Framework and patterns of business (model) innovation, collection of good practice examples

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About Climateurope2

Timely delivery and effective use of climate information is fundamental for a green recovery and a resilient, climate-neutral Europe, in response to climate change and variability. **Climate services address this through the provision of climate information for use in decision-making to manage risks and realise opportunities.**

The market and need for climate information have seen impressive progress in recent years and are expected to grow in the foreseeable future. However, the communities involved in the development and provision of climate services are often unaware of each other and lack interdisciplinary and transdisciplinary knowledge. In addition, quality assurance, relevant standards, and other forms of assurance (such as guidelines, and good practices) for climate services are lagging behind. These are needed to ensure the saliency, credibility, legitimacy, and authoritativeness of climate services, and build two-way trust between supply and demand.

Climateurope2 aims to develop future equitable and quality-assured climate services to all sectors of society by

- Developing standardisation procedures for climate services,
- Supporting an equitable European climate services community,
- Enhancing the uptake of quality-assured climate services to support adaptation and mitigation to climate change and variability.

The project **will identify the support and standardisation needs of climate services, including criteria for certification and labelling, as well as the user-driven criteria needed to support climate action**. This information will be used to propose a taxonomy of climate services, suggest community-based good practices and guidelines, and propose standards where possible. A large variety of activities to support the communities involved in European climate services will also be organised.

Executive Summary

Climate services are instrumental in managing climate change risks by supplying insight and knowledge empowering the users in crafting effective adaptation and mitigation strategies, thus accelerating the shift towards climate-neutral and circular economies. The practical application of climate services is progressing at a modest pace, with their full potential remaining untapped. To speed up the deployment of climate services and scale up their impacts, it is crucial to understand and address existing challenges and shortcomings. Enhancing collaborative co-production processes will ensure that climate services are more user-oriented and tailored to specific needs. Reducing uncertainties in climate data and projections can bolster confidence among stakeholders. Improving the platforms for climate service delivery can make these services more accessible and user-friendly. Strengthening institutional frameworks can provide a robust support system for climate service provision. This report emphasizes the development of effective and sustainable business models to ensure the financial viability of climate services. By addressing these areas comprehensively, the demand for climate services can significantly increase, leading to broader adoption and the maximization of their benefits.

An analysis of various business model frameworks applicable to climate services (Section 2) reveals several key insights. Firstly, these frameworks prioritize societal and environmental value alongside financial sustainability. Secondly, user-centric approaches are crucial for the success of climate services, ensuring customization and collaborative design to meet user needs effectively. Thirdly, while financial sustainability is essential for longevity, traditional business models may require adaptation to balance economic viability with broader goals. Moreover, climate services often necessitate alternative revenue models beyond direct user payments, requiring exploration of diverse business models. Finally, while traditional frameworks provide a foundation, adjustments may be needed to align with the unique objectives and nature of climate service initiatives.

An extensive literature review of the penetration of sustainable business model innovation (Section 3) has yielded mixed results. Despite significant progress in the field of climate services, there is still a notable lack of studies reporting on the business strategies, patterns, and innovative mechanisms that ensure the long-term viability of these services and their provision. Compared to the rich and fast-growing literature on business model innovation in other fields contributing to the transition to climate-neutral, resilient, and circular economies, the theoretical and practical application of business model frameworks and ontologies in the domain of climate services is limited. Most of the academic literature addresses these aspects from a theoretical point of view, with only a few reporting on experiences and good practices. The challenge does not stem from a lack of incentives; on the contrary, there is a wealth of incentives and catalysts of innovation emerging from the realm of sustainable finance such as climate-related risk disclosures, corporate sustainability reporting, and principles of the circular economy, all of which encourage the adoption of sustainable practices. To compensate for the lack of explicit business innovation literature on climate services, we provide an overview of lessons learned from other fields of policy and practice. From this review, we extract essential innovation elements crucial for shaping customized business models in the domain of climate services (section 3.3).

To delve deeper into the specific practices of climate service providers, we conduct an in-depth analysis of a series of climate services or initiatives aimed at developing these services (Section 4). Through an initial screening, we identify key beliefs and practices essential for developing and launching these

services. Market evaluation and interaction are paramount to understand user needs and ensure that products cater to diverse market segments effectively. Cost-effectiveness remains a cornerstone, necessitating revenues that surpass all costs, including the often-ignored ones like maintenance and distribution. Customer willingness to pay is a crucial factor, particularly in emerging markets where pricing strategies must be in sync with demand. Varied payment models, including subscriptions and consulting fees, are tailored according to product types. In competitive, fast-growing markets, strategies must extend beyond product quality to include robust advertising and pricing tactics to build trust and transparency with customers. Commercialization success hinges on expertise that spans beyond mere product development. Some products, while not viable commercially, fulfil critical societal needs and thus remain invaluable. Publicly funded climate services play a vital role in this ecosystem by bolstering commercial ventures, fostering innovation, and ensuring the provision of essential services through ongoing support.

Keywords

Climate services; business ontology – business model, framework, theory; sustainable business (model) innovation ; value proposition; enabler and catalysts of business innovation.

1 Introduction

Thematic scope of the WP3 – Value and Business - within the project

Climate services play a crucial role in managing the risks of climate change by providing essential information, data, and tools that facilitate the development of effective adaptation and mitigation strategies. These services enable the assessment of present and potential future climate conditions, highlighting both risks and opportunities. The integration of this information into various domains such as planning, policymaking, and resource management empowers stakeholders to make informed decisions. Using climate services to their full potential helps society and communities to adjust to the impacts of climate change, curtail greenhouse gas emissions, and seize opportunities for sustainable development. The Climateurope 2 project (CE2) is dedicated to exploring how standardization of processes and common concepts can enhance the transparency of provision and adoption of climate services. While the project investigates a wide range of elements, including data and computational processes, market analysis, policy incentives, and community engagement, **Work Package 3** (**Value and Business**) specifically examines the **value that climate services provide to users** (customer value) and the introduction of new ways for delivering these services (**business model innovation**).

Every society is a complex tapestry of values, beliefs, and principles that guide individual choices and justify collective decisions. These values, whether deeply ingrained or newly embraced, play a pivotal role in the policy and decision-making processes. Cultural traditions, religious beliefs, historical experiences, and social norms often shape these values, providing lenses through which communities evaluate their past, present, and chart their future. There are different value systems, and theory-based typologies and value models[1] organize these values into coherent frameworks. Economic values might prioritize growth, sustainability, or equity, while political values may champion democracy, efficiency, or communal decision-making. Environmental values might emphasize nature preservation or ecosystem health. In personal choices, these values might manifest in decisions such as what to purchase, which career to pursue, or where to live. From a customer's viewpoint, **customer value** represents the benefits they receive in comparison to the costs or sacrifices they incur. A crucial component of customer value research involves developing frameworks and typologies to assist companies in understanding the process of value creation[2]. Despite growing interest, the **existing literature on business strategy is sparse in terms of guidance on the specific values to create, the timing for creation, the reasons behind it, and the methods for doing so**, or in providing a clear definition of a product concept from a value perspective (ibid).

Woodruff[3] for example **defines customer value** as "*a customer's perceived preference for, and evaluation of, those product attributes, attribute performances, and consequences arising from use that facilitates (or blocks) achieving the customer's goals and purposes in use situations*". This definition acknowledges the complex nature of a product or service's attributes and considers individual perceptions and evaluations within a certain context. However, it is not particularly practical or quantifiable for operational purposes. Not only is there an absence of a universally accepted definition, but there is also no commonly agreed upon conceptual model, or typology for customer value[2]. Zeithaml et al.[4] examined three paradigms in customer value research. The positivist paradigm sees customer value as concrete and measurable, often in monetary terms or other quantifiable metrics, presupposing that value

assessment is rational and based on objective criteria. The interpretative perspective considers customer value to be deeply personal and subjective, emphasizing that value transcends objective benefits or costs, involving personal meanings, emotions, and experiences tied to a product or service. The social constructionist view suggests that customer value is collectively constructed through social interactions and shared experiences, influenced by societal narratives, peer influences, cultural norms, and collective meanings. The perspective adopted affects how values are organized and how their satisfaction or fulfilment is measured. Under the positivist view, value satisfaction is gauged through quantitative methods like surveys and experiments. Interpretative research employs qualitative methods, such as interviews and focus groups, to uncover deeper insights into individual perceptions and valuations. The social constructionist approach examines how societal elements, cultural norms, and group dynamics affect value perception, using methods like discourse analysis and narrative analysis to investigate societal influences. From this brief introduction, **it's apparent that these three perspectives offer distinct lenses for comprehending and examining customer value**, each highlighting different elements and factors that affect the perception and realization of value.

Business model innovation is equally complex. The primary aim of business innovation is to **improve how customer value is generated and ensuring that a portion of this value is kept within the company to maintain the product or service**. In essence, business models are succinct depictions of the ways in which companies produce, deliver, and secure customer value. The **value proposition** refers to the aspects of a product or service that customers find valuable and appealing, while value capture describes how a company retains a share of the value generated for customers. Putting it differently, business models are "representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network"[5]. They build upon and improve existing products and services[6], acting as productivity enhancers[7] and market devices[8].

