SENSES

Cross user analysis and guidelines for co-production techniques with regional stakeholders

Co-producing scenarios and adaptation pathways for local and regional impacts, adaptation, and vulnerability assessments

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Contents

1. Introduction

The most recent set of widely applied scenarios for investigating impact, adaptation and vulnerability (IAV) is the climate research community scenarios comprising the Shared Socio-economic Pathways (SSPs) and Representative Concentration Pathways (RCPs) (O'Neill et al., 2020). The SSPs describe a set of alternative plausible trajectories of future societal development, which are based on the best current hypotheses about which societal elements are the most important determinants of challenges to climate change mitigation and adaptation. RCPs have been applied first to climate models to produce climate scenarios at multiple scales for investigating climate change impacts and risks and SSPs are being more recently being scaled for different geographical and sectoral applications. The use of SSPs and RCPs as "reference framework" for IAV is sought to increase consistency and comparability across the climate research and IAV communities.

Largely stemming from the IAV community, co-production approaches are increasingly acknowledged as an integral tool of state-of-the-art participatory scenario methodologies both to capture bottom-up and contextual knowledge when data is scarce, but also to capture different values and trade-offs in the complexity of uncertain future socio-economic development.

Co-production integrates academic knowledge with decision makers' and practitioners' (identified as "stakeholders") experience and knowledge. After identifying specific decisions to be informed by science, stakeholders jointly define the scope and context of the problem, research questions, methods, and outputs, make scientific inferences, and develop strategies for the appropriate use of science (Beier et al., 2017). Different perspectives exist regarding what co-production is and how it should be used. Bremer and Meisch (2017) differentiate between the *'iterative interaction'* where science providers and users produce more useable climate information based on the scientific knowledge and the '*extended science'* where the knowledge and values of non-scientists are integral to the process of scientific knowledge production.

In considering scenario processes, co-production could be used from both the *'iterative interaction'* and the '*extended science'* perspectives. From the *'iterative interaction'* perspective, co-production could be implemented to produce knowledge for policy-making purposes based on a set of scenarios (e.g., scenario planning, robust decision making, etc.), while from the *'iterative interaction'* viewpoint, co-production is used to include stakeholders and non-scientists opinions as part of the scenario production exercise.

The SENSES project recognises the applicability of co-production techniques both for developing scenarios and producing climate information based on existing scenarios. For climate policy makers at global scale, co-production will be mainly used for an iterative interaction process, to better identify the user needs and to understand how the various user groups want to use scenario information. For regional scenario users, this will focus on techniques to develop and connect regional socioeconomic scenarios and adaptation pathways with global climate change scenarios (Absar and Preston, 2015; Carlsen et al., 2013; Kok et al, 2016).

This report utilises two case studies to explore how user-driven regional scenarios can be connected to the global scenario architecture via different co-production techniques (Chapter 2). The focus in both case studies has been put on informing regional decision makers about local implications of global socioeconomic and climate change and guiding them in developing regionally relevant scenarios. To this end, a key research question we explored is how important it is to link scenarios across geographical scales, and if so, how could this effectively be operationalized.

Through participatory processes and workshop series in two case studies, we explored methodologies and processes for the co-production of socioeconomic scenarios, scenario knowledge and adaptation pathways at local and regional scales linked to global socioeconomic and climate change scenarios. Using lessons learn from case studies, we developed effective approaches and best practice guidelines for using co-production techniques and processes in sub-global IAV studies (Chapter 3).

2. Co-production techniques to develop adaptation planning

We selected Kenya and the Overijsselse Vecht region in the Netherlands as the regional case studies in SENSES to i) related to both developed (Netherlands) and developing (Kenya) countries, ii) investigate our research question in countries representative of certain regions with similar challenges to climate change adaptation, and iii) examine how to link regional scenarios to global socioeconomic and climate scenarios in information-rich versus information-scarce contexts.

The two selected case studies differ significantly on the level of existing socioeconomic scenarios and adaptation pathways. The Netherlands is a context with multiple sets of existing scenarios. Several national scale socioeconomic scenarios (exploratory) for the Netherlands have been developed in the past years and many of these have been downscaled to the regional level for Overijsselse Vecht. Next to these socioeconomic scenarios, national and regional visions (normative) have been developed, which consist of long-term goals and target that are elaborated with strategies and look far ahead to 2030-2050 (See D2.1).

Kenya on the other hand, is considered a knowledge-scarce context regarding existing scenarios and pathways. The most high-level national-scale scenario in Kenya is Vision 2030, outlining the country's socio-economic and political development aspirations (Government of Kenya, 2007). Kenya Vision 2030 consists of one normative vision and functions as an agenda setting policy document, and in this sense, does not really present socioeconomic scenarios in the strict sense. Kenya at the crossroads is the only other socioeconomic scenario set in the Kenyan context which was developed in 2000 and looked at socioeconomic developments in 2010 and 2020 (IEA/SID, 2000).

Depending on the existing knowledge, different types of scenarios and knowledge need to be produced, and different co-production techniques and processes could be implemented. In knowledge-scarce contexts, an exploratory phase and the development of socioeconomic scenarios is the necessary starting point for identifying desirable adaptation actions and pathways. However, in knowledge-rich contexts, it is possible to take on board a set of existing socioeconomic scenarios and start directly from the normative phase where visions and pathways are developed and integrated. When exploring plausible socioeconomic futures is necessary, exploratory co-production methods and techniques are used in the scenario process. These methods and techniques are designed to answer to the question of 'what could happen'. On the contrary, in the normative phase of a scenario process, methods and techniques with strong normative features are used to facilitate finding answer to the question of 'what should happen'.

As explained, in the Kenya case study, we worked in a knowledge-scarce context, and therefore, we designed an exploratory phase using a selection of exploratory co-production techniques. In the Netherlands case study, however, we mostly used normative co-production techniques as the context was already rich in exploratory socioeconomic scenario knowledge (Cf. Figure 1). Note that the method mix developed for each case study displays only examples of co-production techniques that could be utilized in exploratory and normative processes. Alternative exploratory and normative co-production techniques could be used in similar research scope and settings. A comprehensive overview of different methods and tools for different co-production objectives can be found on the SENSES toolkit, Co-production Techniques Finder. See further Section 3 below.

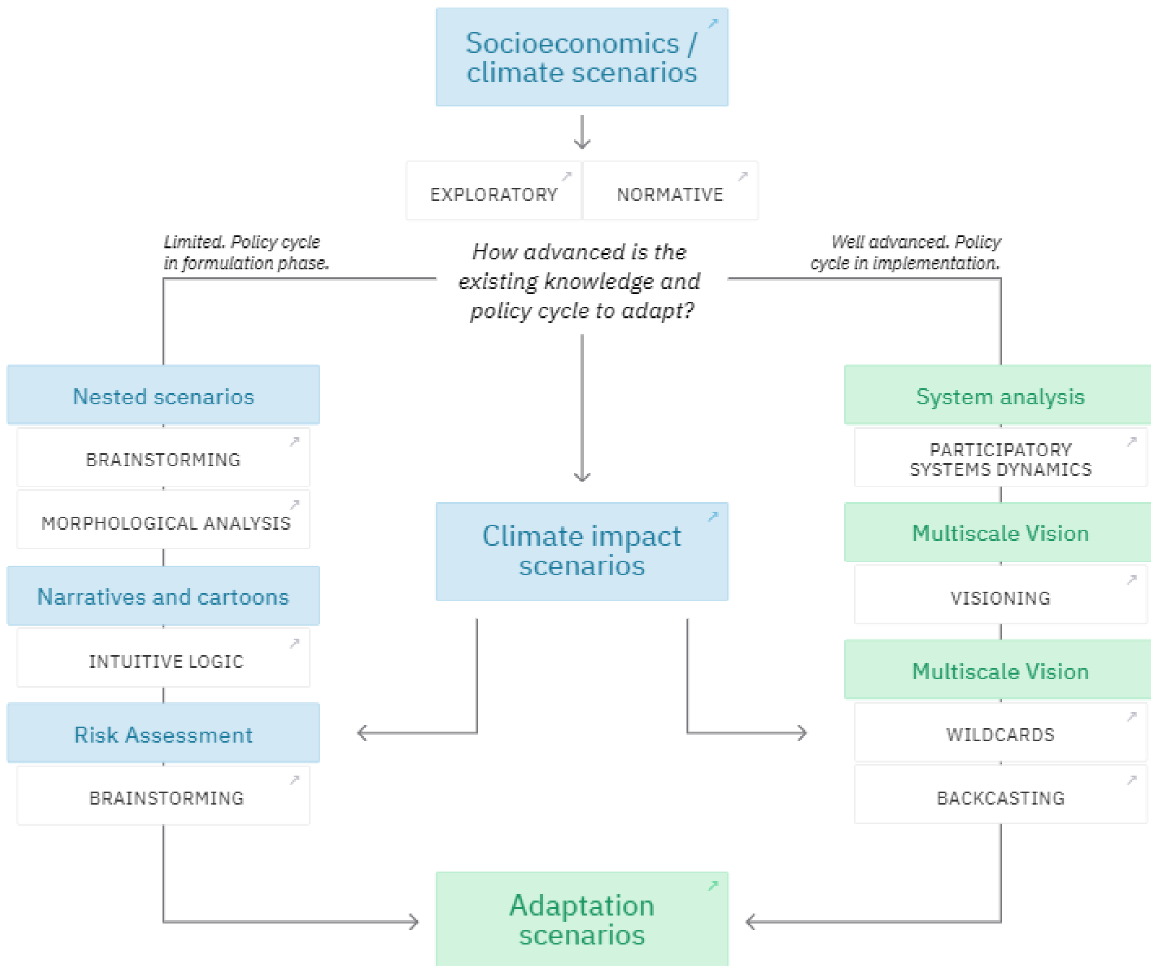

Figure 1. knowledge-rich vs knowledge-scarce contexts

2.1 Kenya

2.1.1 Background

Kenya, like many other African countries, is among the most vulnerable to impacts of climate change within its borders, but also to impacts transmitting across borders to the country (Hedlund et al., 2018). Understanding such cross-border climate impacts is dependent on the socioeconomic drivers and conditions, like for example population growth and economic development. Therefore, there is a need for enhancing the capacity to interpreting and building integrated scenarios in a context as such to improve impact assessment and adaptation planning. Exploring socioeconomic futures of Kenya as the case study and linking those to the global scenarios offers a comprehensive framework for identifying cross-border climate impacts and adaptation responses.

