characterized by a worsening economy and environment, and persistent social unrest. Due to lack of security, services and jobs and unaffordability of food, urbanization goes into reverse and people move to the countryside and the urban fringe from larger cities. However, due to limited infrastructure, villages are unable to support the influx. A poorly maintained suburban and rural housing stock and infrastructure is struggling to withstand the impacts of climate change. Upgrading would require major investment that is not available because of poor economic conditions. An increasing part of the population lives in urban and rural ghettos without even the most basic of public services such as education and healthcare. The most vulnerable such as the elderly are faced with mounting health problems, unmanageably high cost of food and utilities and depression. Forests are hit by increasingly common fires, and crop failures become more common due to a combination of factors, including drought, heat stress, soil degradation and invasive species, coupled with eroding farm management

capacities. A growing part of the population is trying to become self-sufficient in food by re-learning forgotten gardening and livestock keeping practices.

From 2070 to 2100: By 2070 energy shortage becomes the main policy issue. Power plants are overused and due to low maintenance the possibility of a nuclear disaster increases. Water shortages are common and affect particularly industry and large-scale agriculture, contributing to an overall reduction in the amount of farmed land, but increasingly also municipal water supplies due to the combined effects of poor infrastructure maintenance and common droughts. The liveability of cities further declines and urbanization stops.

Hydrological regimes become irregular and unpredictable. Floods risks of the Danube are accentuated in winter, while hot summers and lack of precipitation lead to extremely low water levels to the point where navigation becomes disrupted during summer. Lake Balaton dries out by 2070 and part of it is turned into farmland. Large blocks of forests are no longer viable and indigenous tree species gave way to invading species better suited to the new more extreme ecological conditions. Cybercrime is rampant and manipulation of people through the Internet and the media is ubiquitous. Whatever new technologies emerge serve only the interest and needs of the elite and the purpose of control. Inequalities are accentuated as social cohesion is low and corruption high, only quasi-autonomous local communities scrape by. Persistent crises in Europe's immediate and more distant neighbourhood lead to a steady and massive influx and settlement of migrants and refugees and resulted in a major transformation of the demographic, cultural and religious landscape. A growing number of people with non-European ancestry make it into politics. A completely different culture evolves, with Hungarians becoming a minority. Whatever was left of traditional ways of life that could co-exist with nature vanishes. A new multicultural melange emerges with no semblance to Hungarian traditions, culture and ways of life.

Hungary SSP4 'Inequality'

From 2010 to 2040: Reliance on subsidies is a dominant strategy in Hungary as the main source of capital and widespread in the EU. While some enterprises, individuals and communities have privileged access to subsidies and financial support, most SMEs and other actors outside of this circle have no access to capital. The country has a strong state apparatus, but it is highly dependent on external factors. Landownership is concentrated in the hands of a selected few. Corruption and populist measures lead to political and economic power to converge in a few hands, leading to increasing discontent in the population. External and internal migration are significantly reduced by European governments and a resurgent EU.

Subsidies and corruption as key factors trigger a financial crisis. Following failed elections and a political collapse a new election is held and a new leader emerges, who is facing an overwhelming demand to keep the political scene stable and take very strong measures to stabilise the country. This results in an even higher degree of centralisation, close to a dictatorial system with a strong state. Contrary to initial expectations, differences between the elite and the non-elite not only remain, but even intensify. By 2040 the level of education of the lower classes falls to a fully manipulated level, whereas the elite continues development thanks to a stable Hungary. The elite reaches a degree of self-sustenance and independence that is out of reach for the general population. The EU will be complacent with this shift because it maintains a safe status-quo with regard to migration, subsidy regimes and multinationals continue to have access to Hungary's markets and persistently cheap, even if poorly educated labour force.

Water and energy use falls due to the initial investment of subsidy funds in modernization and efficiency improvements and a slightly declining and predominantly poor population that has to save

to make ends meet. Rural to urban migration continues due to poorly paid but stable urban employment prospects and the interest of large landowners on the urban-rural fringe in subdividing land for housing development. Agricultural production becomes more industrialized and intensive on the large estates of the elite.

From 2040 to 2070: With the economic conditions of the poor unchanged or falling, differences between ethnic groups are reduced as living standards converge at a lower level. Current differences between the high reproduction rate of the Roma population and poorer segments of ethnic Hungarians will converge. Birth rates among the lower classes are higher and the level of education and health is low. Ghettoes develop everywhere and epidemics spread among the poor. Due to the lack of prevention, diseases such as tuberculosis return in a more virulent form due to drug resistant bacteria. Plant and animal diseases also become again more common due to poor management conditions in the holdings of the poor and due to excessive monoculture on the land of the elite. At least in the short-term, the State finds crisis management less costly than prevention. They mobilise disaster forces, disinfect and prepare for the next epidemic. Around 2050, the education system collapses and traditional middle schools are phased out, leading to riots and the deployment of the police and military to restore 'order'. Left on their own, this makes people understand that they need to find their way out of the system and increases creativity. New forms of collaboration emerge: the old educate the young, people develop survival mechanisms, and many go offline and leave the formal structures of society to lead quasi-independent (though vulnerable to external shocks), more autonomous lives. Intensive forms of food production possible on limited amounts of rural land not used for industrial agriculture or in urban allotments enjoys a revival. At some point during this period the supply of some key commodities such as fertilizers and fossil fuels become more frequently disrupted and industrial scale agriculture collapses as oligarchs are no longer able to sustain the system using existing methods. This further contributes to a growing interest in decentralized renewable energy and off-grid solutions plus reuse and recycling, including for example the reuse of wastewater as fertilizer. The poor develop their own 'green methods' based on a mix of traditional knowledge and new citizen science-based inventions. Despite these developments, the life of the majority is still a struggle, with a controlled media and education system.

From 2070 to 2100: By this time population growth peaks as deaths rates start overtaking birth rates. Food crises and hunger riots are widespread. A softening dictatorship, led by the second generation of the elite, realises that they have to show flexibility to preserve the system to avoid a revolt. Around 2070 a new popular, charismatic and spiritual leader is found whose authority the people recognize and who is revered almost as a king. This charismatic person has to provide a vision and feeling of security even though there is still widespread poverty and subsistence living. Structural unemployment is stuck at a high level, as artificial intelligence allows the elite to increasingly substitute human labour with robots. Common people make use of a mix of low-tech local innovations and cheap, mass-produced technologies in the routines of daily life and subsistence living. The use of water and energy is stable at a low level, urban-rural migration is tightly controlled and farmland allocations are stable. Pressure on natural ecosystem due to global change is still significant and apart from the artificially maintained sanctuaries of the powerful the environment is intensively used, but helps meet the basic needs of locals. Society is still deeply unequal, but people are happy with what they have.