Sustainable business models are business models that incorporate multi-stakeholder management engagement, and address how monetary and non-monetary value is created for a broad range of stakeholders and from a long-term perspective[9]. **Sustainable** business model **innovation** refers to the process of developing and implementing new ways of conducting business that prioritise environmental, social, and economic sustainability. It involves rethinking and redesigning the fundamental elements of a business model to align with principles of sustainability and address the challenges posed by social and environmental issues. Taxonomy of business model innovation is a systematic categorization or classification of different types or approaches to innovating business models. Various attempts to classify sustainable business models show where progress was made. Through the analysis of real business models, Bocken et al.[10] analysed real-world business models and identified technological, social and organizational model archetypes (i.e. recurrent patterns). Gassman et al.[11] used a who-what-how-why framework to reduce the complexity of business model ecosystems into 55 patterns. Lüdeke-Freund et al.[12] employed a quasi-experimental approach to derive from a literature-based collection of business models, an original taxonomy of 45 patterns, which collect inputs from the previously mentioned works and synthetize findings. **So far there is no specific taxonomy focused on business model innovation for climate services**, and creating such a taxonomy is one of the goals of the Cimateurope2 project.

Standardisation plays a vital role in making climate services comparable and trusted. By establishing common standards, protocols, and guidelines, standardisation ensures consistency, reliability, and interoperability across different climate service providers. This instils confidence and promotes

transparency, reliability, and credibility. Climateurope 2 project promotes standardisation across various areas of practice in climate services, including data, methodological, quality control, communication, and ethical standards. Data standards play a crucial role in integrating and comparing data from different sources. Methodological standards ensure consistency in analysing and interpreting data, enabling comparisons across studies or services. Quality control standards ensure the reliability and accuracy of climate services. Communication standards ensure clear and understandable dissemination of results to various stakeholders. Ethical and privacy standards guide the ethical collection, use, and protection of climate data, considering privacy, informed consent, and data security considerations.

Standardisation fosters sustainable business model innovation by creating an environment that supports providers in focusing on their unique value propositions and encourages collaboration within the industry. Sustainable business model innovation involves restructuring incentives and revenue mechanisms to capitalize on sustainable solutions[13]. This approach has the potential to generate greater returns compared to other forms of innovation while also offering additional benefits in terms of risk mitigation and resilience. Traditional business models may not fully capture the unique characteristics and evolving demands of the climate services domain. Hence, businesses operating in this domain are increasingly exploring and implementing innovative approaches to their business models to enhance their impact, scalability, and long-term viability.

Scope of this report

The purpose of this report is to review and analyse business models for climate services and sustainable business model innovations. It focuses on understanding how business models are designed, implemented, and used to generate benefits and value in decision-making processes. This report compiles evidence regarding the integration of business innovation into the theory and practice of climate services development. It elaborates on the key strategies used to overcome barriers to the adoption and utilization of climate services and aims to establish existing patterns in this domain. The review serves as an initial stocktaking of existing practices and development trends, aiming to identify key success factors, understand challenges, and pinpoint potential bottlenecks in the adoption of these models.

Climate services rely on the expertise, knowledge, and intellectual capabilities of individuals or organizations. They involve the application of specialized knowledge, information, and skills to provide value to customers. Climate services leverage expertise in climate science, data analysis, modelling, and interpretation. They transform climate-related information into tailored knowledge, supporting policy and decision-making across various geographic and functional boundaries and governance levels. Climate services face diverse and complex challenges, relying on intricate interpretation and analysis of technical concepts, weather and climate data, and socioeconomic impacts. They utilize various data sources, including satellites and climate models, necessitating specialized knowledge and skills. Tailored solutions are crafted to address clients' specific needs, considering industry context, objectives, climate science, risk assessment, and adaptation strategies. Climate services heavily depend on human capital and knowledge, making standardization challenging[14]. However, they play a vital role in fostering innovation through co-production efforts[15]. Overall, climate services embody these characteristics and integrate them into their business models[16]. The level to which business models for climate services have been effectively employed to improve the marketability of services is analysed in this report.

Business model innovation is often associated with private service provision and **commoditization of climate knowledge**. The latter refers to the process by which climate-related data, information, and insights become products that can be bought, sold, and traded in the market. As with the commoditization of any other type of knowledge or information, this process involves transforming something that was once freely available and non-excludable into a good that can be controlled, packaged, and sold for profit. Our research address both public and private climate service provision and is not limited to profit-seeking activities. While the commoditization of climate knowledge has the potential to drive innovation and provide valuable services, it also raises several ethical and practical concerns. These include questions about who has access to this knowledge and who benefits from it, as well as concerns about privacy, data security, and the potential misuse of information. There are also questions about the accuracy and reliability of commoditized climate knowledge, as well as the risk of creating a dependency on a small number of private providers for critical climate services.

Terminology used in the report

The discourse on business model innovation covers a broad spectrum of definitions, each emphasizing the unique dynamics pertinent to specific sectors and fields. Although a universally recognized set of definitions has yet to be established[17], there is an emerging convergence among academics and industry professionals. Here we provide a list of the most frequently used definitions and their meanings as used in the report.

- **Business model ontology** is a conceptual framework that structures the domains of business models, facilitating a deeper understanding of how businesses operate, create value, and sustain themselves in a competitive environment[18]. The origins of business model ontology trace back to the Resource-Event-Agent (REA) model[19] developed in the 1980s and gained popularity and widespread reference through the work of Osterwalder and Pigneur[20], building on the earlier ontology of business models by Osterwalder[21]. The ontologies standardize and clarify the components and relationships within business models, focusing on actors, resources, and resource transfers between actors. They enrich the understanding and analysis of business models by providing a comprehensive vocabulary and structured depiction of a firm's business logic.
- **Business models** (BMs) are "representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network"[22]. They build upon and improve existing products and services [6], acting as productivity enhancers[7] and market devices[8]. BMs are a simplified description of how companies frame, deliver and capture value proposition. **Value proposition** is what the customers value and what makes a product or service attractive to them. Value capture means how the company retains a proportion of the value created for the customers.
- **Sustainable business models** are business models that incorporate multi-stakeholder management engagement, and address how monetary and non-monetary value is created for a broad range of stakeholders and from a long-term perspective[9]. **Sustainable business model innovation** refers to the process of developing and implementing new ways of conducting business that prioritise environmental, social, and economic sustainability. It involves rethinking and redesigning the fundamental elements of a business model to align with principles of sustainability and address the challenges posed by social and environmental issues.
- **Taxonomy of business model innovation** is a systematic categorization or classification of different types or approaches to innovating business models. Various attempts to classify sustainable

business models show where progress was made. Through the analysis of real business models, Bocken et al.[10] analysed real-world business models and identified technological, social and organizational model archetypes (i.e. recurrent patterns). Gassman et al.[11] use a who-what-how-why framework to reduce the complexity of business model ecosystems into 55 patterns. The unit of analysis to enhance classifications is a crucial variable, as explained in Remane et al.[23] who employed the Business Model Canvas as a tool to create a database of 182 business models patterns. Lüdeke-Freund et al.[12] employed a quasi-experimental approach to derive from a literature-based collection of business models, an original taxonomy of 45 patterns, which collect inputs from the previously mentioned works and synthetize findings. **So far there is no specific taxonomy focused on business model innovation for climate services**.

- Business model innovation can include **innovations of revenue model** – building upon new pricing and revenue-sharing models, **value proposition innovation** enhancing the unique value that a climate service delivers to a user, **ecosystem innovation** by reconfiguring the network of partners, suppliers, and stakeholders to create new value, process Innovation improving the internal operational processes underpinning a business, **customer experience innovation** enhancing the way customers interact with a business and the value they derive from those interactions, or **business model architecture innovation** which involves reconfiguring the entire structure of the business model.

The structure of the report

After establishing the context of the review and outlining the scope of Task T3.2 in this section (1), **Section 2** explores theories, frameworks, and models used to organize components of business models and elucidate their underlying logic. The selection of 14 models (Section 2.1) is drawn from a larger collection of over 260 references compiled by the WP3 team, which is still being analysed to identify common components. Section 2 introduces the reader to the variety of business models developed and referenced across the business innovation literature. It helps to familiarize readers with the concept and covers the various ways in which the business logic is structured and conveyed.

Section 3 focuses on examples of business innovations drawn from the climate services and related domains of business innovation. Firstly, the subsection 3.1 introduces the drivers and catalysts of business innovations for climate-neutral, resilient, and circular economies. Subsequently, the section 3.2 delves into a literature review analysing the extent to which the concepts and theories have permeated the peer-reviewed literature on the development and marketing of climate services. Finally, subsection 3.3 summarizes the insights from across the non-peer-reviewed literature and business innovation examples from other fields of inquiry.

Section 4 provides insights into the business logic of 18 existing climate services or initiatives aimed at developing services. The selection of the cases follows the common cases chosen in the project to facilitate cross-WP collaboration and integrated analysis and extends this with additional tools to populate the initial insights.

Section 5 concludes the comprehensive review presented in the report and outlines the next steps for further research and action.

2 Exploring the Landscape of Business Models Literature.

2.1 Diversity of theories and frameworks of Business Models and their Applications

This chapter presents the most prevalent frameworks for designing business models, which can also be applied to the climate services sector. These frameworks and theories were chosen based on desk research and practical experience in business modelling activities. A total of 10 frameworks and 4 theories are outlined and discussed in detail.

2.1.1 Value Proposition Canvas

Initially developed by Alexander Osterwalder, the Value Proposition Canvas is a framework that aims to achieve a fit between the product and the market.