Kenya is among the top 30 countries that score high in term of exposure to cross-border climate impacts (Hedlund et al., 2018) suggesting that national level impact assessment and adaptation planning must consider ever increasing connectedness and interdependencies between Kenya and other counties in the future.

As mentioned, Kenya is a knowledge-scarce context in term of exploratory socioeconomic scenarios. Kenya vision 2030 which is the most important future-oriented piece at the national scale (Government of Kenya, 2007), is not an exploratory scenario set and only functions as an agenda setting goal for 2030. Other scenario sets are either not representatives of exploratory scenarios in technical terms or outdated in term of time horizons (e.g. Kenya at the crossroads (IEA/SID, 2000)).

Looking at the Kenyan policy context (e.g., National Climate Change Action Plan 2018-2022, Kenya Vision 2030, National Climate Change Response Strategy 2010, National Adaptation Plan 2015, Climate Change Act 2016), it is evident that Kenya's adaptation planning does not consider alternative pathways for adaptation, but only describe a set of policies, actions and needs for adapting to climate change impacts. Moreover, Kenya's adaptation planning is designed to only consider impacts of climate change within Kenya's border. There is no reference to impacts of climate change originated from global flows and outside its borders, and consequently, plans and/or proactive action items to prepare for or mitigate those risks in Kenya's climate policies and adaptation plans.

2.1.2 Problem statement: Understanding future cross-border impacts of climate change

The main objective of both case studies in SENSES was to explore how stakeholder-driven local and regional scenarios can be linked to the global scenario architecture. With respect to this overarching goal, the challenges in the Kenya case study were: i) how to justify the link to global scenarios for local stakeholders and scenario users, and ii) how to demonstrate the usefulness of cross-scale scenarios as such in national-scale impact assessment and adaptation planning.

The focus on a special aspect of IVA studies – cross-border climate impacts – provided a strong argument for both linking scenarios across scale and exemplifying the application of cross-scale scenarios in national adaptation planning. Climate impacts are highly dependent on the socioeconomic context, hence, impacts that are transmitted across spatial scales are inevitably dependent on socioeconomic contexts of where they originate and where they are transmitted to. In other words, when studying future risks associated with cross-border climate impacts for a given country, it is necessary to understand socioeconomic developments within the borders of that country, but also in other countries and geographical contexts to which that country has interconnections. Given the growing globalization and increasing interconnections between spatial scales and places, we argued that local and regional socioeconomic scenarios for a given country need to be linked to global scenarios to provide a consistent baseline for analysing climate impacts originated from global flows.

To show the usefulness of cross-scale scenarios in national-scale adaptation planning, we used the developed cross-scale scenarios to explore future cross-border climate impacts and adaptation responses together with stakeholders. We developed a framework using the cross-scale scenarios and a set of four climate risk pathways (Hedlund et al., 2018) to answer to the question the focus question:

1. 'What are the most important future cross-border climate impacts for Kenya in the People, Biophysical, Trade and Finance risk pathways given the alternative scenarios?'
2. 'What are the key adaptation options for Kenya to adapt to future cross-border impacts?'.

2.1.3 Methodology

To develop cross-scale socio-economic scenarios, we linked local scenario development to the global SSPs (Ebi et al., 2014; O'Neill et al., 2017; van Ruijven et al., 2014; van Vuuren et al., 2014). We used a combined top-down and bottom-up approach (Nilsson et al., 2017) to develop Kenyan scenarios linked to the SSPs, where the top-down element was a sub-set of the SSPs, and the bottom-up element included stakeholder-generated local and regional knowledge concerning future vulnerability to cross-border climate impacts. To constrain the number of scenarios for consideration and decrease the complexity of the process, it was decided to use only four out of the five SSPs. As SSP2 (Middle of the Road) storyline lacks a certain level of diversity in relation to the other SSPs and represents a business-as-usual scenario, we decided to exclude SSP2 from our scenario set.

Co-production process for developing scenarios was implemented in a workshop series involving a diverse range of local and regional stakeholders including planners, government officials, private sectors representatives, researchers, and civil society members*. Brainstorming* and *morphological analysis* and *intuitive logics* were used as the main co-production techniques.

The process started with the bottom-up element where, using brainstorming techniques, stakeholders generated information on the relevant socioeconomic drivers for understanding future vulnerabilities to cross-border climate impacts. In the top-down element of the process, the global SSPs were introduced as 'boundary conditions' for the future development of the key driving forces. A variation of morphological analysis was used to identify plausible future states for the identified key drivers, by asking questions about how the locally generated drivers might unfold, given global development as described in the four selected SSPs. The combination of key drivers and their associated states given each SSP provided the skeleton for the sub-global extensions of the respective SSP.

In the next step, *intuitive logics* was used for developing narratives and visualizations for the extended SSPs (van 't Klooster and van Asselt, 2006). In addition to the co-production of scenario skeletons, we used the SSP quantifications database (Riahi et al., 2017) to add quantitative projections on economic development (GDP) and population growth (Crespo Cuaresma, 2017; Kc and Lutz, 2017) for each scenario.

To further enhance the narratives and better inform adaptation planning to cross-border climate impacts, we also used results from global climate impacts modelling to illustrate future risks to food security via import of wheat, rice, and corn. Although the quantitative elements of the scenarios did not involve any co-productions process, we believed that adding quantitative modeling results supplements the exploratory narratives and improves stakeholder engagement.

In the next step, stakeholders were invited to identify the most important future cross-border climate impacts for Kenya given the extended SSPs.

Finally, participants were invited to generate adaptation options to address a specific impact. Both processes for identifying future impacts and generating adaptation options were operationalized using *brainstorming* as the co-production technique.

2.1.4 Results

Extended SSPs for Kenya

The perhaps most tangible results from a co-production perspective were the Kenyan Extended SSPs. The four socio-economic scenarios were positioned on a scenario cross (Figure 2) which shows two main drivers and their associated states as polarities. We dedicated one axis to level of climate change for the region with polarities ‘Medium/high-end’ (corresponding to emission levels in line with RCP6.0) and ‘Low-end' (RCP2.6), and one axis to regional collaborations within the East African Community (EAC) with polarities ‘high-level regional collaboration’ and ‘low-level regional collaboration’. When picking the second axis, we aimed to select a driver that represents a key socioeconomic dimension most relevant to the focus of the case study, i.e. challenges to Kenya with regards to cross-border climate impacts.

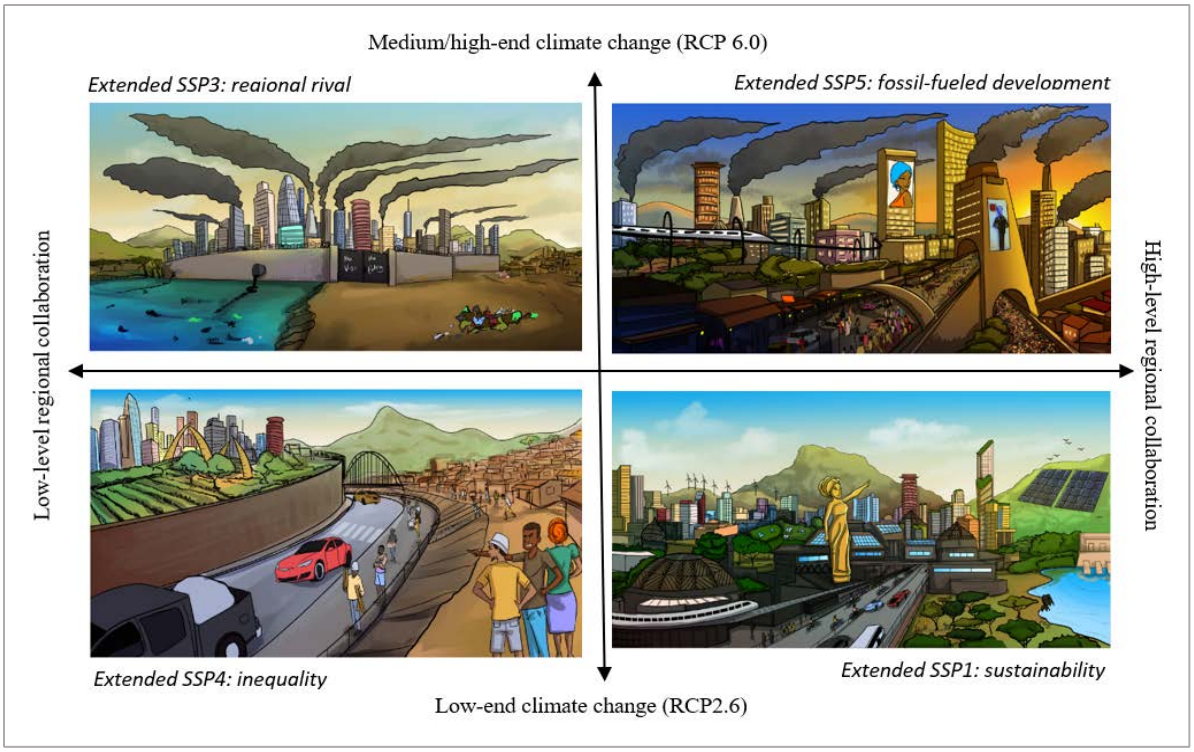

Figure 2. Extended SSPs across climate change and regional collaboration axes

The four scenarios comprised a storyline (one written page each) and associated quantifications for population and economic growth. *Sustainability* is a scenario where regional collaborations towards sustainable development improves within East Africa. Clean energy is accessible for a larger share of Kenyan population. *Inequality* is a scenario where regional collaboration in East Africa is fragmented and unstable. Kenya – like most low-income countries – struggles to bridge the gap between rich and poor. *Regional rivalry* is a scenario where Kenya cooperates with neighbouring countries around common interests and together, they aim to compete against other regional blocs. Access to the technological innovations becomes extremely difficult for Kenya because knowledge sharing practices are securitized, and innovations are strictly patented and expensive. *Fossil-fuelled development,* finally, is a scenario where regional collaboration in East Africa increases with a focus on economic growth and increasing competitiveness in global market.

Future GDP projections for the time-slice around 2050 vary from ca. 300 billion USD (*Regional rivalry* and *Inequality*) via ca. 600 billion USD (*Sustainability)* to ca. 800 billion USD (*Fossil-fuelled development*). Population numbers for the same time-perspective runs from ca. 65 million (*Sustainability* and *Fossil-fuelled development*) to ca. 90 – 95 million (*Regional rivalry* and *Inequality*).