Hungary SSP5 'Pató Pál Úr'

From 2010 to 2040: Consumption and corruption are increasing in Hungary. There is a positive feedback between economic growth, technology, energy demand and consumption, and individual behaviour. These elements interact and reinforce one another. Increased consumption is in part driven by a continuing and pervasive ICT revolution and results in a total transformation of society's

consumption patterns. People spend their life online. Social or 'real' interaction, and community-based activities become part of the past. Online shopping is ubiquitous and many people conduct their business on the internet, resulting in accelerating economic activity. The community characteristics typical of today's Hungary, therefore, dies out. Increased economic activity and energy demand are met with provision of the most 'readily' available source of energy: fossil fuels. No extra investment is needed: if more energy is needed, we just produce more using present infrastructure and import more (for this, there are also stronger ties with Russia, the Middle East and the US). To meet the new lifestyle demands and in sync with economic growth, technological development takes over in other sectors, such as precision farming, the use of robotics in manufacturing and moving many services to digital platforms. Because of increased energy demand, some 'shortcuts' become inevitable in policy-making, reinforcing corruption, which - ironically - contributes to a virtuous cycle to further economic output. Unbalanced repartition of energy supply – as a result of corruption – further deepens the gap between those who can afford it and those who remain out of the economic growth loop. 'Brain drain' still affects the country, but migrants also appear as a lower cost workforce. This results in increased unemployment for Hungarians and some social unrest. However, due to the revenues created by economic growth, governments continue to prop up the social welfare systems for locals and immigrants, mitigating social unrest. The political elite manages to maintain high levels of popularity and a degree of stability. The rate of the brain drain slows. CO₂ emissions grow and extreme weather events, environmental catastrophes are more frequent and violent. These natural disasters, aging infrastructure and overuse of energy lead to some black outs. This damages agriculture and the economy in general. Temporary water shortages, epidemics, droughts and floods due to environmental degradation are also common. The government reacts with very effective crisis communication to prevent social unrest.

From 2040 to 2070: Reliance on foreign energy supplies creates supply chain risk and makes the system vulnerable to disruption such as social unrest and terrorism. Work patterns and the nature of unemployment continue to change as a result of technological innovation. This includes technology to further exploit fossil energy, healthcare, biotechnology and transport, among others. The education system reflects the new stratified Hungarian society. Education is also stratified and the rich have access to good quality private education. The orientation of school curricula is highly technical. In Hungary, 'educated' becomes synonymous with 'technically skilled worker'. Due to this, the 'brain drain' reverses. Mobility is still high for professionals across Europe. Economic and professional growth is built on a weak foundation and is vulnerable to even small shocks. For example, as resources start to diminish, governments have to further redirect investments away from social (unproductive) welfare. Investments are made in industries and mechanised intensive agriculture to ensure maximum economic output. Unemployment for Hungarians starts to increase again among the low skilled population in part due to competition by low-skilled immigrants. Despite unemployment, Hungarians still have what is considered a decent lifestyle. All levels of society are material and energy hungry but the quality varies hugely between rich and poor (quality vs. low-cost). Hungarians have become information-rich but knowledge-poor. Due to environmental degradation and continued globalization (including soaring global trade facilitated by a series of well-entrenched 'free' trade agreements) new pandemics and invasive species appear in Hungary. The general health status degrades. Life expectancy is low and child mortality is high. However, mechanised agriculture can still sustain food production and high technology in healthcare can partly mitigate negative impacts and slow further escalation. For a short while, technology can still help solve temporarily the problem of energy depletion by exploiting remaining energy resources cost-efficiently. Just before the 2070s, people can still maintain their lifestyle, in a degraded Hungary. However, atomization of society, lack of resources, pollution and increasingly ineffective policy-making are reaching a tipping point. Some people still want to keep their lifestyle, but many others are starting to become aware of the unsustainability of this situation.

From 2070 to 2100: The lack of environmental concerns and long-term sustainability strategies in the ‘technically educated’ elite reflect the short sightedness of energy demanding lifestyles. Life is getting difficult and the usual consumption lifestyle cannot be maintained anymore. While the ruling elite has secured its future, the rest of the population starts to lack even basic provisions such as water, food and housing. Also because of extreme climate change, most people experience food shortages and the governments (both local and national) can no longer respond to crises as even agriculture collapses. Production and consumption patterns are forced to change, leading to a countrywide to chaos. During these difficult times, diseases also decimate the population. This shock is the tipping point where the increasing awareness of previous decades starts to result in new trends. Food production becomes localised, which leads to pockets of local food security, but apart from that, food shortages are the rule. Communities re-emerge to develop joint survival mechanisms. In this framework, education undergoes transformation to focus on the importance of knowledge. Green technologies around 2095 become again popular in political discussions. Because of fossil fuels are increasingly expensive even for fossil fuel rich countries, the national elites need also to change in the same direction as the local communities. The country gets on the bumpy path towards a post fossil fuel era that was abandoned decades before.

3.4.2. Key (story) elements

An overview of key elements for the four Hungarian SSPs is given in Table 11 and Figure 3.

Table 11: Key elements in the Hungarian SSP narratives. The graphs shown in Figure 3 below summarise the trends qualitatively for these elements for all four Hungarian scenarios.

	Element	Indicator
1	Kormányzat és irányítás (Government and management)	Civil szervezetek száma (Number of civil organisations)
2	Nemzetközi kereskedelem (International trade)	Külkereskedelmi egyenleg (Trade balance)
3	Területhasználat és művelési ágak (Land use and agriculture)	Földhasználat-változás (Land use change)
4	Népesség és egészség (Population and health)	Városi népesség aránya (Ratio of urban population)
5	Vízhasználat (Water use)	Közüzemi víztermelés (Domestic water use)
6	Energia (Energy)	Alap-energiahordozók termelése hőértékben (Primary energy production by type of energy)
7	Élelmezés (Food and nutrition)	Az ökológiai gazdálkodásba bevont területek mezőgazdasági területen belüli aránya (Area of land that was converted to ecologically certified land)
8	Pénzügyek és gazdasági növekedés (Finance and economic development)	Az egy főre jutó GDP 2005 évi átlagáron (GDP/capita – 2005 baseline)