The canvas is divided in two sides, illustrated in **Figure *1*** and ***Figure 2***:

- **Customer Profile** to clarify the customer understanding by breaking the customer down into its:
  - Gains: Positive outcomes customers want to achieve or the concrete benefits they are seeking
  - Pains: Negative outcomes, risks, and obstacles related to customer jobs
  - Jobs: what customers are trying to get done in their work and in their lives, as expressed in their own words

- **Value map** to describe how to create value for that customer by breaking the value proposition down into:
  - Gain creators: How the products and services create customer gains
  - Pain relievers: How the products and services alleviate customer pains
  - Product/services: List all the products and services the value proposition is built around.

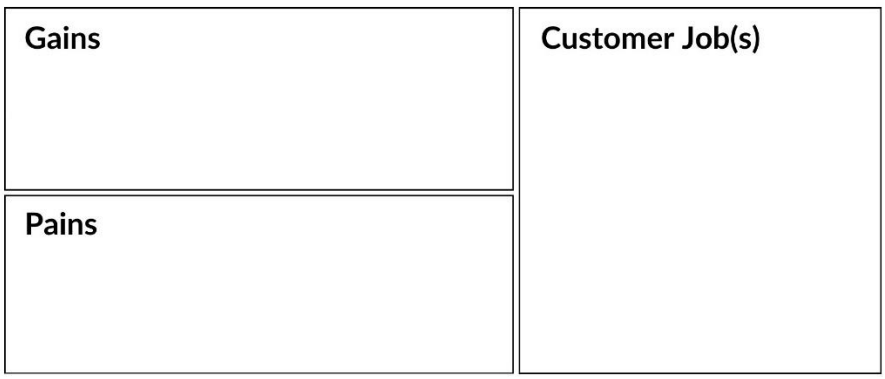

Figure 1 - Value Proposition Canvas - Value Map

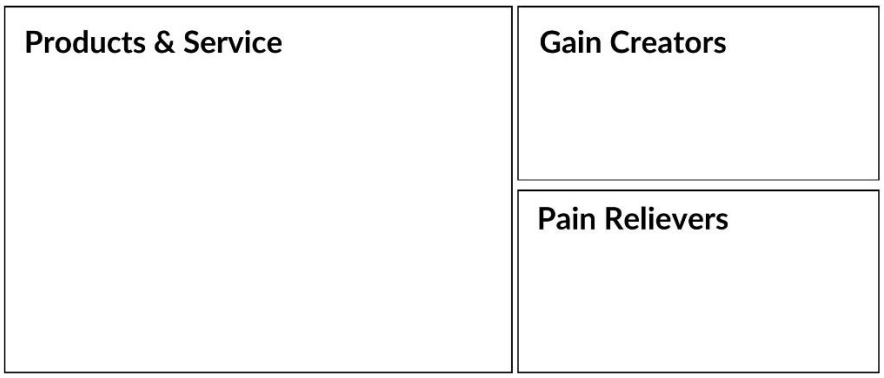

Figure 2 - Value Proposition Canvas - User Profile

When applied to climate services, the Value Proposition Canvas can play a crucial role in ensuring that these CS effectively address the needs and challenges of users. The Value Proposition Canvas is a first step to complete the Business Model Canvas.

2.1.2 Business Model Canvas

The Business Model Canvas, illustrated in ***Figure 3*** was also developed by Osterwalder. It is a business tool used to visualise all the building blocks in the creation of a new business, including customers, route to market, value proposition and finance. This tool is used to map out a business or product's key actors, activities and resources, the value proposition for target customers, customer relationships, channels involved and financial matters. It helps identifying requirements to deliver the service and provides a clear visual of what the business model is and how the activities should be aligned[24].

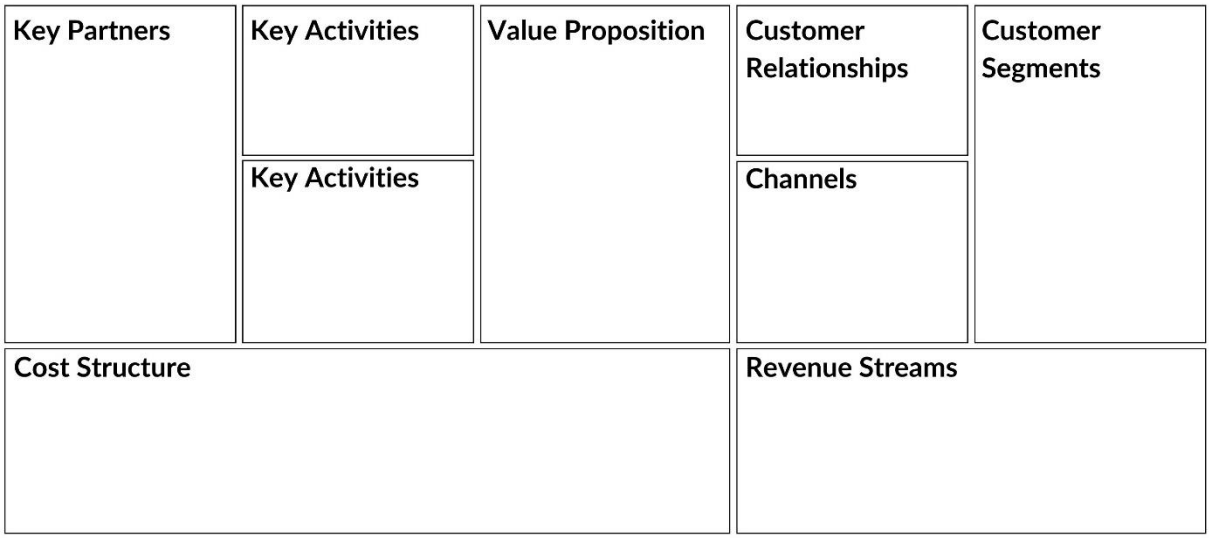

Figure 3 - Business Model Canvas

Each of the block has a specific goal to help build the overall BMC. They may be applied to the field of climate services:

Value proposition

The value proposition is a simple statement that summarizes the competitive advantages and the innovative aspects of the solution (product or service). In other words, it addresses the following

questions: "*Why would a customer choose this solution over another one? What does this solution do better?*" The previous tool "Value Proposition Canvas" contributes to defining this value proposition through the value map. In the climate services field, the value proposition of the climate service is crucial as it will define whether the CS is adapted / tailored to its user or not. This could involve accurate climate data, risk assessments, predictive modelling, sectorial or geographical-specific information, or other insights that help users make informed decisions related to climate change and its impacts.

Customer segments

As customers are at the heart of the business creation, the type of customers that are targeted must be identified clearly. That include the specific groups, sectors, end users and beneficiaries of climate services. This may be individual stakeholders, government agencies, private companies, NGOs etc.

Customer relationships

The objective of this section is to define the nature of the relationship or interactions that will be cultivated with each customer segment over the course of their engagement with the organization. For climate services, this may consist in the co-design of the climate service with the user, and beyond its design, an ongoing support, training, data customization, or feedback mechanisms to improve the relevance of the CS for its users.

Channels

Communication and dissemination channels are leveraged in order to communicate with and reach out to the potential customers. Channels are the touchpoints that connect customers with the organization. The distribution channels to deliver the climate services can be diverse: They might include online platforms, institutionalization of the service within the existing decision support systems, partnerships with meteorological agencies, participation to national events, dissemination of climate information via WhatsApp to smallholders' farmers etc.

Key activities

This section describes the activities and tasks that are essential to be completed to fulfil the purpose of the business. There are several key activities required to deliver climate services such as data collection and analysis, model development, monitoring, updating of climate information etc.

Key resources

Some resources are essential to be able to carry out the key activities. Generally, they consist in human resources (employees, staff), Financial resources, Intellectual resources (brand, patents, IP, copyrights, trade secret) and Physical resources (equipment, buildings etc.). In climate services more specifically this may also include data sources, partnerships with climate research institutions, skilled and experienced personnel who has close links with the CS user etc.

Key partnerships

Key partners are external to the organization and aim to help the business carry out its key activities. They may be suppliers, financial partners, experts, subcontractors etc. Strategic partnerships in climate

services will most likely involve collaborations with meteorological agencies, research institutions, technology providers, or industry associations.

Cost structure

This section identifies and categorizes all the major costs associated with the operation of the business model. Businesses can be cost-driven (focusing on minimizing costs whenever possible) or value-driven (focusing on providing maximum value to the customer). The main costs associated with the provision of climate services may include technology development, data acquisition, staff (salaries) and maintenance.

Revenue streams

Finally, revenue streams categorize the sources from which the company generates money through its business model. The sources of revenues for climate services vary depending on the business model, whether it is grant funded, subscription models, one time data sales or partnerships with other organizations.

Despite its prevalence, the Business Model Canvas has however been under criticism due to its inability to consider impacts and consequences of the business beyond the financial viability perspective. Different derivatives of the Business Model Canvas have therefore emerged such as the Flourishing Business Model Canvas, the Sustainable Business Model Canvas, the Triple Layered Business Model canvas and others. These alternative frameworks aim to incorporate social benefits, environmental regeneration, and financial viability, going beyond a sole focus on financial profitability criteria. They strive to integrate sustainability at the heart of the business, to maximize positive impact while minimizing negative effects on society and the environment.