To further enhance the Kenyan Extended SSPs we run crop models under low-end and medium/high end climate change (RCP2.6 linked to ESSP 1 and 4 and RCP6.0 linked to ESSP 3 and 5) for two time-slices, 2035-2064 and 2070-2099.

Overall, results show that annual crop production decreases are expected in all countries exporting essential crops to Kenya given low to medium global warming (RCP2.6) between 2035-2064 and 2070-2099 which results in a shrink in their export capacity. Production of wheat, corn and rice either remains steady or faces insignificant changes in most countries exporting essential crops to Kenya given high global warming (RCP6.0) between 2035-2064 and 2070-2099.

Future cross-border climate impacts

Stakeholders identified 15 future cross-border climate impacts for Kenya (Table 2). Looking across the risk pathways, five future impacts were identified under the people pathway, five under the biophysical, two under the trade pathway and three under the finance pathway. Future impacts transmitted through the trade and people pathways were recognized by stakeholders as the most important challenges and were repeatedly mentioned in the context of several scenarios.

Table 1. Future cross-border climate impacts for Kenya across four transmission pathways and four scenarios

Risk pathway	**Scenarios**			
	Extended SSP1: Sustainability	**Extended SSP3: Regional rivalry**	**Extended SSP4: Inequality**	**Extended SSP5: Fossil-fueled development**

People	-	Regional conflicts	Climate-induced economic migration	Climate-induced economic migration
			Regional conflicts	Regional conflicts
		Reduced tourism	Reduced tourism	Unsustainable tourism
			Cross-border disease transmission	
Biophysical	-	Increased water use by neighboring countries	Increased water use by neighboring	Increased water use by neighboring countries
			Migration of invasive species	
			Migration of wildlife	Pollution
			Seasonal migration of livestock	
Trade	-	Limited import and export markets	Reduced demand for high carbon exports	Reduced demand for high carbon exports
Finance	Reduced official development assistance (ODA)	Reduced official development assistance (ODA)	Reduced foreign direct investments (FDI)	Reduced official development assistance (ODA)
	Reduced green climate funds	Reduced foreign direct investments (FDI)		

Adaptation options

In total, 41 adaptation options were identified. Looking across scenarios, the Sustainability scenario was associated with the least number of adaptation options (6), due to a small number of future impacts. Most adaptation options were identified for the Regional rivalry scenario (17). Stakeholders associated many adaptation options with regional collaboration and multi-governmental resource management. This explains the identification of fewer adaptation options in the Inequality scenario (9) compared to the Regional rivalry scenario. In the Inequality scenario, the lack of regional collaboration excessively undermines the possibility for planning and executing adaptation options. While, on the contrary, in the context of the Regional rivalry scenario, regional collaborations between the countries in the region facilitate efforts for adaptation planning and resilience building.

Table 2. Key areas of adaptation for Kenya

Adaptation area	Description
Transnational collaboration and governance	A big number of adaptation options identified were transnational (regional, international) adaptation activities suggesting that despite the historical trends, stakeholders believe that to be effective, adaptation is a collaborative progress being made through transnational governance and transboundary progress.
Increased research on cross-border climate impacts and transboundary adaptation	Stakeholders emphasized that investing in research on cross-border climate impacts is necessary to prepare adaptation planning in Kenya to address future impacts transmitting across borders. Several adaptation options encompassed urgent needs for investing in research and development and financing climate-smart technologies especially in regions more vulnerable to cross-border climate impacts.
Public-private partnership for resilience building	Stakeholders recognized the importance of public-private partnership at both national and transnational levels for adaptation governance by touching upon the importance of private investments for financing adaptation research and development. Co-managing business activities in shared ecosystems was another role for private sector that would address the impact of decreasing economic activities in sectors such as tourism.

2.1.5 Lessons learned

In this section we first reflect on the co-production techniques used in the Kenya case study. Thereafter we reflect over the broader process of linking scenarios across scale in a participatory process.

Brainstorming: In the Kenya case study, brainstorming as a method for collective generation of new and novel ideas was used extensively. We used it for generating local socioeconomic drivers, for generating ideas about impacts and finally, for generating adaptation options.

The first utilisation was a rather standard set up *á la* Shell/GBN (Schwartz, 1991) where we started with a blank table and collectively generated ideas for local socioeconomic drivers (i.e. building blocks of future scenarios). As part of this brainstorming session, we conducted a voting protocol to rate the level of importance and uncertainty of the identified drivers. In this session, we observed that most drivers were rated low on the uncertainty level by stakeholders. Theoretically, a driver's uncertainty rating should be proportional to the discrepancy between plausible states of that driver. Looking at the next steps in the scenario development process, we observed that several drivers rated low in uncertainty, were assigned with divergent states with completely different directions. Therefore, we believe that the facilitation team was not completely successful in communicating the conception of uncertainty in scenario planning to stakeholders.

In the second utilization, we started with a structured framework, consisting of the global SSPs and climate risk pathways, and used brainstorming techniques to generate ideas about future cross-border impacts given specific scenarios and pathways. Compared to the first, this brainstorming session was more guided and heavier facilitated by the given inputs and the research team to make sure that ideas for impacts are relevant to the given context and pathway.

The third brainstorming session also started with a structured framework, setting the global SSPs and identified impacts in the previous step as the context. This was also a rather guided brainstorming session where facilitators assisted participants in generating relevant ideas while keeping the alternative contexts (i.e., the SSPs) in mind.

When facilitating all three brainstorming sessions, we strived to give all participants equal voice and time in order to address power structures among the stakeholder group. We also clearly separated idea generation phases, where no critiques were allowed, with phases where discussions and even critique were sought after. Overall, brainstorming functioned well and allowed equal representation of participants' opinions and input. Using brainstorming techniques for idea generation is a standard procedure, but the importance of strong and very well-structured facilitation cannot be over emphasised. It is in many ways a very free process for people to engage in, and therefore it is important to steer the process to the end-goal while at the same time maximising everybody's contributions.

Morphological analysis: As opposed to standard Shell/GBN procedure where scenario-axes techniques are used to identify drivers states, we used a variation of morphological analysis (Ritchey, 2018; Zwicky, 1969) to assign states to key drivers and build skeletons of the SSPs extensions. This variation could create up to four plausible states (i.e. the number of selected SSPs) for each locally identified driver and respectively up to four sub-global scenarios. In contrast to standard morphological analysis, this approach does not allow to freely combine states for building scenarios. We believe this approach has advantages compared to the 'scenario-axes' technique (van 't Klooster and van Asselt, 2006) which is mostly used in the climate change community (see e.g. Nakicenovic et al., 2000; Rounsevell and Metzger, 2010). When using scenario axes as the scenario development technique, two main driving forces with two plausible polarities are identified and build the overall structure of the scenario set. We believe that using a larger number of key drivers to build scenario structures (instead of emphasising two dominating drivers) allows for a more diverse and comprehensive scenario set where many drivers are considered important for driving future changes. Moreover, having the structural possibility to assign each driver with a larger number of plausible states (instead on only two polarities) also adds to scenario diversity and assists in reflecting on a wider space of future possibilities (Carlsen et al., 2016).

Intuitive logics: Generally, intuitive logics refer to a whole process designed for scenario development, which starts with brainstorming ideas for building blocks of scenarios, identifying two polarities and assigning drivers with plausible states based on those, and developing scenario narratives. While we used morphological analysis to identify driver states, once we arrived at a skeleton of drivers and associated states, we turned to intuitive logics again for crafting the storylines. Using intuitive logics and placing the scenario skeletons in a two-by-two scenario-axe assisted us in drawing the interactions between key drivers and crafting short narratives for the alternative scenarios. Moreover, this allowed us to better communicate the extended SSPs to local stakeholders and also add the climate dimension to the qualitative narratives. This step only involved the research team, so strictly speaking this step didn't qualify as a co-production technique. However, since it was part of the wider co-production process it is worthwhile to include it here, not least because stakeholders used the result of this step in identifying impacts and adaptation options.

Using global socioeconomic scenarios: Using the concept of cross-border climate impact, we succeeded in communicating the importance of global socioeconomic context (SSPs in this case) to local and regional scenarios, impacts and adaptation options. The lack of detailed information on local and regional contexts is a significant challenge to using the SSPs in sub-global studies. Our approach to extending the SSPs through a combined top-down and bottom-up approach provides an opportunity to address this challenge by combining local and regional socioeconomic factors with global scenario information and expand the relevance of the SSPs for application across sub-global studies. Using co-production techniques proved to be a suitable approach to identify local drivers and produce sub-global knowledge which was at the same time linked to the global context.

Using quantitative scenarios: We observed that integrating the qualitative narratives with quantification of some scenario drivers by global impacts models could increase stakeholder's engagement in the scenario process. Although quantifying scenario drivers did not involve stakeholder engagement, communicating the results of this process provided stakeholders with an opportunity to see the extended SSPs in a global context more clearly, which is key when studying cross-border climate impacts. Adding quantitative components to local and regional scenario sets is recommended specially to investigate the impacts of different global flows on regional conditions. However, our observation when engaging with stakeholders was that the results of quantitative impact modelling was useful to stimulate the co-production process and the identification of future cross-border climate impacts, rather than deriving specific decision processes. For example, modelling results motivated stakeholder discussions about food imports and food security in future.

Stakeholders and stakeholder engagement: In the Kenya case study, we observed that the global SSPs, cross-scale scenarios and cross-border impacts of climate change are all new topics for local and regional stakeholders. Many participants were familiar with scenario studies and most were connected to the adaptation community through policy, academy and/or research organizations. Nevertheless, the notion of using socioeconomic exploratory scenarios as the first step for adaptation planning was not common among the participants. We believe that more studies using scenario frameworks and focusing on cross-border climate impacts are necessary for improving the adaptation planning in Kenya. In term of engagement, we had a relatively low response rate when inviting stakeholders for both workshops. We believe that the timing, at least for the first workshop, contributed to the low response rate. Overall, it seems like in the context of Kenya, gathering stakeholders for physical workshops (as appose to virtual perhaps!) is a challenge, and needs a lot of pre-workshop promotional activities and networking. However, we observed a satisfying level of engagement from the present stakeholders in the two workshops. They were interested in the topic and actively participated in the co-production process for both building and using the cross-scale scenarios.