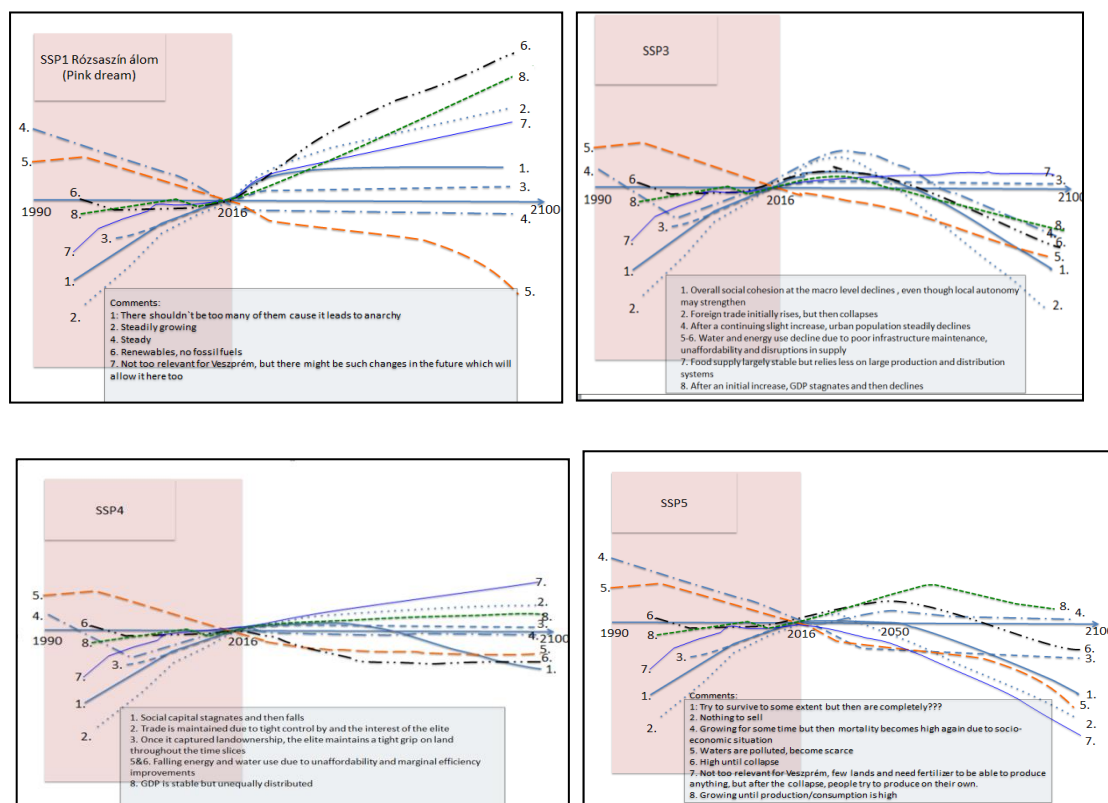


Figure 3. Qualitative trends for key elements in the four Hungarian SSP scenarios. See Table 11 for the key for each numbered line.

3.4.3. Trends for key (model) variables

Impact modelling in the Iberian case study focuses on the key issues of water management and agro-forestry using the SWIM (Krysanova et al., 2000) and LandClim (Schumacher et al., 2004) models, respectively. Thus, stakeholders were asked to provide trends for variables related to these key issues, as well as the capitals, that were then quantified using the fuzzy sets method (Table 9). In addition, stakeholders were asked about specific assumptions related to domestic water supply (Table 10).

Table 4: List of variable trends for Hungarian scenarios for three time slices (2010 to 2040, 2040 to 2070, 2070 to 2100). Increases (+ or ++ or +++) or decreases (- or -- or ---) or no changes (0) expressed as change compared to the baseline, 2010.

Model parameters and capitals	SSP1 <u>Rózsaszín álom</u>	SSP3 Regional <u>Rivalry</u>	SSP4 Inequality	SSP5 <u>Pató Pál Úr</u>
Agricultural land	Very slow linear decrease ($\frac{1}{3}$ -, $\frac{2}{3}$ -, -)	(+, 0, 0): arable land initially increases (-, -, --): deforestation increases	(+, -, 0): collapse around 2050	(-, -, -)
Outdoor recreation	Increase and levelling (+, +, +)	(+, -, --)	For elite (+, +, +). For other people (-, --, --).	(-, -, -)
Net migration to/from town (increase=to towns; decrease=from town)	Stabilization (+, 0, 0)	(0, -, -)	($\frac{1}{2}$ +, +, 0)	(+, ++, +)

Model parameters and capitals	SSP1 <u>Roszasim alom</u>	SSP3 Regional <u>Rivalry</u>	SSP4 Inequality	SSP5 <u>Pató Pál Úr</u>
Green in urban areas	Increase and levelling (+, +, +)	(0, -, -)	(0, -, -)	(-, --, --)
Human capital	Increase and levelling (++, ++, ++) (gets high soon)	Decrease but flattening due to self-reliance (0, -, -)	(---, --, -)	(-, -, -)
Social capital	Increase and levelling (++, ++, ++) (gets high soon)	(+, -, -): increases due to crises, decreases due to institutions	(0, --, -)	(-, -, -)
Manufactured capital	(0, -, -)	(+, -, --)	(-, --, -)	(+, ++, ++)
Natural capital	(0, +, +)	Decrease – some flattening due to reduced input use and pressure (-, --, -)	(--, -, 0)	(-, --, --)

3.5. Central Asian socio-economic scenarios

3.5.1. Narratives

Central Asian SSP1 'Sustainability'

From 2010 to 2040: The governments in Central Asian countries invest in the economy. To achieve steady growth and limit energy price volatility, governments decide to aim at increasing energy security. They promote green technology development to diversify the energy portfolio by supporting know-how and development of SMEs. This trend materialises first at the Expo in Astana in 2017 featuring smart green energy solutions which propagate across Central Asian countries. These solutions and accompanying increased economic output boost an increase in cooperation between Central Asian states which is formalised in a supervisory intergovernmental body around 2040. Increased cooperation also stimulates stability in the region which catalyses a slow but steady establishment of harmonized legislation for sustainable development. Implementation of new rules is facilitated by the promotion of Central Asian values and commonalities across these countries. For example, the importance of family values and culinary traditions are promoted to culturally bond the countries and promote mutual respect. People realise that family and hierarchy are key values to ensure prosperity for future generations.

From 2040 to 2070: Around 2040, the increased cooperation is formalised in a 'Supervising Intergovernmental Body' which guarantees and formalises collaborative initiatives in many sectors and across countries. Conflict resolution is a key mandate of this Body and is effectuated due to its political authority and economic funds to operate (e.g. 'innovation funds'). The key political strategy is a search for win-win solutions by cross-sectoral linkages, for example between water management and food security.

In water management, specific committees are appointed to implement the win-win principle also at the smaller scale of transboundary water governance. Strategic changes in water extraction or dam building are decided case by case with both upstream and downstream countries in order to ensure compensation for possible economic and environmental losses. Although Central Asia cooperates in many sectors with external partners, such as China, Russia, EU and US, most energy, water and food demand is met through internal supply. Risk of terrorism from outside Central Asia also decreases as

a result of increased stability. Towards 2070, barriers related to knowledge sharing and innovation decrease. This trend fuels and is fuelled by increased job opportunities for the educated youth. More and more people find employment in SMEs as a result of the effective measures taken the decades earlier.

From 2070 to 2100: The Central Asian population has grown steadily, as a result of increased demand for a qualified workforce, and increased immigration and decreased out-migration. Higher income, in turn, has resulted in higher investments in education for everyone. Increased opportunities result in less ethnic conflicts and an integration of minorities in the economic life of all countries. People choose where they want to live and both cities and the countryside offer job opportunities, which leads to a repopulation of the countryside. With sufficient access to water and energy, food production is ensured by a strong agricultural sector. In cities, the service industry has become dominant. On a domestic level, the Intergovernmental Body has contributed to key reforms such as a taxation system in all countries that has helped SMEs and technology to flourish. At the international level, the Body is the entity that collaborates with Russia, China and other neighbouring countries. The reputation and the relations developed over the years have guaranteed the access of large shares of population in the region to global markets. Due to this, energy and food price volatility has significantly decreased, and the region is regarded as an important global player.