2.1.3 Sustainable Business Model Canvas

The Sustainable BMC integrates sustainability into the core business by focusing on the ecological and social consequences of the activity. Its objectives are to maximize positive impacts and to avoid negative impact on society and nature[25]. Its main differentiation with the BMC relies in the addition of the sections “Eco social costs” and “Eco-social benefits”. These categories are therefore relevant for climate services as they consider the positive as well as negative impact of CS on the environment and on society.

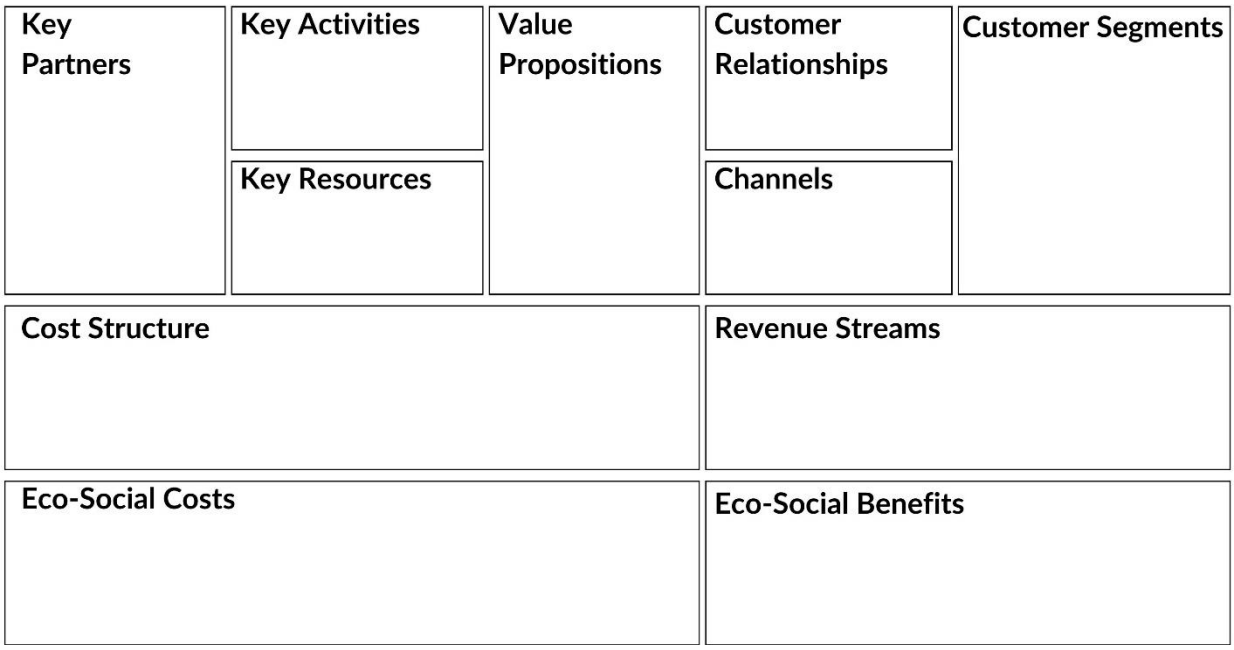

Figure 4 - Sustainable Business Model Canvas

2.1.4 Flourishing Business Model Canvas

The Flourishing BMC aims to consider the complexity of the world by considering the full context of a business (Environment, Society and Economy) without leaving behind the financial sustainability. This tool strives to help designing business models that are socially beneficial, environmentally regenerative, and financially viable[26].

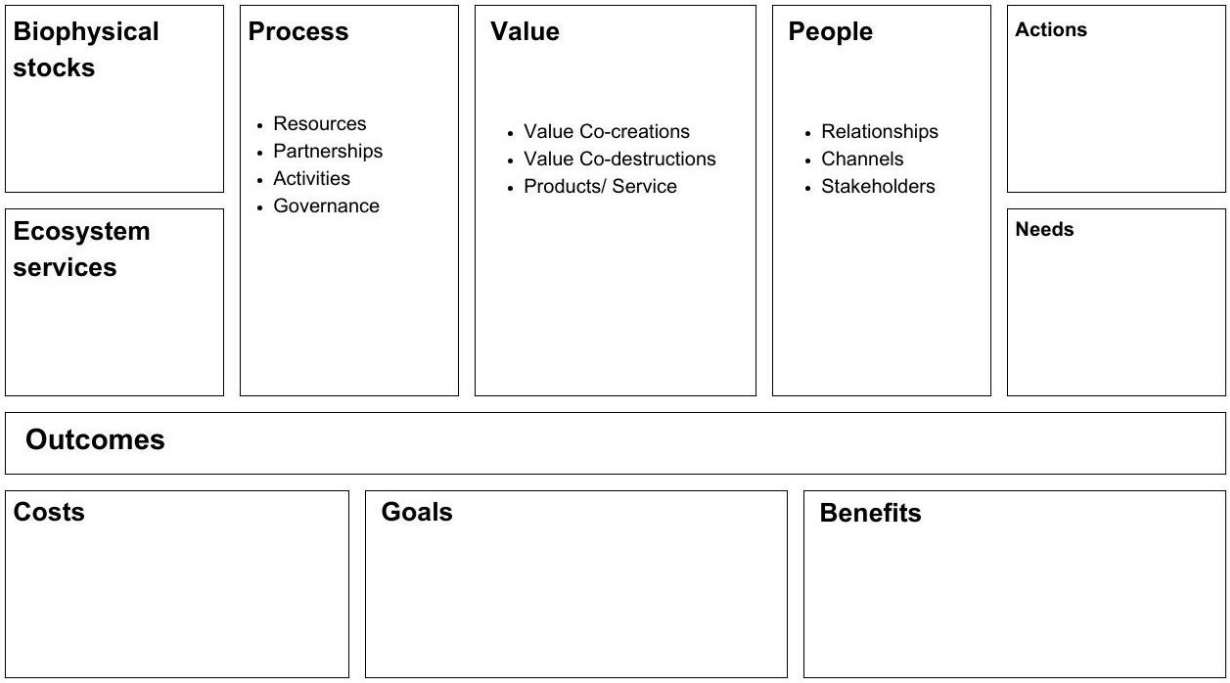

Figure 5 - Flourishing Business Model Canvas

Business models developed with the Flourishing Business Canvas articulate how an organization defines and achieves its goals over time. It includes the nine questions posed by the BMC but "upgrades" them to consider the impact of the other contexts. For example, "Customer Segment" in the BMC has been upgraded to "Stakeholder" in the Flourishing Business Canvas. The design of the Flourishing Business Canvas adopts a humanistic approach, to explicitly avoid colonizing or trauma-based mind[26].

2.1.5 Triple Layered Business Model Canvas

The Triple Layered Business Model Canvas serves as a tool for exploring business model innovation with a sustainability focus. It expands upon the original business model canvas by incorporating two additional layers: an environmental layer and a social layer. When considered together, these three layers explicitly illustrate how an organization generates economic, environmental, and social value. The environmental layer of the TLBMC is founded on a lifecycle perspective of environmental impact. Simultaneously, the social layer builds on a stakeholder management approach, and aims to explore an organization's social impact by balancing the interests of various stakeholders[27].