2.2 The Netherlands, Overijsselse Vecht

2.2.1 Background

The Overijsselse Vecht river is the largest of the small and the smallest of the large rivers in The Netherlands. The Vecht flows through the province of Overijssel, located in the east of the Netherlands. The Vecht river originates in Germany and flows into the Zwarte Water at Zwolle and is part of the Rhine river basin. The river has a total length of 167 km and covers a catchment area of 3785 km^2 . In the past, the river has been channelled to manage flood peaks discharges and to enhance flood safety. Furthermore, floodplains and riparian zones along the river channel were reclaimed for agricultural use. The groundwater levels are regulated by river weirs and its floodplain currently meets the needs for agricultural demands.

Agriculture is one of the main pillars of the economy in the region. It determines the appearance of the region and the identity of the region to a substantial extent. Agriculture in the Vechtdal consists of dairy farming and other grazing animal farming; 62% of the area is grassland and 21% is corn. Intensive livestock farming is limited. Of the dairy farmers, the majority (80%) has 50 to 110 dairy cows. Farmers are owners of their land which, in many cases, is limited to a land-use function only for agriculture.

The Vecht river table and the (ground) water table in the area are managed by two regional water authorities, the east part of the river by water authority Vechtstromen and the west part by water authority Drents Overijssele Delta. The province of Overijssel and the municipalities of the regions manage the public spaces in the area and natural areas are managed by (public and private) nature organisations (e.g., Staatsbosbeheer, Natuurmonumenten). The national government manages the larger public roads and has limited power in the determination of land-use. Almost all land in the area is managed and has a specific land-use function, determined by the province.

Due to the many different parties involved in the management of the area, and the long history of water authorities as the first democratic and centrally organised institutions in The Netherlands, participatory processes are common in the area. Stakeholders in the area are familiar with long-term planning and the democratic structure of the authorities enhances the inclusion of stakeholders. For water authorities, these stakeholders are farmers. For the province and municipality, these stakeholders are inhabitants and businesses (of which farmers). Furthermore, institutional capacity resulted in the collection of multiple types of data, for instance on river flow, water demand, land-use, soil quality, etc. Therefore, the area can be considered information-rich regarding participatory processes and long-term planning based on biophysical data.

2.2.2 Problem statement and objectives

The Overijsselse Vecht case study area is facing several challenges. Firstly, the Overijsselse Vecht area is vulnerable to climate change due to low groundwater levels (drought) and high discharge peaks (floods) of the Vecht river, and its importance for the agricultural sector. Therefore, many local adaptation plans and scenarios exist to anticipate future biophysical change of the river. Yet, local adaptation plans, historically, do not put emphasis on anticipated future socioeconomic changes. Future socioeconomic changes can equally impact the area, mostly because the area is heavily managed. Currently, the flow in the river is controlled with weirs and regulates the water tables according to agricultural needs. Investments in hydrological infrastructure are designed with a lifetime varying between 30 and 80 years and mainly serve current agricultural practices.

With a change in socioeconomic requirements of the area, specifically related to agriculture, current adaptation plans, and scenarios lack insights of anticipated socioeconomic change.

Secondly, national Dutch mitigation plans, including energy and climate policy for 2050, must be implemented on a local scale and require space. The battle for space in the highly managed area therefore requires the identification of potential trade-offs and synergies between climate adaptation and climate mitigation. Choices and/or combinations need to be made between land use for agriculture, land use for climate adaptation and land use for climate mitigation. Here, multiple stakes exist which require careful consultation between stakeholders.

Thirdly, the region, and country, has a tradition in participatory processes, including the use of visioning and scenarios by using drivers of change. However, potential discrepancies arise between drivers of change on multiple scales and the methodological integration of drivers of change on multiple scales is lacking. This lack of integration potentially leads to the exclusion of projected global changes and therefore the failure of locally implemented initiatives on the long-term.

Together, these challenges require integrated planning. Since the Dutch case study area is heavily managed, anticipating the future of the area depends highly on the normative goals that are set to reach a desired state. These goals are set on multiple geographical scales, therefore, integration of drivers and long-term targets amongst scales is crucial to increase the feasibility of the desired future. Furthermore, interventions to reach a desired state need to anticipate socioeconomic change as well as climate change. Anticipating these changes is crucial to enhance the robustness of the path towards the desired future state.

Therefore, the overarching SENSES research question is supplemented by the main objective of the case study: *to increase the feasibility of the desired future and enhance the robustness of the path towards this desired future, while accounting for multiple stakes and values that exist in the area.* Three subobjectives are distinguished:

1. to identify short and long-term system drivers, challenges, and targets on multiple scales,
2. to co-produce socioeconomic robust pathways towards a desired future,
3. to increase the feasibility of the pathways towards the desired future.

2.2.3 Methodology

The case study methodology varies for each subobjective and includes several co-production techniques. We first used scoping interviews and a grey literature policy review. We conducted a stakeholder analysis for the interviews to determine perceived system drivers and challenges. The policy review aimed at determining long term (2050) adaptation and mitigation targets on multiple scales, to identify the desired future state, *visioning.* We collected the long-term targets in a multi-scale vision, consisting of three geographical scales and four overarching vision themes.

Secondly, we used *backcasting* to co-produce pathways towards the multi-scale vision during a stakeholder workshop. Socioeconomic robustness of the pathways was achieved by assessing them against global socioeconomic scenarios (the SSPs) in the form of *wildcards*. Both the vision and wildcards were pre-developed to facilitate the workshop discussion process. In this process, stakeholders were asked to determine required actions to reach the vision while discussing challenges that might arise regarding the wildcards of the different SSPs. The wildcards were developed by interpreting the global SSPs on a regional level, and relating them to a hypothetical low-probability, high-impact event.

Thirdly, we used scenario visualizations of global model simulations and short movies from local adaptation initiatives during a second stakeholder workshop to enhance the feasibility of the pathways. The feasibility of the pathways was enhanced by assessing them against both global and local drivers of change. During the feasibility check, stakeholders were first asked to determine how the presented simulated global changes would affect the pathways, and which additional actions were required to overcome possible implications. Global changes were visualized by using simulations of two models, IMAGE[1] and MAgPIE[2]. Secondly, stakeholders were asked to identify how the presented local initiatives could be incorporated in the pathway. Local initiatives were visualized by using videos from initiatives in the region, named the 'Lumbricus[3]' program. For a more in-depth methodological description, please see SENSES D2.3.

2.2.4 The results

System driver analysis

[1] https://models.pbl.nl/image/index.php/Welcome_to_IMAGE_3.0_Documentation.
[2] https://www.pik-potsdam.de/en/institute/departments/activities/land-use-modelling/magpie.
[3] https://www.programmalumbricus.nl/

The system driver analysis has highlighted that land and river use in the Vecht is demand driven. Land and water use will evolve depending on allocation, priorities and practices in the agriculture, nature, and energy sectors. Local actors tend to address climate adaptation first because mitigation is perceived as a global problem, too large to address locally. Local advantages of mitigation are not clear, especially if 'others' don't take actions, while local advantages to adapt are directly visible. Overall, resistance to land use change for mitigation is stronger, particularly due to NIMBY.

Four drivers of change that directly or indirectly influence climate adaptation and mitigation in land use (or also posted as 'climate smart' land use) are: 1) alternative business models, 2) population decline, 3) technology investment and 4) climate events. Vice-versa, climate smart land use is perceived to negatively impact current agricultural practices and is therefore not (yet) profitable for the local economy.

Multiscale vision

The multiscale vision is based on ten climate mitigation and climate adaptation policy documents at national, regional, and local levels (Table 4). Four overall themes between mitigation and adaptation were identified: Land use and Agriculture, Climate and Energy, Nature and Socioeconomic development. The multiple goals within the themes and scales are visualised as a flower (Figure 3). The goals are long term (2050) and vary from strictly defined goals (such as 95% reduction of greenhouse gasses by 2050) to more loosely defined goals (such as healthier lifestyles). In the centre of the flower, the regional goals are visualized, and the outer parts of the flower present the national goals.

Table 3. Consulted policy documents

THE NETHERLANDS	• Dutch Climate Law, 2019 (Dutch: Klimaatwet)
	• Dutch Energy Agreement, 2018 (Dutch: Energieakkoord)
	• National Adaptation Strategy, 2016 (Dutch: Nationale klimaatadaptatie strategie)
	• Delta plan spatial adaptation, 2018 (Dutch: Deltaplan Ruimtelijke adaptatie)
PROVINCE OF OVERIJSSEL	• Regional Adaptation Plan Overijssel, 2017 (Regionaal adaptatie plan Overijssel)

	• Analysis sustainability targets rural area Overijssel 2050, 2018 (Dutch: Analyse verduurzamingsopgaven landelijk gebied Overijssel richting 2050, 2018)
	• Enironmental vision Overijssel, 2017 (Dutch: Omgevingsvisie Overijssel, 2017)
LOCAL VECHT REGION (GENERAL GOALS FROM EXISTING VISIONS)	• Vecht Vision, 2000 (Dutch: De Vechtvisie, 2000)
	• Cross-border vision, 2009 (Dutch: Grensoverschrijdende Vechtvisie)
	• Lumbricus goals (lumbricus doelstellingen)

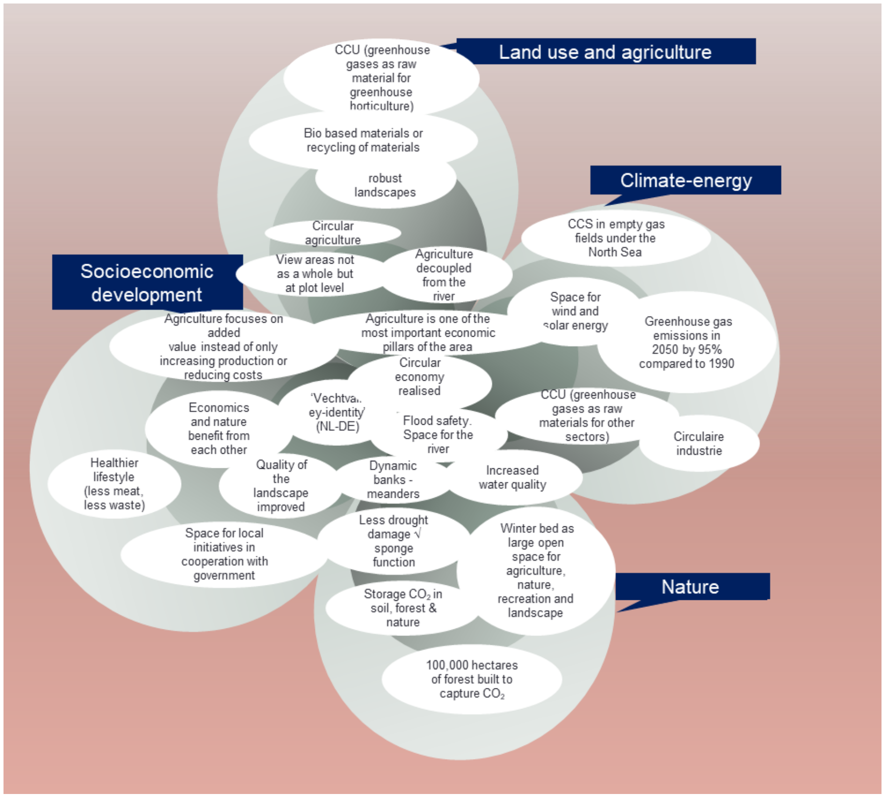

Figure 3. Multiscale vision Overijsselse Vecht

Wildcards

The four wildcards consist of 4 pictures with short narratives (Figure 4). The narratives include a short event sketch and the associated impacts in the perceived SSP world.