Central Asian SSP3 'Regional Rivalry'

From 2010 to 2040: Exclusive economic development leads to food insecurity, because priority is given to resource use for export, which supports external competition. It also means that water is exported or water is used for hydropower that is exported rather than for supply to the local population. The exclusive development pattern also reinforces the ruling elite and maintains a system of resource exploitation for external competition. Low investments in the domestic population result in low health and education standards and high inequality in society. A global food price spike before 2020 has a large impact on the local population. Water management focuses on extraction and building dams. Development of water resources in Afghanistan reduces downstream flow to the region. Pakistan invests in hydropower in Tajikistan without cooperation of Uzbekistan. Uzbekistan reacts by cutting off electricity supplies and stopping food and fuel exports to Tajikistan. As a result of increasing tensions the International Fund for Saving Aral Sea (IFAS) collapses in 2022. Tensions thus increase between upstream countries (Tajikistan and Kyrgyzstan) and downstream countries (Uzbekistan, Turkmenistan and Kazakhstan) with regard to transboundary water governance. Tajikistan manages water resources to disrupt irrigation flow downstream. Transboundary water governance in the region collapses completely by 2030. The breakdown of cooperation extends to other resources with no food and fuel supplied to upstream countries. Food prices rise and this leads to food riots and increasing social tensions, as well as blockage of roads and transport infrastructure. The breakdown of cross-border infrastructure, including oil and gas pipelines, fuels ethnic tensions and conflicts. The high level of small scale conflict between populations, in particular in environmentally degraded parts of the region, and the competition at the local level for resources such as food and water leads to increasing out-migration from the region. The increasing chaos towards 2035 sees an increase of shadow economies and illicit trade and the actors who profit from these activities have an interest in maintaining the chaos and rivalry. Ultimately, by 2035 the breakdown of resource export for external markets undermines the 'integrity' of existing political systems. There is a systems breakdown across the region, which sinks deeper into chaos.

From 2040 to 2070: After a period of regional chaos, Russia and China, supported by Iran, step in to impose some stability in order to secure their access to the resources of the region and to prevent spill-over effects to their territories. A new political system (back to INTEGRITY) is put in place that delivers 'exclusive economic development' for the purposes of meeting external demand for

resources and (geo-political) stability of the region. Since it is imposed from the outside this political system is fragile. Resources are managed only for the interest of the dominant powers – not for local inclusive development. The Collective Security Treaty Organization (CSTO) and the Shanghai Cooperation Organization (SCO) move in, using their mandates to assert greater control over the region in order to prevent massive destabilisation and negative spill over. There is a renewed agreement between upstream and downstream countries for basic transboundary water cooperation. Russian investment supports building a canal to divert water from the north and thus improve food security in Central Asia. China invests massively in order to stabilize the region, including further developing hydropower for export out of the region, and also moves a large number of Chinese into Central Asia. Out-migration of the Central Asian ethnic population continues. Human development remains low and social tension is very high. There is Islamic radicalization in several areas including from Afghanistan into the Ferghana Valley, Kyrgyzstan, across the borders of Tajikistan and Uzbekistan leading to border disputes, threats to infrastructure and terrorism. This period of externally imposed stability ends in the mid-2070s as a result of conflict between Russia and China. There are a number of triggers for this conflict – first and foremost the increasing competition for control of resources. China controls upstream water resources limiting downstream irrigation in Russian territory. China makes land claims for territory and for food to provide resources for a growing population (and substitute for degraded resources in China).

From 2070 to 2100: With the external powers in conflict and no longer providing support, the Central Asian region falls back into chaos. Around 2075 there is a large wave of out-migration, followed by slower depopulation as the chaos continues. The economy shrinks rapidly and by 2100 is smaller than in 2015. Water consumption declines, as investment in technology decays rapidly. Social capital declines as a result of internal social conflicts and outmigration.

Central Asian SSP4 ‘A Game of Elites’

From 2010 to 2040: The scenario starts from a current situation of five nation states that have a strong, top-down government with a relatively high inequality in most countries. National governments gradually increase their own power by concentrating wealth in the upper class. Their position is further strengthened by “second generation” policy makers returning from top universities in Europe and US, who join as members of a highly educated group of families at the top strata of society. Towards 2040, this increasingly powerful elite is firmly established in all countries with strong connections and regional collaborations. Although the efforts of the elite mostly aim at increasing (economic) power, there is increasing interest to address certain environmental issues. In part this is because the global situation is changing, in part because of similar tendencies elsewhere in the world, particularly in Europe. Issues addressed are particularly those large-scale problems that could threaten the position of the elite. Extra effort is therefore put in, for example, water and energy issues. At the same time, worldwide the carbon footprint is lowering, which explains partly why we end up in this society: the surplus is so low that it can keep the elite wealthy, but not sufficient to support a large middle class, which therefore gradually decreases to a minimum. Because of the starting point of the countries in the region, it is easier to keep the wealth concentrated at the top. Towards 2040, low-intensity military conflicts begin because of water issues. But the elite, having made connections through their Western education, conspire and collaborate with nations across the globe to put in place rules and command and control mechanisms in Central Asia, working together to keep the masses suppressed, creating a sort of loose political alliance in the region.

From 2040 to 2070: Shortly after 2040, the newly formed alliance institutes basic rules of conduct regarding water management, infrastructural projects (water, road, rail), energy production, etc. These regimes of collaborating elites are even more repressive and authoritarian than before. Media become centralised and under state control, or under control of the loyal oligarchs or families. They

pitch conservative values to everyone in the region; families, kids, stability, no war. The standard of life is deteriorating: no welfare state, private insurance, no access to good education, or at a minimal level. Other basic human services are likewise reduced to a minimum. Yet, developments are gradual and without much direct visible impact on daily life. The masses receive a minimum of services, which keeps them relatively satisfied. Globally, developments are similar to those in Central Asia with powerful elites ruling in many countries, also in Europe. Yet, economic development is stronger in many of those, including Russia and most of Europe. Particularly the remaining middle class in Central Asia is attracted to those countries, resulting in strong outmigration of highly educated people and disappearance of the middle class. At the same time, an influx of Chinese migrants starts intensifying. Initially, this is desired and allowed by the elite, who welcome extra work force but it is later kept under control by strict and strictly enforced migration control procedures. Yet, it activates anti-elite sentiments that slowly take root.

From 2070 to 2100: Around 2070, anti-elite movements have become more widespread and are now accompanied by social unrest, an increase in number of conflicts, and multiple ethnic clashes. The elite, however, takes swift action by promising an increase in standard of living. Although these promises are only partly realised, the anti-elite feelings are kept under control. Rather than rebellion, there is an increased use of narcotics among the general population as a means of escapism, as life gets harsher and depressing for the lower classes. Overall, this period is characterised by a lowering stability and somewhat dwindling control of the elite. Besides lowering standards of living, natural catastrophes start intensifying in frequency and magnitude. At the same time, there are more diseases particularly towards the end of the century. Yet, in general this affects the general population, not the elite that safeguards its position and control up until 2100. By the end of the century, a new religion is developing, which has its foundation in anti-materialism. Although it is too early to conclude on its influence, the elite strongly supports this development and actively promotes participation as it decreases the chance of revolts.

Central Asian SSP5 'Fossil-fuelled Development'

From 2010 to 2040: The international 'market-driven regime' influences the region more and more. Money and talent go where opportunities are best. For all Central Asian states this means that outmigration of young people is increasingly seen as problematic for the governments' ambition to compete on the global market. On the other hand, the increased demand for fossil fuels and the search for new energy extraction possibilities slowly increase the inflow of foreign direct investments, notably in Kazakhstan and Turkmenistan. Investments in the region's potential for hydropower is, however, lower. The main interest in water management is in developing irrigation systems and other technologies for improving agricultural productivity of food and cotton production. This ambition, in combination with increased environmental problems e.g. droughts, acts as an incentive for cross-country cooperation on water management. As a result, an agreement on regional water legislation for all five Central Asian states (CAWMA – Central Asian Water Management Agreement) is signed in the early 2030s. The agreement was reached after intense and long negotiations with international support. The agreement is based on international principles and conventions. People in the region slowly adopt a more globalized lifestyle with consumption patterns mirroring those in other parts of the world. Religion though plays an important role in many people's lives.