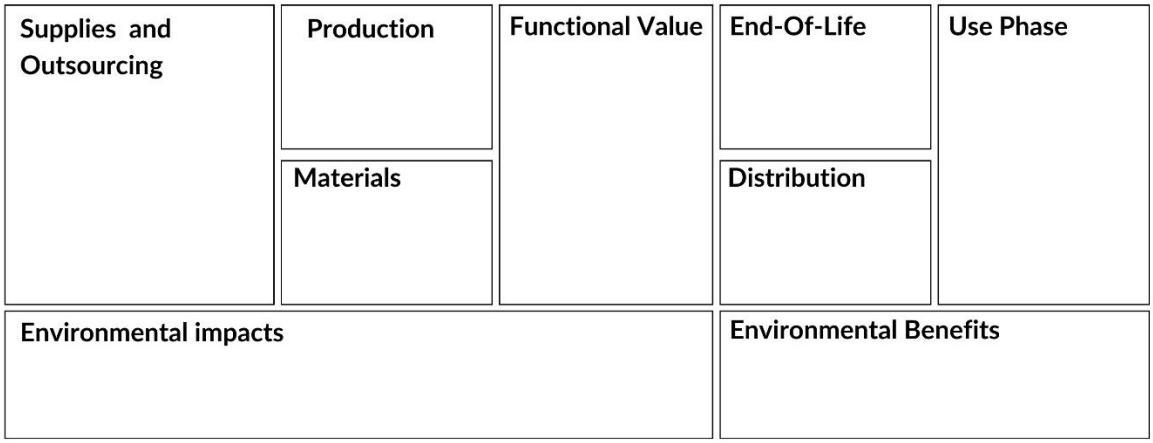

Figure 6 - Environmental Life Cycle Business Model Canvas

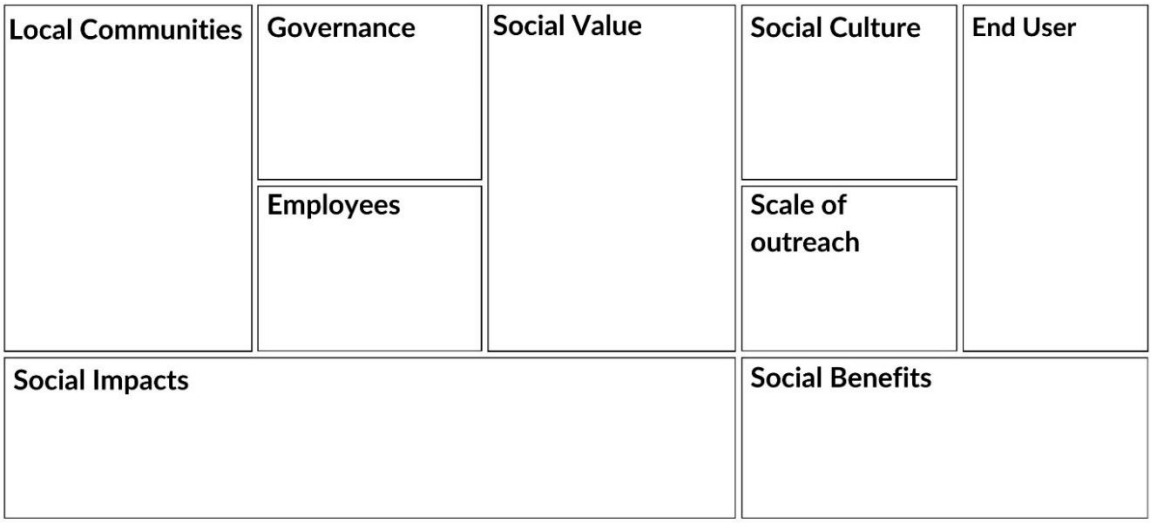

Figure 7 - Social Stakeholder Business Model Canvas

2.1.6 Social Business Model Canvas

The Social Business Model Canvas focuses on the impact the business creates for beneficiaries. This tool considers additional factors to help creating a social business model.

<table>
<tr><td>Key Resources</td><td rowspan="2">Key Activities</td><td>Type of intervention</td><td>Segments
Beneficiary</td><td>Value proposition
Social Value Proposition</td></tr>
<tr><td>Partners + Key Stakeholders</td><td>Channels</td><td>Customer</td><td>Impact Measures
Customer Value Proposition</td></tr>
<tr><td colspan="2">Cost Structure</td><td>Surplus</td><td colspan="2">Revenue</td></tr>
</table>

Figure 8 - Social Business Model Canvas

In comparison to the traditional BMC, it takes the following aspects into account:

- "Customer segments" is divided into "beneficiary" and "customer", supporting the fact that beneficiaries often do not pay anything but are crucial for the business model. Additionally, the user of a climate service and the beneficiary can be different categories of stakeholders.
- The Value Proposition is replaced by "Social Value Proposition", "Customer Value Proposition" and "Impact Measures", which defines how social impact is controlled.
- The type of intervention describes the type of product that will deliver the value.
- Besides partnerships, it includes the key stakeholders that should be involved in the program.
- Finally, "Surplus" describes where profits are planned to be invested[28].

The relevance of this canvas for climate services relies in the fact that CS should be user-centric, and users must be at the centre of their design.

2.1.7 Lean Canvas

Derived from Osterwalder's Business Model Canvas, the Lean Canvas is tailored for the Lean Startup methodology and places a significant focus on identifying customer problems to address. Its primary emphasis lies in establishing a solid foundation for the customer-problem-solution framework, making it particularly well-suited for early-stage innovation projects and startups. The significance of ensuring the accuracy of customer and problem assumptions is highlighted, as without this foundational alignment, the entire structure depicted on the canvas becomes vulnerable to collapse[29].

Problem	Solution	Unique value proposition	Unfair Advantage	Customer Segments
Existing Alternatives	Key Metrics	High Level Concept	Channels	Early Adopters
Cost Structure			Revenue Streams	

Figure 9 - Lean Canvas

2.1.8 Empathy map canvas

The empathy map helps gaining a greater understanding of the user by adopting their perspective and truly grasp their experience using the product or service. Its objective is to develop deep, shared understanding and empathy for other people in order to improve customer experience, to design better work environments, or design tailored products and services[30].

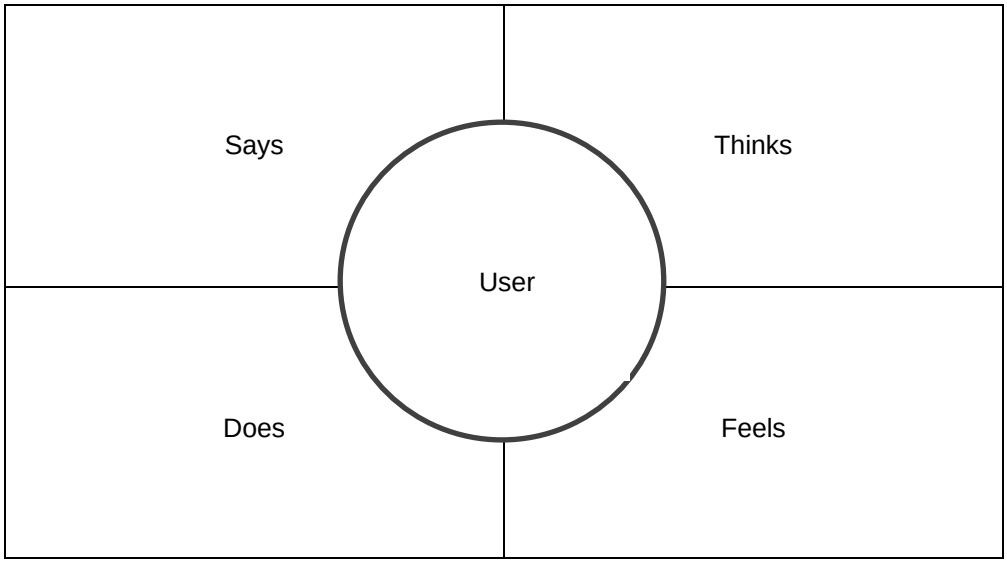

Figure 10 - Empathy map canvas

2.1.9 User centred design canvas

The User centred design canvas is built upon a user-centred approach and enables a comprehensive analysis of the user and the business main goals.

The canvas is segmented into nine fields with the Users field placed at the core of it. The left side of the canvas focuses on the users, the right side on the business. The analysis of these fields leads to the elaboration of a unique value proposition. User-centric design leads to superior usability, through the deeper understanding of users' needs[31].

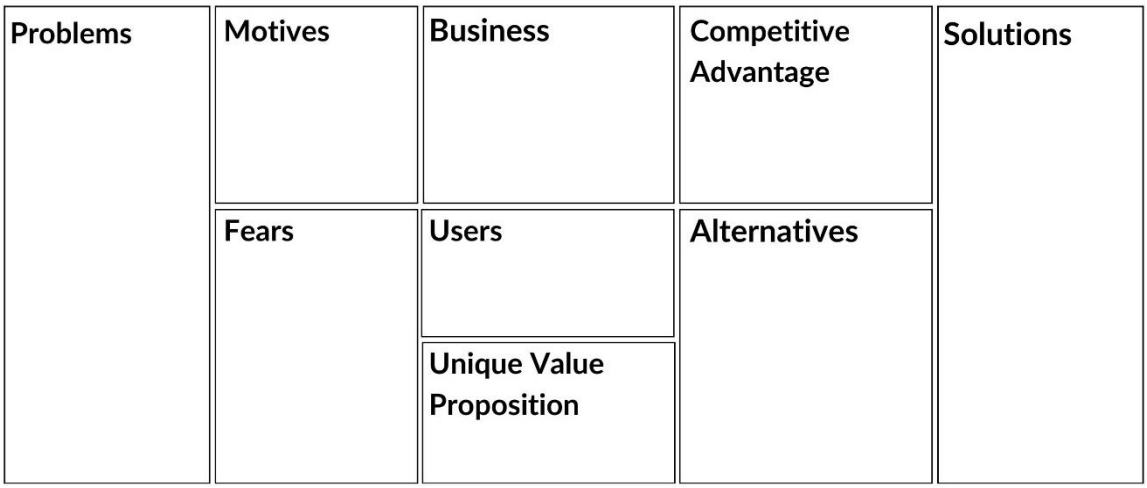

Figure 11 - User centred design canvas

2.1.10 Mission model canvas

The Mission model canvas takes the perspectives of organizations, governments, military organizations, or intelligence communities that do not have revenue streams but mobilize resources and a budget to solve specific problems and create value to beneficiaries. For such organizations, the BMC is not fully relevant as there is no revenue to measure. In this tool, the following fields were updated[32]:

- Mission Achievement replaces the Revenue Stream box: Then it focuses on the value that is created for all the beneficiaries and for the greater good.
- Customer Segments is changed to Beneficiaries.
- Cost Structure is changed to Mission Cost/Budget.
- Channel is changed to Deployment.
- Customer Relationships is changed to Buy-in/Support.

As climate services providers may not generate revenues, this framework is a relevant alternative.