Figure 4. Wildcards as regional interpretations of the SSPs

Figure 4 (A). Wildcard SSP1

Chicken epidemics (Wildcard SSP1 "Sustainability")

Event sketch:

On a sunny Sunday morning in Overijssel, Sanne gets up to feed her chickens, as always. As soon as she arrives at the chicken coop there is no movement. All chickens are dead. She looks at the fence or maybe a marten has come through. "Oh," she thinks, "That is how nature works, they must have been eaten." Unsuspectingly, she goes to visit the neighbour. All the chickens are dead there too. "Quite strange". After having made a tour through the living commune, the chickens are found dead everywhere. Also, with her sister, who lives in a residential group in Zeeland, all the chickens are dead.

Impacts:

Most people depend on their own (or in small groups) garden and animals for daily food supplies. The food supply is vulnerable because of the ban on pesticides. The death of the chickens is the first wave, after which it is discovered that crops will no longer generate a harvest.

Most households count on their own food supply. The strong bond in neighbourhoods has led to joint production. After one day all supplies are exhausted and people are forced to look outside their area to get food.

Figure 4 (B). Wildcard SSP3

Canary Islands volcano eruption (Wildcard SSP3 "Regional Rivalry")

Events sketch:

Kirsten follows the news with interest. Her bed & breakfast in Overijssel is fully booked and all the extra beds that she could find are crammed into the rooms. The minister has just indicated that the Randstad will be evacuated. "And now those Randstatters want to go this way," she thinks, slightly frustrated. "They also benefit from our windmills".

A few hours ago, the volcano erupted on one of the Canary Islands. This causes a huge tidal wave that is coming towards the Dutch coast. All new dike reinforcement projects in recent years are not designed for a tidal wave. After hours of tension, the advice is therefore given to evacuate the Randstad as much as possible and to regard the Randstad as lost.

Impacts:

Overijssel is faced with a huge population increase. This makes land scarce and the housing market exploded. Refugees from the Randstad try to fight for a place with their few possessions.

Figure 4 (C). Wildcard SSP4

The week with no wind (Wildcard SSP4 "Inequality")

Events sketch:

Jan puts his hand out of the window, "he still has no wind" he tells his son Piet. The weather has been totally silent for a week. The Netherlands is in the eye of a large hurricane that is slowly weakening but not displaced. It feels sultry in Overijssel and the mosquitoes cannot be hardened. "I hope we will get the fridge back from the municipality soon."

Impacts:

In this world, energy generation is mainly regulated from wind energy from Overijssel. The large green companies are in control of the energy supply and distribution. The power is phased out in phases. Jan is in welfare, and because he is not working for his energy, the first austerity measures are applied to this group of people. The fridges and other steam eaters have already been collected. The large companies that keep the

Netherlands stable and move the economy forward have the latest rights to energy, "Otherwise the Dutch economy collapses".

Figure 4 (D). Wildcard SSP5

Google stopped working (Wildcard SSP5 "Fossil Fuel")

Event Sketch:

Lisa is on her way to a meeting in her self-driving car. "I should have gone to sleep a bit earlier," she thinks, while slightly indulging in the car. Suddenly she suddenly sees a car shooting to the left in front of her. Less than a second later, her navigation system makes a loud beep and it drops out.

Impacts:

Many systems depend on Google. The shutdown of Google causes chaos on the roads and public transport. Supermarket doors no longer work and people can only reach each other over the telephone, "but then again, who still has call minutes if everything can be done via Google".

Paying via Google-pay no longer works, luckily there are people who arrange their payments through other apps.

Co-production robust Pathways

Two separate robust pathways for two combined vision themes (1. Nature, Climate & Energy and 2. Land use and Agriculture, Socioeconomic development) include multiple items brought by stakeholders (Figure 5) and are visualised in one robust pathway (Figure 6).

The inclusion of the wildcards resulted in the identification of robust synergies and challenges between the four vision themes of climate change adaptation and mitigation targets. The synergies and challenges relate to topics including clarifying the role of farmers as land stewards; development of regional land use policy, particularly related to energy and agricultural development; changes in the mentality and attitudes towards accepting variability; and the transformation of the agricultural sector as an energy supplier.

Synergies – Agriculture and the farmer are at the centre of all themes and scenarios and are perceived to be crucial for transformation. It was found that agriculture can be transformed if it is complemented with energy generation. Regarding mitigation, solar panels and energy projects are considered to become a promising source of income for the region. Finally, a system perspective will enhance a mentality change towards a circular system.

Challenge – Land based adaptation and mitigation by using nature (e.g., plant coniferous trees, room for the river, change in crop types, invest in healthy soils) while maintaining income for the farmer as agriculture is iconic for the stability and identity of the region. However, this also implies identifying who should take the lead (e.g., farmers, government, investors).