From 2040 to 2070: The need to collaborate around water management opens the door for others forms of collaborations, e.g. within trade. Collaboration between upstream and downstream countries works better and better. The competitive environment continues into the second period. The competition concerns many areas of society, e.g. between sectors of society, between states, between companies. But the competition is seen as more or less fair. The boom in the fossil fuel sector has a positive impact on all Central Asian states, directly or indirectly, although countries with those

resources gain more, mainly from taxation on companies in the sector. Continued high demand for energy incentivized investments in the Kyrgyzstan and Tajikistan hydropower sector. Cotton is still important in the Uzbek economy but the big economic lift is due to a fast growing garment industry attracting investments mainly from China; the Uzbek economy succeeds in moving up the value chain from only cotton production to also garment production, hence diversifying the economy. All Central Asian states invest in education in order to stay competitive in the globalized market. A better education system, together with other social reforms slowly changes the pattern of out-migration of young talent into a small net inflow of young people looking for opportunities. Although the society is characterized by competition there is a relatively strong sense of social cohesion, partly due to better social security and an ambition of progressive taxation of income. A better educational system also builds increased capacity for technology transfer into the region. A substantial part of the income from oil and gas industries goes to developing the agricultural sector. One main driver is employment. Despite increased food productivity, the region is more dependent on food import from the global market, partly due to increased demand for imported food (changing life styles). The region also exports more food in this scenario compared to the situation back in 2015. Kazakhstan wheat still plays an important role in regional food security.

From 2070 to 2100: Environmental problems now become more and more serious and people really start to worry about negative impacts on society. Without global institutions for tackling environmental problems, the region is left on its own dealing with such challenges. The solution is often technology-based as a reflection on the general faith in socio-technical solutions for problems in general. Economic growth is still high but now it becomes more and more evident that the resource-intensive life still comes with a price.

3.5.2. Key (story) elements

An overview of key (story) elements for the four Central Asian SSPs is given in Table 12. The table is based on five 'key questions' that were defined prior to the workshop as essential in the context of the future of Central Asia. Questions were posed to stakeholders during the workshop, upon completion of the SSP narratives.

Table 5: Key elements of the four Central Asian SSPs narratives.

Other key questions/elements	SSP1 Sustainability	SSP3 Regional Rivalry	SSP4 A Game of Elites	SSP5 Fossil-fuelled Development
What are the opportunities and challenges for effective water sharing agreements between upstream and downstream countries?	Estimate of water and energy production to reach common interests. Establishment of a neutral committee to ensure cooperation and fair distribution.	High challenges due to heightened competition within CA and foreign interference in water management. Lack of investment in water (irrigation) technology will add to competition for scarcer resources.	Water management is regulated to a certain extent, where profitable for the elites that collaborate. Local issues are ignored.	Agreements are established within CA. Collaboration between upstream and downstream.
What are the opportunities and challenges for food security in the region?	Food might be volatile. A fund is established to sustain energy connection between countries to increase trade within CA based on diet and production.	Low food security. High challenges due to exclusive water management and conflicts. General breakdown in trade (downstream countries restrict food exports).	Investments in agriculture to appease general populace and large collective farms controlled by elites.	Low challenges to food security. Revenue from fossil fuel industries invested in agriculture: Increased production and food imports (changing lifestyles).
What are the key energy outflows from the region?	Sharing electricity within the region, dismantle nuclear energy with increased recycling nuclear waste from other countries. No key energy outflows.	Water, hydropower. General breakdown in trade (restriction of fossil fuel exports) and blockade of transboundary infrastructures.	The connected elite shares electricity within the region, increasing focusing on renewables (mainly hydropower). Increased export to China through pipeline but volume remains limited. Pipeline to Russia as well.	Out-flow of energy resources is the key driver for the development in the region. In the fossil-fuelled scenario this is what creates the economic resources for building up the region. Due to the importance of the oil and gas sector, countries with such resources dominate the region. However, this does not create tension between the states, partly due to good cooperation around water management. The group did not discuss concrete infrastructure routes.

Other key questions/elements	SSP1 Sustainability	SSP3 Regional Rivalry	SSP4 A Game of Elites	SSP5 Fossil-fuelled Development
What is the potential for mass population movements into or out of Central Asia?	Stable immigration trends, but people will move out for better opportunities. Better economy and education policies will invert youth migration trend.	High out-migration due to higher ethnic conflicts. Influx of Chinese workers in the region in the period after 2040.	Strong outmigration of highly educated middle class. Regulated influx of Chinese migrants.	High mobility, positive net inflow of young educated people in search of job opportunities.
What is the likelihood of military conflicts between Central Asian States and Central Asian States and external powers?	Initially risk of terrorism from outside with decreasing trend with increased cooperation within and outside CA.	Very high between Central Asia, lower with Russia and China. High border disputes and risk of terrorism with other countries (e.g. Afghanistan).	Low-intensity military conflicts occur within the region, likelihood increases again towards 2100. General low intra-regional risk. Risk for conflicts with external power is present but low (potential trigger: natural resources).	Very low: strong commercial ties within CA and outside.

3.5.3. Trends for key (model) variables

Table 13 provides information on future trends in three time slices for a number of selected model variables and the main forms of capital. Trends were estimated by stakeholders during the workshop. The first four variables (GDP, population growth, domestic water use and irrigation efficiency) have been quantified by stakeholders using the fuzzy sets method.

Table 6: Qualitative information for selected key (model) variables and capital forms for Central Asian SSPs. Increase or decrease compared to 2010 are indicated for three time slices (2010-2040; 2040-2070; 2070-2100).

Model parameters and capitals	SSP1 Sustainability	SSP3 Regional Rivalry	SSP4 A Game of Elites	SSP5 Fossil-fuelled Development
GDP	+, ++, ++	-, +, -	0, 0, 0	++, +, +
Population growth	0, +, + (steady slow linear growth)	++, ++, -	+, ++, 0	0, +, + (++ in Kazakhstan 2070-2100)
Domestic water use	0, -, --	++, ++, ++	0, -, --	-, -, 0
Irrigation efficiency	+, ++, +++	++, ++, ++	-, 0, 0	+, +, 0
Human capital	+, ++, ++	-, --, ---	-, -, --	+, +, 0
Social capital	+, ++, ++		-, --, --	+, +, 0
Manufactured capital	++, ++, ++	0, 0, --	-, -, -	+, +, 0
Natural capital	0, 0, +	-, -, ---	--, --, --	-, 0, 0

4. Cross-scale analysis

In this chapter we present a short analysis of the socio-economic scenarios in all case studies, with an initial set of cross-scale observations that serve as background for potential scenario users. It is beyond the scope of this Deliverable to provide a full cross-scale analysis of the scenarios produced in IMPRESSIONS. Deliverable 2.4 (due in October 2017) will analyse the products as developed at the various scales in more detail in order to enable integration of the climate and socio-economic scenarios as well as integration across scales.