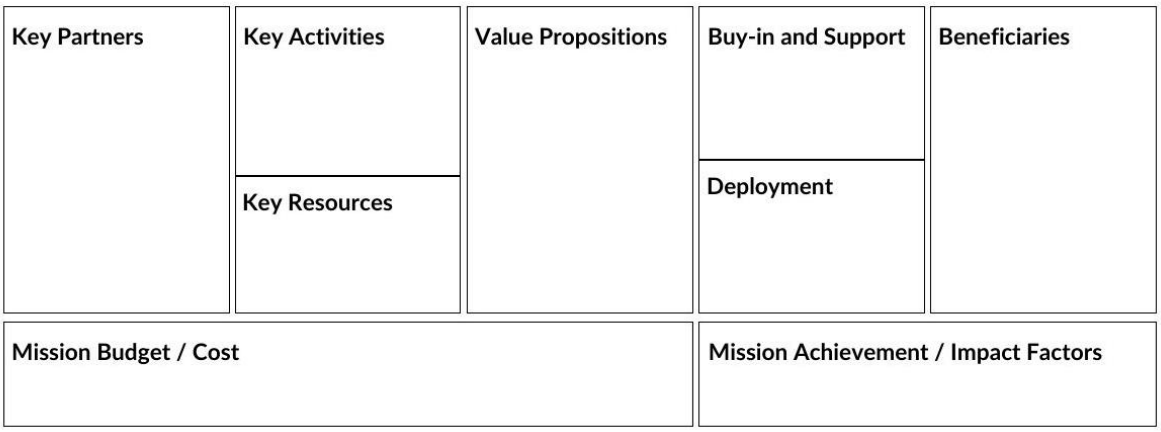

Figure 12 - Mission Model Canvas

2.1.11 Disruptive Innovation Theory

Disruption entails a process where a smaller company challenge established incumbent businesses, despite having fewer resources. As incumbent companies focus on improving their products and services for their most profitable customers, they surpass the needs of certain segments and neglect others. In turn, a disruptive company will target these neglected segments and provide suitable functionality. Because incumbents seek to pursue higher profitability in the more demanding segments, they tend to not be so responsive to these challenger companies. Eventually, "entrants progress to higher market segments, delivering the performance desired by incumbents' mainstream customers while retaining the advantages that led to their initial success. Disruption is recognized when mainstream customers widely adopt the offerings of these entrants."[33]

2.1.12 Business Ecosystem Theory

A business ecosystem refers to a deliberate collaboration between two or more entities (members) with the objective to generate and share collective value for a common set of customers. At least one member will act as the coordinator; all members within the ecosystem will incorporate their brands into the value propositions. It is important to note that "business ecosystems exist to create a higher level of value collectively than the members can create individually considering time, capital, brand permission, market access and other real-world constraints."[34]

2.1.13 Theory of change

Cathy James[35] defines Theory of Change (ToC) as "an ongoing process of thinking about change in depth and how it happens - and what that means for the organizations that contribute to it in a particular context, sector, and/or group of people"[36]. The ToC serves as a visual representant of how and why a desired change is expected to happen in a specific context. ToC is therefore a powerful tool for initiatives to plan how they will create change, assess their effectiveness, and communicate with stakeholders.

According to De Reviers[37], the steps of the ToC are as follows:

- Define the ultimate, long-term goal or change sought;
- Specify the different changes that must occur before the ultimate change becomes possible;
- Explain the assumptions and values that underlie the rationale;
- Specify the links between this rationale and the intervention.

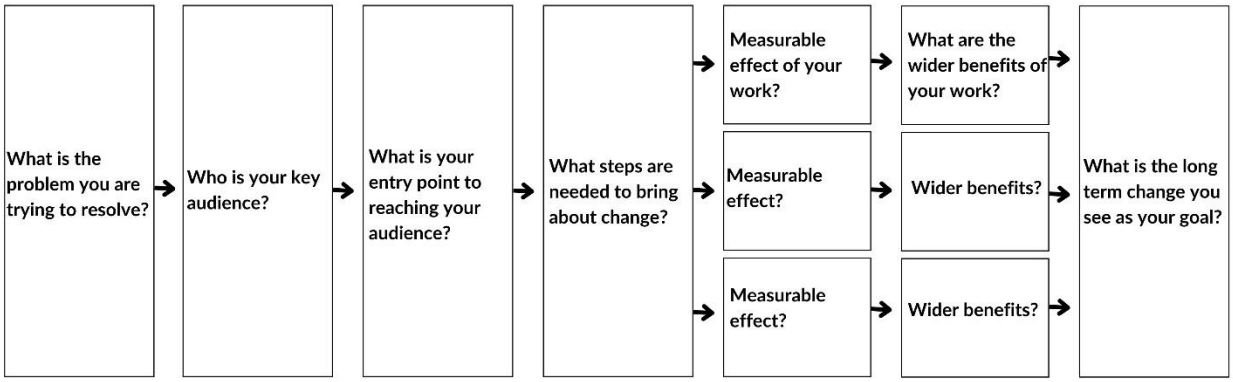

Figure 13 - Theory of change

Similar to the Theory of Change, the logical framework methodology, initially described by L. Rosenberg and L. Posner in 1979, is a planning tool based on the assumption of linear cause and effect relationships. The impact pathways provide a logical causal chain from input to impact, describing how changes are expected to happen based on assumptions made by the people undertaking the work[38]. Metrics and indicators are identified to evaluate the impact based on the identification of the project mission, activities, short-term outputs, medium-term outcomes, and long-term impact of the project.

2.1.14 Impact Lens

Designed by LGI, the Impact Lens proposes to view the scale-up strategy of an organisation through a dedicated tool to design an impactful organization by **finding balance between business and positive outputs** to create long-term, sustainable change. The tool is divided into 3 parts:

- The impact model, where organisations should set their impact intentions and high-level targets.
- The business model, based on the BMC and upgraded with social, environmental, and circular principles, it focuses on impact as a default response.

- The organization model, which strives to make impact systemic.

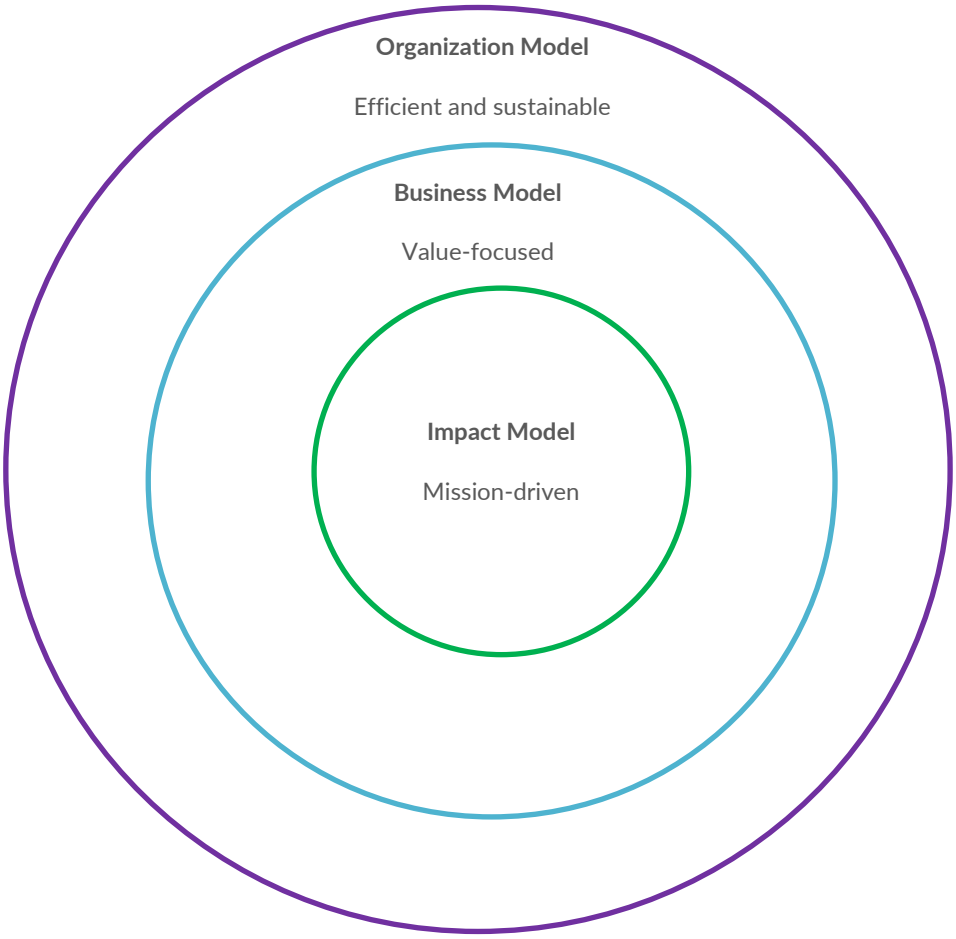

Figure 14 - Impact lens

2.2 Common business model types

In this section, the most common business model types, potentially applicable to the climate services market were identified and described.

2.2.1 Subscription Model

The subscription business model involves selling a product or a service and collecting a recurring revenue in order to continue providing said product or service. Typically, subscription businesses will charge on a monthly or yearly basis. The focus is on customer retention over customer acquisition, ensuring that a customer will make multiple payments over a period of time instead a single large upfront payment. By guaranteeing sales over a set period of time, the company is able to project sales father out with increased accuracy, and more easily make revenue forecasting and business planning.[39]

For example, climate service providers can offer subscription-based CS, accessible by users for a periodic fee (e.g., private weather forecasting companies / consulting firms).

2.2.2 E-commerce Model

In the e-commerce model, businesses sell products or services online. E-commerce can be conducted over computers, tablets, smartphones, and other smart device. Almost anything can be purchased via e-commerce today, from "books, music, plane tickets, and financial services such as stock investing and online banking"[40] to food, clothes, and niche products. Large companies, as well as individual sellers, can engage in e-commerce. By bypassing the need for a physical location, e-commerce offers several distinct advantages: it can occur 24 hours a day, reach international customers, and presents a potentially lower start-up cost, as rent, building maintenance and insurance is not needed.