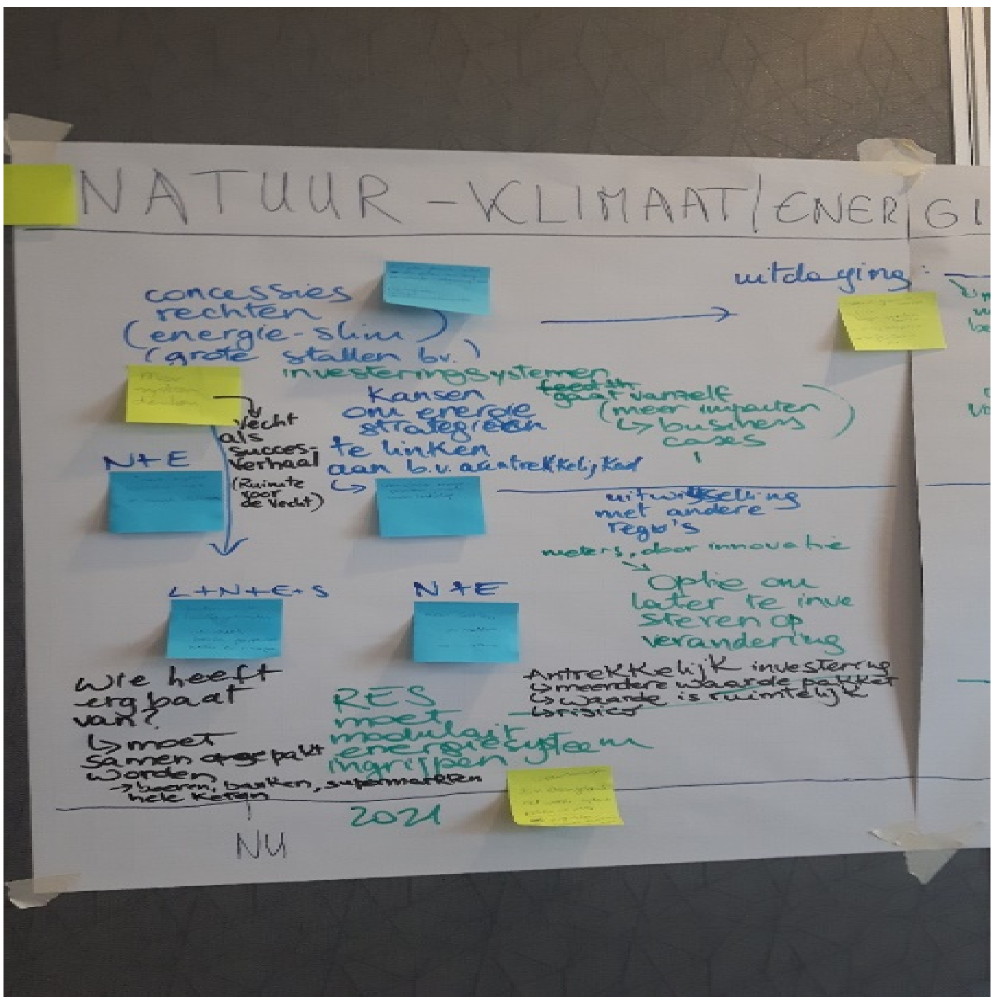

Figure 5. Picture of stakeholder input Pathways

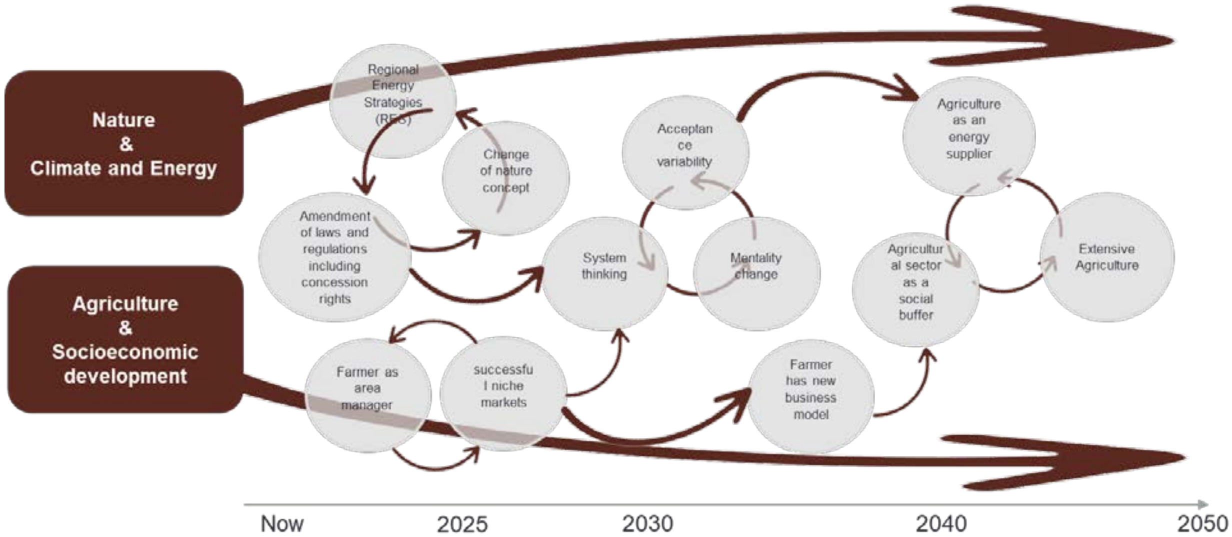

Figure 6. Robust pathway

Co-production feasible pathways

The robustness of the pathways was not challenged, and the stakeholder discussion shifted to fundamental 'how to' questions addressing the initially identified actions (Figure 7). Global drivers of change, visualised by the two model outputs, are interpreted in the pathways, and focused on the potential of agricultural niche-markets in the area due to possible global dietary changes. The type of agricultural niche-markets depends on the soil-type and this determines if the land could also be used for biomass, if so, energy prizes need to rise. The starting point of the pathway for feasibility is the identification of farmers who are 'front runners' and to understand the role of farmers in the transition. Nature is mostly addressed as an ecosystem service with an explicit goal (e.g., flood safety, drought mitigation). Local drivers of change, visualised by the videos, are interpreted in the pathway, and focussed on improving biophysical conditions such as soil quality and more efficient crop production. Current constrains, related to rules and regulations have space for local initiatives but these physical solutions are not enough to reach the desired transformation and should therefore be included in the systemic change to reduce the change of remain 'hanging' in the current system. Within this, rules and regulations should also bend.

Figure 7. Picture of feasible pathway discussion stakeholders

2.2.5 Lessons learned

Pathway content: The Dutch case study results indicate that both climate adaptation and mitigation are strongly related to the agricultural sector, even if long-term policy targets belong to different vision themes, such as ‘nature’, because the sector is the predominant user of land. This demonstrates the importance to address solutions cross-sectorally and reduce trade-offs that might arise with single-focused strategies. Furthermore, stakeholders clearly identified farmers as leaders in climate adaptation and mitigation across all socioeconomic scenarios (the wildcards), provided that a new agricultural business model within new or expanded regulations is developed. Although socioeconomic changes might evoke different types of farming in the future, its iconic role for the region will remain. The crucial element to enable this role for the farmer is the acceptance of different speeds of developments and initiatives, to eventually transform the system.

General stakeholder engagement: The Dutch have a large history in participatory decision making (also known in Dutch as ‘polderen’), in which great value is given to consensus building. Stakeholders regularly have workshops, conferences, and other types of events on different scales which intend to build consensus and co-produce knowledge. Some examples are national climate tables (klimaattafels) and local neighbourhood discussions (inspraakavonden).

Although participation is strongly embedded in Dutch culture ('participate or stop complaining'), we experienced signs of stakeholder fatigue. Due to, presumably, full agendas and aggravated by the complexity/uncertainties of climate change, stakeholders indicate they rather see climate action than discuss what is needed once again. The long history of using participatory methods related to scenarios in the region might explain the fatigue regarding scenario workshops.

Regional stakeholders, especially regional policy makers, were difficult to enthuse for a second workshop, while participants of the second workshop, who were mostly from outside of the region were more receptive towards the use of scenarios outside the scope of the area.

Like many stakeholder workshops in the Netherlands, we aimed at reaching consensus amongst stakeholders, typically appreciated by Dutch culture. However, many participatory processes stagnate when consensus is not reached. Because scenario thinking in participatory processes is not necessarily meant to be normative, consensus does not have to be the absolute aim of co-production. Therefore, it could be interesting to include participatory methods that do not necessarily require consensus building and to give more space for the heterogeneity of fragmented and multiple perspectives. Exploratory scenarios building, cf. the Kenya case study, could be seen as a 'non-consensus exercise' since a set of divergent scenarios are usually constructed.

Visualisation methods: Workshop input, through visualisation methods, facilitated the discussion and shaped the solution space of the discussion. Especially for complex/wicked problems like climate adaptation and mitigation, demarcating a solution space allows for more focussed discussions.

The multiscale vision was presented as a flower with 4 leaves and 3 colours. The visual power of choosing a flower promotes stakeholders to see the vision as a whole, with different elements that are equally important, since they all contribute to the full image of the flower. Since this vision was clearly 'finished' visually, it served its goal to focus the discussion on the co-production of pathways rather than on the vision itself. Presenting a fully visualised and appealing vision, therefore was accepted by stakeholders as a non-discussable workshop input.

The wildcards were presented as short narratives and visualised with a picture. The choice of words and the choice of visualisation was related to the regional interpretation of the SSPs.

Similar to the vision, these were presented as end products, therefore limiting the discussion on the wildcards themselves.

MAgPIE simulations were presented in an animation which provided the opportunity to demonstrate temporal and spatial differences in Europe. Presenting a map of Europe visualised the increased scope of the simulated changes outside of the region and aided the process identifying global processes on the region. IMAGE simulations were presented as graphs and were appreciated for their quantitative indication of change.

Multiscale vision: The use of a set normative goals in the vision allowed for a focal end point and a collective goal. The presented goals in the vision remained broad because the vision was multiscale and included multiple themes. This has the advantage that, although normative, the vision is more inclusive. Some disadvantages are, that the vision is too wide and therefore not concrete enough and that a vision not made by stakeholders themselves might have less support. Since the goal here was to integrate multiple goals, these disadvantages had a limited impact.

Backcasting: Pathways were developed through backcasting to reach the vision. Through brainstorming, post-its were added on the pathway. The backcasting process was not strictly 'from back to beginning' because stakeholders could go forth and back to indicate adaptation options between short, middle, and long term. Although backcasting provides a structured way in theory, in practice we saw a combination of forecasting and backcasting as an iterative process. This iteration between long, middle, and short term gave more freedom than a strict backcasting process, therefore giving more space to integrate multiple items in one pathway.

Socio-economic scenarios as wildcards: Stakeholders were not familiar with the use of socioeconomic scenarios and appreciated and recognised the additional value of incorporating these types of scenarios in adaptation planning. The use of socioeconomic scenarios enhanced the socioeconomic robustness of the pathways and brought clear synergies and challenges for climate adaptation and mitigation. We clearly saw stakeholders outside of their comfort zone (thinking-wise). The SSPs were introduced though a presentation. However, the use of wildcards that were embedded in the SSPs was slightly overwhelming for the stakeholders. The wildcards made sense for each SSP, however, stakeholders were introduced to the SSPs for the first time during the workshop. This gave limited time to fully understand the SSP context behind the wildcard. Some stakeholders developed a slight resistance against the wildcards because they were too 'low-probability' and not concrete. Yet, the introduction of the wildcards in the workshop resulted in additional elements in the pathways and facilitated the process to view the pathways in different societal contexts. Since the inclusion of socioeconomic scenarios in The Netherlands is not common for adaptation planning, the introduction of scenario thinking here is a first step. Although it remains challenging to get stakeholders in the exploratory scenario mood, the inclusion of exploratory socioeconomic scenarios in co-production is essential and overlooked. In this, the use of wildcards to aid this process therefore needs more innovation and further experimenting.

3. Guidelines for the selection and utilisation of Co-production techniques

In this section we first reflect on the lessons learnt in the two SENSES case study about the application of co-production techniques, then we provide a step-by-step guide for how develop local and regional scenarios and adaptation pathways for IAV studies, and how to select and use different co-production methods in each step.

3.1 Synthesis of co-production techniques in the case studies

In both SENSES case studies, we conducted a scenario process and linked regional scenarios to the global SSPs. The process in both case studies was designed in three phases including:

1. Understanding the current situation,
2. Looking into the future, and explore by building scenarios,
3. Adaptation planning by using the scenario knowledge and/or visions to develop adaptation options and assess their robustness.

Studying the present context is a necessary first step to explore ongoing trends and components of the socioeconomic system and assess the existing scenario knowledge in the study domain. This assessment will further determine whether an exploratory process is needed as a starting point or the scenario process can utilize the existing socioeconomic scenario knowledge as the basis and move forward to the normative phase directly.

Looking into future is the stage where scenarios are built or taken onboard and prepared for utilization. In this phase, based on the conclusions in phase 1, exploratory or normative scenarios are either developed or identified, re-framed and prepared for the specific use designed in the case study protocol.

The third phase is a scenario planning procedure where the scenario knowledge co-produced in phase 2 is used as planning tool for identifying and co-produce adaptation options and designing adaptation pathways. In each stage, the two SENSES case studies used a different mix of co-production techniques (table 4).

Table 4. Co-production techniques used in the three phases.

Phase 1 – Understanding the current situation		
Case study	(Co-production) technique	Application
Overijsselse Vecht, and Kenya	Interview	Scoping
	Literature review	Understanding scenario knowledge and needs in Kenya
	Participatory system dynamics	Understanding the socioeconomic system, drivers and challenges
Phase 2 – Looking into future		
Case study	Co-production technique	Application
Overijsselse Vecht	Visioning	Integration of multiple long-term targets
	Wildcards	The wildcards were developed by interpreting the global SSPs on a regional level
Kenya	Brainstorming	Generation of scenario drivers
	Morphological analysis	Generation of states for each driver contingent on global SSPs
	Intuitive logics	Development of narratives for the extended SSPs
Phase 3 – Adaptation planning		
Case study	Co-production technique	Application
Overijsselse Vecht	Backcasting	Generation of adaptation options
	Wildcards	Combining scenarios and adaptation options
Kenya	Brainstorming	Generation of cross-border impacts Generation of adaptation options

Phase 1 - Understanding the current situation

In the first phase both case studies used combinations of methods and activities to understand the current socioeconomic system, create an overview of existing scenarios and adaptation plans and pathways, and identify key stakeholders to engage in the case study.

A combination of literature review, scoping interviews, and system dynamics (fuzzy cognitive mapping) was used to understand the present situation, drivers and challenges to adaptation and determine the level of advancement in the existing scenario knowledge. We used literature review to take stock of the existing socioeconomic scenarios, visions at different scales, and adaptation options, plans, and strategies in the context of both Kenya and the Netherlands. Combining scoping interviews with system analysis assisted the team to study the present situation together with stakeholders and contributed to stakeholder engagement from the first steps of the scenario process.