4.1. European scenarios – equivalent scenarios to the global SSPs

There are several observations on the set of European SSPs (Eur-SSPs), most of which are also valid to a large extent for the other case studies:

- The Eur-SSPs are equivalent to the global SSPs and, therefore, cover a broad range of challenges to mitigation and adaptation in a similar manner to the global SSPs, which makes them relevant for the climate change community in Europe.
- Like the global SSPs, the Eur-SSPs also cover a wide range of the dimensions of sustainability and development, by including highly unequal (SSP3 and SSP4) and equal (SSP1 and SSP5) societies, but also very resource intensive (SSP5 and SSP3) and lower consumption (SSP1 and SSP4) worlds.
- Eur-SSP4 is arguably both the most ‘difficult’ story to tell and the most interesting addition. Globally, a future outlook with a powerful green elite is regarded plausible in many countries across Latin America and Africa. In Europe, the plausibility, credibility, and therefore usability of such a scenario have been a topic of discussion. The resemblance with the CLIMSAVE ‘Riders on the Storm’ scenario indicates that it is a likely emerging type of future, also in the eyes of the broader stakeholder community.

- Eur-SSP3 and Eur-SSP4 are rather similar regarding a large share of the elements and part of the story. Although there are differentiating assumptions (inequality, technological development, etc.), their main difference is in the associated greenhouse gas emissions, which are rather low for Eur-SSP4 and high for Eur-SSP3. The same holds for Eur-SSP1 and Eur-SSP5. This also reflects a main motive for the global climate change community to explore future outlooks that decouple challenges to mitigation and adaptation (SSP4 and SSP5).

The Eur-SSPs were designed to be a set of scenarios that would (also) serve as the starting point for more regional scenario development in the Iberian and Hungarian case studies, and beyond. The resulting stories are, therefore, relatively short and generic to allow application at lower geographical levels. Because the aim was to develop European scenarios that were equivalent to the global SSPs, the content is highly comparable, even though in some cases the text from the CLIMSAVE scenarios was largely followed.

4.2. Central Asian scenarios – using the global SSPs

The global SSPs were used as contextualising scenarios for the Central Asian scenarios (CA-SSPs). This did not strongly limit stakeholders in their possibilities to create their own versions which more closely reflected the context of the five Central Asian republics. Across all scenarios, there are a few particular recurring issues. These mostly relate to the very uneven distribution of resources and included:

- **Geopolitical stability and regional governance.** The five countries were all part of the Soviet Union. Although their independence is now 25 years ago, individual countries and their internal relations continue to be a main source of discussion and a key factor in all scenarios. The region's ability to act strongly together affects its economy, technological development, food security, etc.
- **Transboundary waters.** There are large water issues between the countries. How they deal with them (or do not) is also a recurring issue in most scenarios.
- **Food security.** The agricultural sector and food production and its distribution are important, again because of the unequal distribution of resource. In this case it is focused on productive agricultural land.
- **Regional conflicts.** Related to geopolitical stability and also fuelled by the current instability in surrounding countries, is the issue of regional conflicts that play out in the more regionalised scenarios: CA-SSP3 and to an extent also CA-SSP4. In all scenarios, preventing conflicts is an important issue.

Overall, the CA-SSPs include a set of consistent narratives that cover a set of region-specific issues, while at the same time ensuring consistency with the global (and thus with the equivalent European) SSPs.

4.3. Scottish scenarios – using the CLIMSAVE scenarios

The process of developing the Scottish SSPs (SC-SSPs) was conceptually similar to the European scenario development process. As a second case study in the CLIMSAVE project, a set of existing scenarios was available and it was decided to match the SSPs and the CLIMSAVE scenarios to develop a set of SC-SSPs. To this end, an expert meeting was organised during which the foundations were laid for the SC-SSPs. Fundamentally different to the European case study was the decision to make the CLIMSAVE scenarios, rather than the global/European SSPs, leading in the process of writing the SC-SSPs. Similar to the European case study, three SSPs matched with the CLIMSAVE scenarios, but an equivalent for SSP5 was absent. Rather than using the fourth CLIMSAVE scenario, a Scottish SSP5 was developed during a mini-workshop with a smaller number of representative stakeholders. Thus, four

SC-SSPs were developed that were largely based on the CLIMSAVE equivalent scenarios, but with a newly developed SC-SSP5.

Overall, there is a – perhaps surprising – overlap between the underlying rationale of the SSPs and the SC-SSPs. As they are based on a different scenario logic (CLIMSAVE vs SSPs), a set of at least partly differentiating future outlooks was expected. Yet, by and large, the Scottish scenarios map onto the global and European SSPs, hence the use of “SSP” in the naming of the scenario set. The scenarios do have a (large) number of elements that give them their Scottish identity, for example:

- **Naming.** Contrary to other case studies, there was a huge and partly unresolved discussion on the naming of the scenarios. All names directly refer to Scotland, with titles such as MacTopia, Mad Max, and Tartan Spring/Tartan Unrest/Jacobite Uprising.
- **Length of the narratives.** Scotland produced the longest stories, up to twice the length of an average European scenario, reflecting the need for local detail.
- **Scottish independence.** The position of Scotland in the UK is a central issue in all scenarios.
- **Well-being and lifestyle.** Contrary to the European scenarios, stories are very detailed on changes in human well-being, social capital, and e.g. the role of the Clans.

In short, the SC-SSPs map onto the Eur-SSPs to a very large extent, yet without losing their own identity; they read like a set of stories that cover crucial uncertainties related to Scottish independence and Scotland’s international reconfiguration, Scottish identity, economic growth, and effects on human well-being.

4.4. Iberian scenarios – one story for two countries

The Iberian scenarios (IB-SSPs) faced the issue that the peninsula is made up of two countries, Spain and Portugal. While the diversity of the multiple countries in Europe or even among the five Central Asian republics cannot be represented in a single future scenario, this is different when it only concerns two countries. Additionally, (over)emphasising developments in either of the countries could potentially lead to rejection of the story by participants from the other country. The resulting stories, therefore, are purposefully neutral and mostly refer to Iberia (“Iberian cities”) or joint initiatives (“joint Portuguese-Spanish Agency”). Although not aimed for, this resulted in stories that were somewhat shorter and more generic. Similar to other case studies, a number of regional issues surfaced:

- **Unemployment.** Rather than economic revenue, the current huge unemployment is the issue that is problematic and that needs to be addressed.
- **Coordination between Spain and Portugal.** Similar to Central Asia, regional collaboration and resulting strengths or weaknesses is crucial in any future outlook.
- **Transboundary rivers.** Again similar to Central Asia, transboundary waters (in this case two major rivers) are a source of conflict, worry, and need for collaboration.
- **A range of issues specific to the Mediterranean climate** are apparent in most scenarios. Drought, water demand/supply particularly related to agriculture, and tourism play a role in all stories.

In short, the IB-SSPs nicely map onto the Eur-SSPs, partly because of the somewhat more generic nature of the narratives. Yet, Iberian and Mediterranean issues are crucial in all scenarios and provide the local identity and flavour.

4.5. Hungary – towards local SSPs

When designing the multi-scale scenario process, it was clear that the Hungarian scenario development process was likely to present most difficulties in producing localised SSPs, as the focus was on two municipalities rather than one or more countries. Using a European context to develop scenarios from a local perspective indeed proved challenging. Out of all case studies, the Hungarian scenarios (HU-SSPs) were most dissimilar to the European SSPs. Yet, they did not differ to the degree that they could not be referred to as SSPs. Unique elements included:

- **Hungarian names.** Scenarios were all originally written in Hungarian and titles were not translated, leaving a distinct local flavour.
- **Stronger non-linear changes.** There are many more instances of sudden, abrupt, and fundamental changes littered across most scenarios (e.g. “water use fails”, “structural poverty”, “unknown clean technologies”).
- **Unconventional interpretation of context scenarios.** Both SSP4 and SSP5 were interpreted more negatively than in most of the other case studies. Together with the dystopian SSP3, the set of scenarios in Hungary is a fairly negative set of future outlooks.
- **Narrative content does not necessarily include many issues specific for Hungary;** most are present in the European scenarios as well. This is partly due to language issues, which could have obstructed local flavour ending up in the stories.