2.2.3 Freemium Model

In the freemium model, a company offers a free and a paid version of its product or service. The basic version of the product is available to users at no cost. Although the features are limited, users can get to experience the product and get a better understanding of its value proposition. The company creates brand awareness by attracting a large user base. In addition, a paid version of the product, with additional features or exclusive content, is also available to consumers who seek more advanced capabilities. The freemium model "capitalizes on the idea that a significant portion of free users will eventually convert to paying customers if they find enough value in the product or service."[41]

2.2.4 Marketplace Model

The online marketplace business model is a form of eCommerce platform where numerous buyers and sellers can connect and engage in transactions. The marketplace operator plays a pivotal role by providing the necessary infrastructure and tools to facilitate these transactions, including payment processing, shipping, and customer service. Revenue for the platform is generated through fees or commissions charged on transactions conducted within the marketplace. These online marketplaces can specialize in specific product categories, such as fashion or electronics, or adopt a more general approach, exemplified by platforms like Amazon or eBay. For businesses seeking to harness the

benefits of digital technology without the need for substantial infrastructure investments or additional personnel, the marketplace model presents an attractive option.[42]

The marketplace model connects buyers and sellers and takes a commissions or fee for each transaction.[43]

Figure 15 - Marketplace model

2.2.5 Transaction Cost Economics (TCE) business model

Transaction costs refer to the expenses that are incurred in economic trade within a market. They do not benefit any participant directly. Transaction costs include:

- Search and information costs: associated with acquiring relevant information and meeting transaction agents, for example stockbroker fees on the stock exchange
- Bargaining costs: related to reaching an agreeable contract between parties
- Policing and enforcement costs: incurred to ensure contract compliance, often involving legal fees if the parties deviate from the agreement

Transaction Cost Economics was introduced by economists Ronald Coase and Oliver Williamson. According to TCE, in a perfect market companies would not be necessary as market forces would efficiently coordinate production activities. However, due to imperfect information and bounded rationality, companies with hierarchies are deemed more effective at allocation resources than markets. The TCE theory shines a light on the role of hierarchies in efficiently managing resources in the real-world market.[44]

2.2.6 Razor and Blade Model

The Razor and Blade model involves selling a primary product at a low price or even providing it for free in order to attract customers, while generating higher margins from the sale of complementary goods. This model is named after the practice of selling razors inexpensively to drive the sales of replacement blades. The initial product (razor) is often sold with a slim margin or even at a loss, while the recurring purchase (blade) becomes a profitable source over time. This model creates a lock-in effect, as customers who invest in the initial product are more likely to continue purchasing related products due to compatibility and convenience. This model is effective for building long-term revenue streams, relying on customers' continuous need or desire for the complementary product.[45]

2.2.7 Pay-as-You-Go Model

The pay-as-you-go business model, an alternative to the subscription model, charges customers based on their actual usage or consumption. Commonly associated with subscription services, cloud computing, utilities, and on-demand services, the pay-as-you-go model offers flexibility, cost control, and scalability, aligning costs with actual usage. This model benefits both businesses and consumers by

minimizing waste and optimizing resource allocation. It can appeal to budget-conscious consumers who sporadically or temporarily use a product or service. Implementation can take two forms: customers purchasing credits that decrease with usage or being billed for the resources utilized over a predetermined period.[46]

2.2.8 Franchise Model

A franchise is a type of license that gives a franchisee permission to use the franchisor's proprietary knowledge, processes, and trademarks. Thus, the franchisee can market a product or service using the franchisor's business identity. Typically, in return for obtaining the franchise, the franchisee pays the franchisor an initial startup fee along with annual licensing fees. From the franchisor's perspective, this may be a good way to increase its market share and geographical scope. For the franchisee, who may be an entrepreneur, it is a good way to start a business, particularly when one is entering a very competitive industry. By using an established company's brand name, one does not need spend as many resources on marketing and brand recognition activities.[47]

2.2.9 B2B (Business-to-Business) Model

In the B2B model, a company will sell their products or services to another company that needs them for their activities. Typically, gaining new customers in the B2B model takes longer than in the B2C model. Because of the high value of the transaction, a contract agreement must be made between both parties, and this can lengthen the sales process. B2B tends to grow through business relationships and networking.[48] Depending on the nature of the products and services sold, some companies may combine B2B and B2C.

2.2.10 B2C (Business-to-Consumer) Model

Companies sell products or services directly to the end users. Typically, B2C businesses will market their products and services to a specific target audience and strive to understand their needs and expectations. The B2C model has gained prominence in recent years, especially with the rise of e-commerce. Companies will focus on building brand loyalty and quickly adapting "to changing consumer preferences and market trends to remain competitive in the industry."[49]

2.2.11 Open business models

In the open business model, companies will involve external partners in traditionally closed processes such as research and development. The company must identify areas in the value creation process suitable for external contributions and that will benefit the original business. These external contributions can come from consumers, partners, researchers, and other businesses. There are various advantages to opening up one's business and leveraging other parties' resources and innovative ideas: improving efficiency, gaining market share, benefiting from strategic advantages.[50] An important consideration is ensuring compatibility between the company's profitability and the partners' objectives.

2.2.12 Platform business model

The platform business model facilitates interactions among a multitude of participants. These interactions may involve short-term transactions like connecting buyers and sellers, forming longer-term social relationships, collaborating for shared outcomes, or supporting sustained efforts to enhance participant performance collectively. While traditional linear business models create value through products or services, the platform business model distinguishes itself by not owning the means of production. Instead, it focuses on creating and facilitating connections. The platform business's role is to establish a governance structure and a set of standards and protocols to enable interactions at scale.[51] John Hagel identifies four prominent categories of platforms:

- Aggregation Platforms: These bring together diverse resources, facilitating transaction-focused interactions. Examples include marketplace and broker platforms like eBay, where the platform owner brokers all transactions in a hub-and-spoke model.
- Social Platforms: Such platforms, exemplified by Facebook and Twitter, aggregate people with common interests, fostering engagement and relationship-building rather than transactional tasks.
- Mobilization Platforms: These bring people together to work collectively, especially in extended business processes like supply networks. They emphasize longer-term relationships over short-term transactions.
- Learning Platforms: Focused on facilitating learning, these platforms bring participants together to share insights over time, fostering trust-based, long-term relationships.

2.2.13 Public private partnership model (External funding)

New CS projects are mostly funded by large funding organisations. They are often integrated into larger projects or groups of CS providers to ensure their long-term sustainability (e.g., CLIMTAG). Current large CS providers are funded by international and national bodies and are an integrated service, composed of numerous smaller CS providers (e.g., ECMWF). These services that are provided to users for free and are mostly operated by government agencies or meteorological departments.

2.2.14 Consulting and Advisory model

This model consists in providing consulting services to businesses and governments on climate-related risks, strategies, and adaptation measures.

2.2.15 Data as a service model

The Data-as-a-service is a business model approach that consists in organizations providing their customers and partners access to valuable data that they pay for. For example, it can consist in the sale of climate data or access to data sets to businesses, researchers, or other organizations.[52]

2.3 Summary for climate services

Chapter 2 identified the most prevalent business model frameworks, theories, and types, with an overview on those more commonly found in the climate services (CS) field. The following conclusions are highlighted:

- Several business model frameworks are applicable to climate services, and their relevance lies in their value-oriented approach, aiming to achieve social and/or environmental impact rather than solely prioritizing financial sustainability.
- Some of the identified frameworks place a strong emphasis on the user, a critical aspect in the context of climate services. This emphasis is essential because an effective climate service must be tailored to meet the specific needs of users and should be co-designed collaboratively to ensure alignment with user requirements.
- The financial sustainability must still be considered as it is a prerequisite for the long-term viability of climate services. The business model plays a pivotal role in defining how the climate service will achieve financial sustainability over the long term. It provides a roadmap for balancing the economic viability of the service with its societal and environmental goals, ensuring a holistic and enduring approach to addressing climate challenges.
- While CS may adopt conventional business models, a key distinction lies in the fact that users may not always bear the cost for the climate services they utilize. This underscores the necessity to explore and identify alternative business models that can sustain the provision of climate services without relying solely on direct user payments.
- Traditional business model frameworks and business model types can therefore serve as foundational tools for developing business models for climate services. However, their effective application may require adjustments and additions tailored to the specific nature and objectives of the climate service.

3 Exploring the Landscape of Business Models Innovation

3.1 Catalysts for business innovation toward zero carbon and climate resilience

In 2015, the Paris Agreement established the goal to limit the global temperature rise, by the end of the century, well below 2°C compared to pre-industrial levels and, possibly, below 1.5°C. The IPCC estimated stated that achieving this objective without significant overshooting requires a reduction of approximately 45% in net anthropogenic CO2 emissions from 2010 levels by 2030, ultimately reaching a net-zero status by 2050[53]. Hence, prioritising immediate climate change actions is indispensable to limit the effects of global warming on societies, economies, and ecosystems. **A fast transformation of economies is required to significantly reduce emissions and stay on track to reach the net zero goal**.