The results of this phase confirmed that Overijsselse Vecht is in fact a scenario knowledge rich context and there are different sets of exploratory and normative scenarios specific to the local context that can be used as a starting point. In contrast, the results of the Kenya case study showed that Kenya is a scenario knowledge scarce context and therefore, the scenario process must start with an exploratory process, developing socioeconomic scenarios for Kenya.

Phase 2 – Looking into future

Moving on to the second phase of the scenario process, the NL case study started the scenario co-production process with a normative approach and utilized visioning techniques to collect the existing long-term targets and normative scenarios. Combining the identified future visions, we created a multi-scale vision, consisting of three geographical scales and four overarching vision themes. The use of a multi-scale vision allowed for a focal end point and a collective goal.

It is important to note that while the overarching approach of the NL case study scenario process was normative, exploratory activities were also conducted prior to the scenario process through literature review and scenario mapping. As part of this exploratory process, we interpreted the global SSPs into a set of socioeconomic wildcards (i.e., low-probability and high-impact events) on regional level. Regional interpretations of the SSPs served as the basis for using wildcards technique in phase 3.

The Kenya case study conducted phase 2, looking into future, through developing exploratory socioeconomic scenarios specific to the context of Kenya. We used a combination of brainstorming, morphological analysis, and intuitive logics for scenario building. Brainstorming, a creative, participatory, and interactive co-production technique facilitated creative thinking and motivated stakeholders to break out of narrow and routine discussions and generate new ideas. We chose morphological analysis as the main co-production technique for building scenario structures linked to the global SSPs. While morphological analysis provided us with a structured framework to improve scenario diversity, we observed that it is not an appropriate technique for developing scenario narratives and communicating scenario knowledge to stakeholders. Therefore, we took advantage of using Intuitive logic as an additional technique for crafting the storylines and better communication of the extended SSPs.

Phase 3 – Adaptation planning

The NL case study used *backcasting* to co-produce adaptation options and pathways towards the multi-scale vision. As a strategic problem-solving technique, backcasting assisted stakeholders to identify feasible adaptation options, measures and actions on a tangible time scale required to reach the multi-scale vision. An advantage of backcasting in the NL case study was that it was implemented in an iterative way, rather than strictly 'from back to beginning', hence, stakeholders could go forth and back to indicate short, middle, and long-term adaptation options on the pathways. Following the backcasting process, wildcards, were used to test the robustness of the adaptation pathways. Wildcards technique was chosen as an appropriate technique to both link Overijsselse Vecht adaptation pathways to the global SSPs (phase 2) and stress-test those pathways given future developments at the global scale (phase 3).

In the Kenya case study, we used brainstorming as our chosen co-production technique to first identify future cross-border climate impacts and then adaptation options to address those impacts. Both these brainstorming sessions were guided and heavily facilitated, compare to the brainstorming process in phase 1 of the processes. We designed a framework using the extended SSPs and a set of risk pathways and advised stakeholders to generate ideas for impacts and adaptation options specifically in the context of scenarios and pathways. Using brainstorming techniques for idea generation worked well and facilitated creative thinking, but the importance of strong and well-structured facilitation cannot be over emphasised. We compensated the possibility of free thinking and high level of engagement in a brainstorming setting with structured framework and consistent facilitation to steer the process to the end-goal.

3.2 Guidelines for co-production of regional scenarios and pathways for adaptation

Drawing on lessons learn from the two case studies within SENSES, in this section, we introduce a set of practical guidelines on how to select and utilise co-production techniques to engage local and regional stakeholders in the development of socioeconomic scenarios and adaptation options and pathways. We recommend a series of steps to be taken for designing and running a co-production process grouped together in four phases and for each step, we suggest a set of methods and techniques which are appropriate and applicable for conducting co-production activities in that specific step. All co-production techniques recommended in this guide are introduced in the Co-production Techniques Finder.

The process consists of four phases:

1. Preparation and set-up
2. Understanding the current situation
3. Looking into the future
4. Adaptation planning

Phase 1 – Preparation and set-up

Step 1 – Stakeholder engagement

We recommend identifying and engaging with local and regional stakeholders at the very beginning of any co-production process. Although this step could also be placed in later stages of the process, we argue that inviting stakeholders to the process from the start improves the process design by considering the cultural context; unique characteristics of the region under the study; and local and regional knowledge and expertise. Stakeholder engagement, not only in data collection and analysis, but also in scoping and conceptual design of a study should be a fundamental characteristic of co-production approaches. Therefore, connecting with relevant stakeholder groups must be considered as one of the first preparatory steps for the entire study process. Moreover, involving stakeholders from the onset facilitates buy-in and participation commitment from stakeholders and increases chances of adoption, implementation and communication of the co-production process results and conclusions.

Stakeholder engagement and selection will strongly depend on the method that is being employed, but on a general level the following aspects should be considered in the different phases. In the first phase – about understanding the current situation – it is of course vital to include stakeholders with the relevant expertise and perhaps also ownership of the system(s) under study. This is not necessarily people involved in climate adaptation planning. However, it is also important to involve policy makers working with climate adaptation early in the process to get the right framing of the process, as well as people from the business community and civil society. In the next phase – the exploratory phase – it is important to include stakeholders that can assist in 'thinking outside the box', i.e., beyond those directly involved in adaptation planning. This could include artists, authors, journalists, researchers outside climate change etc. Referring back to the current situation, this phase could also include stakeholders working on for example research and development for the system under study. The important thing in this phase is to try to include a broad range of expertise to span the space of possible futures. Heterogeneous groups are advantageous as they provide diverging, new and interesting perspectives, and knowledge, broaden the scope of the discussions and, in doing so, create interesting results

In the last phase – adaptation planning – it will be important to involve adaptation expertise, for example policy makers working with climate change and adaptation issues, but also those involved in related issues such as spatial planning, adaptation practitioners in regional, national, and sub-national government, and adaptation specialists in universities, research organizations. Furthermore, stakeholders from civil society, NGOs and public organizations that work with adaptive capacity issues with local communities should be considered in this phase.

The total number of participants invited to any particular phase in the process will vary from one project to another, depending on goals, budget and the nature of the problem. The number of stakeholders is also dependent on the exact method employed in each of the phases.

Step 2 – Process design and set-up

A co-production process is most often conducted through participatory and interactive settings. As part of the preparation and process design, we recommend exploring different platforms and approaches to organizing the interaction with stakeholders. There is a vast spectrum of options, approaches, and tools, from online platforms for knowledge sharing and collective decision making, to multiple set-ups for face-to-face meetings focused on participatory processes, including workshops, world cafes, etc.

When selecting among different meeting set-ups for co-production, we recommend considering the possibilities for online meetings to reduce impacts of traveling. However, in regional and local processes it might be feasible to organise physical face-to-face meetings, and it should be underlined that, if possible, face-to-face meeting are preferable since they tend to create much more of creative thinking, especially in the exploratory phase. In case a physical meeting, event organization and logistics issues should be planned for well in advance. Instructions and guidelines on organizing workshops and participatory events are similar in global and regional co-production processes. To explore general instructions and more details on how to organize workshops, please refer to the global stakeholder manual for co-production on the SENSES toolkit.

Phase 2 – Understanding the current situation

Step 3 – Understanding the current situation

This first step in Phase 2 includes two topics to be investigated:

1. Overview of existing scenarios, pathways, and other products
2. Understanding of the current system

In the third step, we recommend a combination of desk-based research and co-production techniques to explore the adaptation landscape, policies in action, and overall assessment of impact and vulnerability, and adaptation needs. This helps in determining how a scenario process and development of socioeconomic scenarios and pathways could fill gaps and add value to the current adaptation planning.

Exploring the present situation finally leads to an assessment of the level and variety of existing knowledge on socioeconomic scenarios and adaptation pathways. This step answers to the question of how advanced the existing knowledge is and depending on the existing knowledge, different types of scenarios and knowledge need to be produced, and different co-production techniques and processes could be implemented. Understanding the current situation determines the design and scope of a reliable scenario process for adaptation planning.

An important aspect of this step is to try capture the understanding of multiple perspective and ambiguities in how the current system is perceived. Different stakeholder groups (cf. Step 1 above) can have very different, and indeed sometimes conflicting – views on how the system under study should be understood.

Recommended co-production techniques for step 3 – understanding the current situation
***Participatory System Dynamics (SD)*:**   System dynamics is an approach to understanding the nonlinear behaviour of complex systems using stocks, flows, internal feedback loops, table functions and time delays. Participatory system dynamic is a variation of system dynamic that uses co-production processes and stakeholder engagement for understanding the system.
***Fuzzy Cognitive Maps (FCM)* :**   Fuzzy Cognitive Mapping is a tool to represent mental models suggested by multiple participants in a workshop as causal relationships. FCMs are directed graphs useful for exploring and eliciting causal relationships, used for modelling dynamic and complex systems which have many parameters and are difficult to model using a mathematical approach.
***Participatory environmental Scanning*:**   *Environmental (also called Horizon Scanning) Scanning implies a systematic process for reviewing, capturing, and monitoring the external environment to distinguish among what is constant, what changes, and what constantly changes.*
***Focus group*:**   *Focus groups are usually conducted and facilitated by a researcher or trained group leader who guides the conversation among a small group of respondents, participants or stakeholders on a specific topic.*
***Affinity diagram*:**   *An affinity diagram is a tool for organizing ideas, issues, or components of a topic or problem space into related groups and clusters. The method is usually used combined with brainstorming and categorizes a large number of fragmented disorganized information into logical cohesive groups.*

Step 4 – Scoping the scenario process

This step is designed to determine the scope of scenario process and whether an exploratory scenario process is needed before starting the normative process and adaptation planning, drawing on the level of advancement in the existing knowledge (investigated in step 2). In information-scarce contexts, an exploratory phase and the development of socioeconomic scenarios is the necessary starting point for identifying desirable adaptation actions and pathways. However, in information-rich contexts, it is possible to take on board a set of existing socioeconomic scenarios and start directly from the normative phase where visions and pathways are developed and integrated.