In short, the HU-SSPs provide a somewhat more pessimistic outlook on the long-term future of Hungary, partly due to the interpretation of the set of Eur-SSPs. Similar factors and topics show different developments, particularly in the longer-term time slice (2070-2100).

4.6. Cross-scale comparison

In this section, we compare some overall characteristics, topics addressed, and directions of change described in the socio-economic scenarios, using mostly the information in the narratives.

Overall characteristics

Table 14 provides an overview of the length of the socio-economic narratives as developed in all case studies. In general, storyline length substantiates observations made in previous sections. The Eur-SSPs were purposefully kept short and generic, which is reflected by the lower average length (490 words), while the SC-SSPs included a lot of country-specific detail resulting in the longest storylines (1366 words). Storylines in other case studies are more similar in length, with the shortest being CA-SSP1 and the longest HU-SSP3. SC-SSP5 is remarkably short, which relates to the fact that it was newly developed during a mini-workshop and not based on the existing CLIMSAVE scenarios. It is also interesting that SSP1 is the longest storyline in two case studies (Scotland and Iberia) and the shortest in the other three. The overall characteristics, also related to presence of tipping points, will be further elaborated in Deliverable 2.4.

Table 14: Length of storylines in number of words.

	Europe	Scotland	Hungary	Iberia	Central Asia	Average
SSP1	452	1655	783	900	580	874
SSP3	479	1535	1024	760	752	910
SSP4	570	1558	928	576	725	871
SSP5	458	714	971	648	642	687
Average	490	1366	927	721	675	836

Topics addressed

Table 15 provides a comparison of the key elements addressed in the scenarios across all case studies, without differentiating between SSPs and without accounting for scenario-specific topics. It enables a quick cross-case comparison related to the question of whether all case studies address similar key elements.

Table 15: Key elements in the socio-economic narratives across all case studies. Main entry points are taken from the global SSPs.

Global SSPs Element	Europe	Central Asia	Scotland	Hungary	Iberia
Economic growth	Economic development	Economic development	Economic development	Economic development	Employment
Population	Population and migration	Regional conflicts	Well-being and lifestyle	Migration	Migration
Energy	Renewables versus fossil fuels	Fossil fuels	-	Energy provision	Energy production
Technological development	Technological efficiency	Agri-technology	Technological innovation	-	Technological development
Governance structures	Effective governance and international cooperation	Geopolitical stability and regional governance	Scottish independence, multi-level governance	Multi-level governance, subsidies	Coordination between Spain and Portugal
Environmental change	Water and biodiversity	Transboundary waters, Food security	Countryside	Agriculture, food security	Transboundary rivers

As can also be deduced from the separate case study analyses, the same types of issues can be found across all case studies with economic development, demographic development, technological development, and governance structures being addressed in almost all scenarios in all case studies. Yet, there are many small, and potentially fundamental, differences in what is exactly addressed within these broad topics. Economic development is expressed as “income growth” in most cases, population focuses on migration, but also emphasises well-being and lifestyle (Scotland) or regional conflicts (Central Asia), while governance issues range from effective governance to geopolitical stability to Scottish independence. This gives all case study narratives their specificity, as was intended by the scenario development process. Overall, the narratives yielded what was intended: sets of future outlooks than can be linked to the global (and/or European) SSPs, but that offer regionally and locally relevant information that will appeal to case study specific users.

Direction of change

Table 16 lists the changes in the four forms of capital for the three time slices, four scenarios and all case studies. Included are human capital (health, education, etc.), social capital (networks, relationships, families, etc.), manufactured capital (human constructs such as houses or roads), and financial capital.

In SSP1, overall there is a strong increase across all capital forms, particularly human and social capital. Manufactured capital is decreasing in the two more local cases (Hungary and Iberia). What stands out is the large degree of agreement both in direction and magnitude of change. This is a true Utopian scenario across the board, with few surprising elements at this level of aggregation.

In SSP3, overall there is a (strong) decrease across all capital forms, particularly financial and human capital. Economic recession (financial), breakdown of social security systems and education (human) and lack of resources for construction (manufactured) characterise this future. Social capital is increasing in two case studies (Europe and Hungary), indicating bottom-up organisation in times of misery. This is a true Dystopian scenario across the board, with few surprising elements, except for social capital, that shows the seeds for change.

In SSP4, there are no common trends, with increases and decreases from one time slice to the next within a case study and between case studies. There is little to no similarity between case studies. The European context and main elements were interpreted by stakeholders as rather negative in Hungary and Central Asia, resulting in decreases of most capitals. On the other hand, the context was taken as rather positive in Europe and Scotland; and mixed in Iberia. This observation might be related to the fact that the European and Scottish scenarios were carried over from an earlier project, and were therefore developed a number of years prior to scenario development in other case studies. This needs to be examined in further detail. Finally, social and human capital have some tendency to decrease.

Overall, SSP5 was perceived rather negatively in Hungary and rather positively in the other case studies. Except for Hungary, all capital forms increase at the expense of natural capital (not included here). Similar to SSP4, the SSP5 context was perceived more negatively in Central Asia and Hungary, and most positively in Europe. There is strong disagreement on the development of social capital with strong increases in Europe but decreases in Scotland, Hungary and Iberia.

Table 16: Changes in capitals across all case studies and by scenario. Signs refer to direction and strength of change in three time slices (2010-2040; 2040-2070; 2070-2100).**(a) SSP1:**

SSP1	Europe	Central Asia	Scotland	Hungary	Iberia
Human capital	Strong increase (0, +, ++)	Strong increase (+, +++, +++)	Strong increase (+, ++, ++)	Increase and levelling (++, ++, ++)	Strong increase (+, +++, +++)
Social capital	Strong increase (0, +, ++)	Strong increase (+, +++, +++)	Strong increase (+, ++, ++)	Increase and levelling (++, ++, ++)	Strong increase (++, +++, +++)
Manufactured capital	Steady increase (0, +, +)	Strong increase (+++, ++, ++)	Increase (+, +, +)	Decrease (0, -, -)	Decrease, increase (-, +, ++)
Financial capital	Steady increase (0, +, +)	n.a.	Steady increase (+, +, ++)	n.a.	n.a.

(b) SSP3:

SSP3	Europe	Central Asia	Scotland	Hungary	Iberia
Human capital	Decrease (0, -, -)	Strong decrease (-, --, ---)	Decrease (-, -, -)	Decrease (0, -, -)	Strong decrease (-, ---, ---)
Social capital	Increase, decrease (0, +, 0)	Decrease (-, -, -)	Decrease (-, -, -)	Increase, decrease (+, -, -)	Strong decrease (-, ---, ---)
Manufactured capital	Decrease (0, -, -)	Level, decrease (0, 0, --)	Decrease (-, -, -)	Increase, decrease (+, -, --)	Strong decrease (--, ---, ---)
Financial capital	Strong decrease (-, -, --)	n.a.	Strong decrease (--, -, -)	n.a.	n.a.

(c) SSP4:

SSP4	Europe	Central Asia	Scotland	Hungary	Iberia
Human capital	Decrease, increase (0, -, 0)	Decrease (-, -, --)	Increase, decrease (+, 0, -)	Strong decrease (---, --, -)	Increase, decrease (+, -, --)
Social capital	Decrease, increase (0, -, 0)	Strong decrease (-, --, --)	Small ups and downs (+, 0, 0)	Decrease (0, --, -)	Increase, decrease (+, 0, -)
Manufactured capital	Increase (0, +, 0)	Decrease (-, -, -)	Increase (+, +, +)	Decrease (-, --, -)	Increase (+, +, ++)
Financial capital	Strong increase (0, ++, ++)	n.a.	Increase, decrease (+, +, 0)	n.a.	n.a.

(d) SSP5:

SSP5	Europe	Central Asia	Scotland	Hungary	Iberia
Human capital	Strong increase (+, +, ++)	Increase (+, +, 0)	Increase (0, +, +)	Decrease (-, -, -)	Strong increase (++, +++, ++)
Social capital	Strong increase (+, +, ++)	Increase (+, +, 0)	Decrease (0, -, -)	Decrease (-, -, -)	Increase, decrease (+, +, --)
Manufactured capital	Strong increase (+, +, ++)	Increase (+, +, 0)	Strong increase (+, ++, ++)	Decrease (-, --, -)	Strong increase (+++, +++, ++)
Financial capital	Strong increase (+, +, ++)	n.a.	Strong increase (+, ++, ++)	n.a.	n.a.

4.7. Concluding remarks

This chapter offered an initial analysis of the sets of scenarios within case studies and some preliminary cross-case observations. It is essential to stress that findings are preliminary and need to be discussed and checked with case study leaders and where possible a selection of stakeholders, before we can offer our final insights. In its present state, they should only be used as general indications of similarities and differences between SSPs and between case studies.

Having said that, the results of the analysis seem to indicate that we have successfully married a top-down (downscaling of the global SSPs) and bottom-up (stakeholder-determined narratives) approach. In the very least, the sets of scenarios offer sufficient similarities (to enable comparison and integration) and differences (to make the effort worthwhile) to undertake a full cross-scale analysis and multi-level workshop.

5. Acknowledgements

All WPs have contributed to the development of the SSPs. We also would like to thank the case study leaders and other IMPRESSIONS colleagues for their input on the process of scenario development and insights on the outcome of the scenarios.

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Annex 1: Implications for China and Russia in the CA-SSPs

This Annex contains an overview of statements related to socio-economic future developments under the four global SSPs for Russia and China, as discussed during the second stakeholder workshop of the EUx (Central Asia) case study in Baku, May 2016. The information is taken from the workshop report (Gramberger & Haenen, 2016). Information relates either to the role of China or Russia in Central Asia, or developments in Russia and China itself. It is meant to give a first impression; further integration with the Central Asian scenarios will be part of Deliverable 2.4 (October 2017).

A1.1 China

Overall interests: cooperation and security to maintain stability in Central Asia.

SSP1:

- China: International cooperation; circular and green economy; sharing knowledge with the rest of the world; production moves to southeast Asia; away from consumption to more holistic interpretation of well-being; BRICS bank and Asia infrastructure development bank are key players.
- Consequences: Closer regional cooperation; cultural integration.
- Responses: Cultural exchange mechanisms (NGOs, academia and intermarriage); population decrease might mean drop in trade; mobility, pan-Asian zone; free trade zones and multilateral investments agreement excluding controversial areas such as defense; policy dialogue.

SSP3:

- China: Population decreases but divergent population growth; food security is priority.
- Consequences: Central Asia depends on China for water; political instability; high investment but little trade to Central Asia; migration from Central Asia to China; energy security issues.
- Responses: China increases security interests; China as facilitator in the region but more bilateral approach; reinforce border controls.

SSP4:

- China: Polarisation in Chinese society; population declines; retirement age increases; China becomes an energy powerhouse; smart cities; smart grids; energy storage and new material; water saving technology; religion is more sense of anti-materialism.
- Consequences: China is interested in political stability and fears strategy of Central Asian elites to lead to popular unrest.
- Responses: Chinese share wealth; Chinese NGOs become active and diversify energy portfolio.

SSP5:

- China: Population decreases; increased international involvement and investment (energy dependency); internal migration; health issues; environmental impacts.
- Consequences: Population more vulnerable to climate change; energy policy; higher imports from Central Asia but investments seen as negative due to pollution impacts; relative investments will decrease as other countries compete; Yen replaces dollar as world currency.
- Responses: Cooperation-technology transfer; new Silk Road version 2; smart energy network; high mobility-low migration.

A1.2 Russia

Overall interests: Geopolitical stability; hard security; collaboration; migration control and borders; resources.

SSP1:

- Russia: Internal migration – more even population distribution; diversified economy; extremisms; nationalism and social tensions also related to decreases in religion; rise of middle class raises energy issues; resource issues such as more meat consumption; health care and life expectancy.
- Consequences: Job opportunities; population increases; impacts from climate change; migration.
- Responses: Meat production in the north; capitalise on green economy opportunities; multicultural alignment.

SSP3:

- Russia: Conflicts and tensions, perhaps leading to nationalism and issues with technology.
- Consequences: Lower economic growth; decreasing cooperation; migration from Central Asia to Russia.
- Responses: Reinforce border controls; increase bilateral cooperation.

SSP4:

- Russia: Strong elite will form through a process of competition between smaller elites and organisation into overarching elite, global and neighbouring elite; education to some extent to have a minimum human capital; religion will increase.
- Consequences: Instability and concern of Russian elite; migration; try to orchestrate some conflicts; increase of nationalism; climate change creates opportunities for Arctic exploitation.
- Responses: Strengthening Russian presence: soft power (culture, jobs, language etc.); military; nuclear and renewable energy investments; education – science; support of Silk Road.

SSP5:

- Russia: Possibilities for a diversified economy incentivized by revenue from raw material and higher human capital and education; money in the system; opportunities for technological development and breakthroughs.
- Consequences: Specialisation and trade; no need for migration.
- Responses: Russia will support Central Asia (investments, infrastructure, dealing with migration); partnerships; internationalization; technology; science; healthcare.

A1.3 Central Asian perspective on the role of Russia and China

Overall interests: Integration, but driven by internal Central Asian motives.

SSP1:

- Central Asian perspective: Bottom-up open society; cooperation with Russia and China; bottom-up networks and intergovernmental bodies.
- Responses: High mobility in the whole region; construction of infrastructure; women as leaders; youth and environment are central.

SSP3:

- Central Asian perspective: Border disputes, starting point very realistic; role of technology, hydropower and agriculture is unclear.
- Responses: Agriculture, technology, innovation/education.

SSP4:

- Central Asian perspective: Very close to reality: consortium of many ruling parties and conflict between elites, but keep masses under control at surviving level so they do not bother; religion as a sense of belonging will become more important.
- Responses: Education, SME and private sector investment in general; try to limit inequalities by, for example, democratic countries providing conditionality on trade to improve human rights, education etc.; rule of law and gender inequality.

SSP5:

- Central Asian perspective: Technology; hydropower; socio-economic inequalities; interconnected infrastructure is a vulnerability.
- Responses: Technological innovation; diversification of economy and emission quota; population growth will lead to land expansion and issues with resource management.