In the scoping process it is important to reflect on what is sometimes called 'policy timing'. In almost all cases there will be one or several policy processes surrounding the scenario process and to leverage policy impact these processes need to be considered. In doing this, the policy cycles of relevant policy processes need to be investigated so as to adjust the scenario process to those cycles. If for example one of the key policy processes is in the phase of implementation, then it might be difficult to impose an exploratory scenario exercise into the picture. The exploratory phase, as an example, is better aligned to phase like policy formulation or agenda setting.

Step 5 – Co-producing the future context

This step consists of producing exploratory scenarios and perhaps also vision building. Exploratory scenarios strive for not being normative, while visions are explicitly normative; where do we want to be in *X* years from now, in contrast to the scenarios ethos of 'where can we be?'.

The objective of vision building is to create descriptions of the envisioned future which express the agreed desires and wishes of a future society. The vision comprises of statements that are specific narrative constructs that depict explicit desires, assumptions, beliefs, and paradigms that underlie a desired future.

For a vision to be valuable, it must transcend from the group that created it and become relevant for a wider audience. Communication of the vision to a broader audience or targeted audience is a side-step that may enable value mobilisation of resources for realisation of the vision. Creating a vision can facilitate effective strategic process and identifying adaptation options (see below).

For building future visions, we recommend combining intuitive techniques for structuring and making sense of existing scenario knowledge – to organize and take onboard existing socioeconomic scenarios – with techniques suitable for crafting goal-oriented imaginaries and broad and comprehensive goals and visions.

Exploratory scenario building rest on the assumption that the future is inherently uncertain and therefore we need to explore several different pathways into the future. For the use in IAV at the sub-national scale narratives play a central role. In the context of scenarios, narratives are internally consistent qualitative descriptions of how the future might develop. The rationale for using narratives to improve communication and learning about the future socio-economic development is that people do not randomly add new information about the future to a loose conglomeration of earlier knowledge, but rather that they construct mental models which aid in making sense of observations. The use of narratives can facilitate the translation of scientific data into a form that is related to locally relevant concerns and perceptions.

When exploring plausible socioeconomic futures exploratory co-production methods and techniques are used in the scenario process. These methods and techniques are designed to answer to the question of 'what could happen'. In this case, refer to the co-production techniques finder and choose among 'exploratory' co-production techniques. We recommend combining methods suitable for creative thinking and open exploration with techniques for structured scenario development.

Recommended co-production techniques for step 5 – co-producing the future context
Brainstorming: *Brainstorming is a creative thinking, participatory and interactive technique used in face-to-face and online group working sessions to generate new ideas around a specific area of interest. Brainstorming is usually used in combination with other co-production techniques and methods.*

Intuitive Logics (IL): *Intuitive Logics, also known as scenario matrix, is a scenario building method based on two dimensions of uncertainties or polarities. The four cells represent alternatively the four combinations of the poles of the two uncertainties, each of which contains a kernel or logic of a plausible future.*
Morphological Analysis (MA): *Morphological analysis (MA) is a structured scenario building method that investigates the totality of relationships contained in multi-dimensional, non-quantifiable problem complexes. In MA, scenario are built through alternative configurations of parameters (or drivers and a range of relevant conditions (or states) assigned to them.*
Cross impact analysis: *Cross-impact analysis method is an analytical approach to the probabilities of an item in a forecasted set. Its probabilities can be adjusted in view of judgments concerning potential interactions among the forecasted items.*
Visioning: *Visioning is the process of creating a series of images or visions of the future that are real and compelling enough to motivate and guide people toward focusing their efforts on achieving certain goals. The visioning process is almost always done in a participatory manner.*
Simulation and Gaming: *Simulation and Gaming is an anticipation and planning technique that provides the opportunity to explore various options for dealing with situations that may come up in the future. The simulation itself does not provide guidelines for meeting that future. It does, however, allow the participants (in this case, pilots) to decide how to react to many what-ifs.*

Step 6 – Identifying future climate impacts using scenarios

The adaptation planning phase ideally starts with identifying and assessing future climate change impacts and risks. For this step, we recommend focusing on one specific and pre-defined aspect of climate change impacts or risks and use exploratory and creative co-production techniques complemented with structured facilitation to reach desirable results. A more quantitative approach is to use the scenario data from the exploratory scenarios as input to climate impact models. This is sometimes called story and simulation approaches and it combines qualitative and quantitative data so that outputs from impacts modelling can be linked to qualitative descriptions (narratives), hence contextualizing the numbers.

Recommended co-production techniques for step 6 – identifying future climate impacts
***Brainstorming*:** *See above.*
***Trend impact analysis (TIA)*:** *Trend Impact analysis is a tool to estimate probabilities of occurrence and impacts of future events that bases its forecast on a combination of quantitative data and experts' and stakeholders' opinion about probable events in the future.*

Step 7 – Developing adaptation options

Adaptation options are defined as stand-alone activities and action items that together could form adaptation pathways. In this step, identify and prioritize adaptation options and action items that could improve the adaptation planning. A set of both exploratory and normative techniques could be used in this step, depending on the objective and approach. We recommend opting for exploratory techniques for co-producing radical, novel, and out of the box adaptation options, and normative techniques for identifying more tangible and evidence-based adaptation options involving policy and finance aspects.

Recommended co-production techniques for step 7 – developing adaptation options
***Brainstorming**:* *See above.*
***Nominal group (NGT)**:* *Nominal group is a technique for facilitating participatory process involving problem identification, and subsequently solution generation if needed. It can be used in groups of many sizes, who want to make their decision quickly, as by a vote, but want everyone's opinions considered in the final output.*
***Backcasting**:* *Backcasting is normative approach which works backwards from a particular desired endpoint (goal/vision) to the present to determine the feasibility of that future and what policy measures and actions would be required to reach that point.*

Step 8 – Developing adaptation pathways

A combination of adaptation options and activities could create an adaptation pathway. However, developing adaptation pathways requires an additional step where a timeline is introduced to the process and adaptation options are given time labels. In this step, we recommend using co-production techniques suitable for strategic planning, decision making and action planning which facilitate identifying a path from now towards a desired future with specific milestones.

Recommended co-production techniques for step 8 – developing adaptation pathways
***Backcasting**:* *See above.*

Roadmaping: *Roadmaping is a is a normative and goal-oriented method, where attempts are made to achieve a desired future state of development. Roadmaps provide essential understanding of proximity, direction, and some degree of certainty in planning.*
Robust decision making (RDM): *Robust Decision Making is a combination of scenario planning with powerful computing to support decision makers by helping to identify potential strategies that are robust to future unknowns, characterize the vulnerabilities of such strategies, and evaluate trade-offs among alternatives.*
Wild cards: *Wild cards are low-probability, high-impact events. Wild cards technique may be used in an anticipatory decision-making process to understand the implications of the external environment on a specific decision process and increase the ability of stakeholders to adapt to surprises arising in turbulent environments.*

4. Reflections and conclusions

This document (SENSES deliverable 2.5) reports on the use of co-production approaches and techniques for developing local and regional socioeconomic scenarios and pathways for adaptation in two local and regional IAV focused case studies (Kenya and the Netherlands). An overarching objective of the case studies was to explore how stakeholder-driven scenarios at local and regional scales can be connected to the global scenario architecture (SSPs in this case) via different co-production techniques.

Despite large differences across two case studies, there are strong conceptual similarities in their frameworks and approaches. Both case studies established a co-production process for developing local and regional socioeconomic scenarios and pathways and followed comparable approaches and methodological steps. In this sense, the process in two case studies can be described with one logic of consecutive phases, including understanding the current situation, exploring the future through building scenarios, and adaptation planning by using the scenario knowledge.

We used a combination of exploratory and normative methods in both case studies. While the NL case study was conducted in an information-rich context and focused on normative scenario process, exploratory steps and techniques were needed to understand the current situation and translate the global developments to local and regional scale. On the other hand, in the Kenya case study, it was necessary to utilize normative techniques in the adaptation planning phase, even though the focus of the study was on exploratory processes essential for scenario building in an information-scarce context.

Accordingly, we argue that any co-production process for building local and regional scenarios and adaptation pathways should include a combination of exploratory and normative methods and techniques. In addition, we observed that combining normative and exploratory scenario types assist in both exploring plausible futures and identifying desirable goals and visions in the realm of possibilities. While using a mixed method approach is generally accepted as common practice, combining types of scenarios remains underexplored and rare and needs to be advocated in the IAV research community.

Building upon the lessons learned from the case studies, we developed a step-by-step guide on how to use co-production techniques for building local and regional socioeconomic scenarios and pathways for adaptation. The guidelines presented in this report (Section 3.2) are generic and can be adopted to a variety of IAV studies and adaptation planning processes. The methods recommended for every step however are only suggestions and must be adjusted and exchanged with other techniques based on the scope, objective and focus of any given research or planning practice.

Local and regional socioeconomic scenarios and pathways can be developed through single-scale and multi-scale approaches. While single-scale scenarios are useful for capturing context-specific drivers and nuances, they cannot capture the impact of global developments and cross-border issues on the context under study. In case linking local and regional developments to the global context is an objective, multi-scale scenario approaches must be used. Local and regional adaptation pathways can be designed and operationalized in different ways, with a varying role for socio-economic scenarios, visions, and climate change impacts. Selecting a method mix and process for developing adaptation pathways highly depends on the relative importance of these elements.

Existing scenario knowledge and advanced policy planning play an increasingly important role in information-rich contexts. The long history of using participatory processes for scenario-based adaptation planning has resulted in low level of engagement and stakeholder fatigue in co-production processes. Using underutilized and new co-production methods, tailoring novel application of the commonly used techniques for every co-production process could be a solution for increasing stakeholder engagement throughout the process. In information-scarce contexts however, there is a need to advocate for the use of co-production processes and expansion of scenario building practices to enhance context-specific scenario knowledge and consequently, improve scenario-based adaptation planning. Using novel scenario communication tools, like storyline visualizations, could encourage the development and utilization of scenarios.

Looking at the SENSES co-production techniques finder and referring to the experience from the two case studies, it was evident that a wide spectrum of diverse co-production methods and techniques already exist that can be applied to the development of local and regional scenarios and pathways. However, we observed a gap in co-production techniques utilization, where some techniques (i.e., intuitive logics, brainstorming, etc.) are vastly known and used by IAV researchers and stakeholders, while others (e.g., morphological analysis, fuzzy cognitive maps, etc.) are underexplored and rarely used at local and regional scales. Accordingly, we argue that given the rich diversity of existing co-production techniques, the IAV community does not need extensive efforts for new method development, but rather, there is a need for novel application of the existing methods to investigating a variety of topics and research questions.

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