Extreme weather and climate-related events have already inflicted significant harm on ecosystems, communities, and economies worldwide. According to the Centre for Research on the Epidemiology of Disasters (CRED) and the United Nations Office for Disaster Risk Reduction (UNDRR), climate-related disasters led to annual losses totalling USD 119 billion during the period from 2000 to 2019. Heatwaves, heavy precipitation, droughts, floods, and tropical cyclones grew more intense and frequent in some regions and with every increment of global warming, changes in extremes will continue to become larger.[54] **The status quo in unsustainable business practices is no longer tenable**; thus, a fundamental shift in how businesses operate, and their underlying purposes is imperative. As highlighted by Lüdeke-Freund et al.[55], harnessing the complete potential of companies to address ecological, social, and economic challenges requires more than just introducing new products, processes, or organizational methods. It demands **innovative frameworks for how companies generate, deliver, and capture value**. This entails cultivating business models that actively contribute to the sustainable development of the natural environment, society, and the economy.

This imperative calls for a holistic approach that surpasses mere eco-efficiency initiatives and reimagines the very essence of business operations, including how they design their business models[56]. The design of business models serves as a means to reconfigure a firm's capabilities, allowing it to adapt to a dynamically changing business landscape. **Business models are recognized as potent drivers of innovation, particularly effective in uncertain, rapidly evolving, and unpredictable environments**[57]. They empower companies to define their strategies and adeptly respond to external pressures while affording them the flexibility and agility required for long-term resilience.

When exploring business model innovations aimed at sustainability, it is imperative to re-evaluate the concept of 'value.' Historically, literature has aligned 'value' predominantly with the generation of economic benefits, delivery of customer satisfaction, synergistic components of value creation and delivery, and the bolstering of customer value propositions[57]. However, from a sustainability standpoint, a company's value proposition must be redefined more broadly to include social and environmental objectives alongside financial ones, addressing the needs of a wider array of stakeholders rather than prioritising solely shareholder returns[57]. Sustainable business models are designed to offer exceptional

value to customers which translates into contributions towards the sustainable advancement of the company and the wider community[55].

Circular Economy Business Models. The concept of a Circular Economy represents a significant shift from traditional economic models of consumption and production, contributing vitally to the achievement of sustainable development goals. This approach diverges from the linear 'take-make-consume-dispose' model, introducing a transformative business ethos that prioritizes sharing, leasing, reusing, repairing, refurbishing, and recycling materials and products to extend their life cycle.

A Circular Economy is "*an economic system in which the value of products, materials, and other resources is preserved within the economy for as long as possible. This system aims to optimize resource efficiency in both production and consumption, thereby reducing environmental impact, minimizing waste, and curbing the release of hazardous substances throughout the life cycle of resources by applying the waste hierarchy*"[58]. This not only seeks to prolong the life span of materials and products but also strives to lessen environmental degradation while simultaneously fostering economic and social prosperity. The shift towards a Circular Economy is a cornerstone of the European Green Deal (EGD). The initiative, propelled by the Circular Economy Action Plan (CEAP) introduced in March 2020, has been augmented by over 450 policies and legislative measures specifically aimed at circular economy practices and the adoption of 54 national roadmaps or strategies across more than 100 countries. Furthermore, the formulation of a comprehensive set of standards to support this transition is currently underway[58].

Establishing sustainable circular business models is essential not only for achieving circular objectives but also for transforming traditional business practices into circular ones[59]. The transition to a circular business model is an opportunity far beyond mere compliance; it represents a significant commercial prospect[60]. Circular solutions are projected to unlock global economic opportunities worth approximately USD 4.5 trillion by 2030[58]. Adopting circular business models can lead to considerable cost reductions and the creation of new revenue streams[59]. This strategic shift not only fulfils regulatory demands but also positions businesses to capitalize on emerging market opportunities and achieve a competitive edge.

Innovating within a business model does not necessarily mean devising a completely new framework. Instead, it can involve refining specific aspects or combinations within its value network, proposition, creation, delivery, and capture mechanisms. These permutations, known as 'value strategies,' foster the development of various business models that are better equipped to tackle challenges such as reduced demand, increased competition, and changes in the economic landscape. They also enable companies to tap into new market opportunities that arise from shifting consumer preferences, technological advancements, evolving social norms, and regulatory transformations, thus generating value for all network participants[59]. Indeed, circular business models adopt a more holistic view than traditional models by considering the entire stakeholder network engaged in both tangible and intangible value exchanges, aiming to realize economic, environmental, and social gains[57].

Enablers of circular business model innovation. Circular business models are deeply interwoven with their contextual environment; technological, social innovations, and a variety of incentives—both financial and policy-driven—are integral to enabling such innovation. As Monthe and Nguyen-Thi observed, transitioning to a circular economy represents a paradigm shift that encompasses all types of

innovation. These innovations involve the adoption of ideas, behaviours, systems, policies, programs, processes, devices, products, or services that are novel to both the company and society at large[59].

The advent of new technologies has catalysed a transformative change across the value chains of products and services. For instance, advancements in technology have improved the traceability of materials, bolstered collaborative efforts and knowledge sharing, refined logistics systems, reduced waste, and extended the lifecycle of products. Technologies such as 3D printing have drastically reduced manufacturing waste, paving the way for a make-to-order model and revitalizing the worth of assets through the redesign of spare parts, thereby preventing obsolescence[61]. Additionally, the increasing interconnectedness of devices has led to unprecedented efficiencies in tracking. In the realm of goods production, the Internet of Things (IoT) has enabled businesses to meticulously oversee their value chains and ensure compliance with environmental and social standards. In the service industry, such technologies have provided public and private organizations with the capacity to collect extensive data, which in turn facilitates the provision of sustainable, tailored, and customer-centric services.

However, the full potential of these technological advancements can only be harnessed with simultaneous social innovation. The EC acknowledged that the transition to a circular economy hinge on the decisions of countless consumers, whose choices can either drive or hinder the adoption and proliferation of business models that embody circular principles[59]. **To accomplish this, society must undergo a significant transformation that motivates individuals to change their consumption patterns**. Consumer behaviour typically evolves under compulsion or when presented with a strong rationale for change. This includes recognizing the importance of change, possessing the knowledge and ability to adopt new behaviours, and having the social or physical opportunity to implement these changes[59].

From this vantage point, raising awareness and investing in education are critical for shifting public attitudes, values, beliefs, and, consequently, purchasing decisions[59]. Policies advocating a circular economy are also pivotal, not only in promoting the adoption and diffusion of appropriate circular business models but also in spurring related technical and social innovations. Such policies can provide the necessary incentives to catalyse the transition, including the enactment of intelligent regulatory standards for the production of goods and services, the removal of harmful subsidies, the introduction of fiscal incentives for eco-friendly practices and technologies, and the promotion of responsible design throughout the entire value chain. Moreover, financial, and non-financial incentives are instrumental in helping businesses navigate the initial costs associated with transformative changes and in enabling circular products to achieve market viability[59].

Sustainable finance. The financial sector plays a pivotal role in directing the shift towards an innovation-prone, circular and carbon-free economy, with substantial investments required to reach net-zero emissions, decarbonize the economy, spur ground-breaking innovations, and maintain European economic competitiveness[62]. To accelerate this shift, the sector must reallocate capital and engage in productive partnerships with carbon-intensive industries that are earnestly committed to achieving a net-zero footprint[62]. In sustainable finance, fund allocation aligns with three pillars of sustainability: economic, social, and environmental factors. Environmental factors include issues related to environmental preservation, climate change mitigation and adaptation, and environmental risks. Social aspects cover concerns like inequality, inclusivity, labour relations, human capital investment, and community engagement[63]. Sustainable finance operates at multiple levels within the economy, ranging from promoting investments in economic activities that drive decarbonization, to fostering initiatives at the

corporate level. Transition finance also encompasses the financial portfolio level, emphasizing the need to align investment strategies with the broader goal of transitioning to a low-carbon economy[62].

The ultimate aim of sustainable finance is to enable a seamless and expedited shift of the economy towards a net-zero future, averting potential delays that could result in significant economic and societal costs. An increased exposure to climate-related risks could negatively impact businesses and insurers, escalating overall costs. Banks might particularly suffer from the diminished profitability of firms that are either vulnerable to climate change or heavily dependent on finite natural resources[63]. Yet, the current levels of investment in Europe are insufficient for the development of an economic system that is both environmentally and socially sustainable. Chatham House and Just Economics estimate that global public sector spending on the circular economy totalled between USD 500 billion and 600 billion in 2020, compared to a total government expenditure of approximately USD 13 trillion. In contrast, corporate sector spending on circular economic activities is around USD 850 billion annually, versus 35 trillion on linear activities. This indicates that circular investments represent merely about 3% of total global investment each[58].

Globally, climate finance is distributed unevenly across countries and sectors[54]. The United Nations Environment Programme (UNEP) reports that 75% of all climate finance is allocated to North America, Western Europe, and the East Asia & Pacific regions, with China leading the way. In contrast, regions with lower-middle income countries receive less than a quarter of these financial flows. This disparity poses a significant challenge as the regions most vulnerable to climate change are those that receive the least financial support for adaptation and mitigation initiatives. It highlights the critical need for a rapid and equitable increase in sustainable finance to hasten the global economic transition and achieve the climate neutrality target by 2050.

Leveraging the Green Taxonomy as a mechanism to encourage and facilitate green investments. Emerging financial products aimed at facilitating the transition to a circular economy are gaining traction in the market, bolstered by the implementation of climate finance principles, guidance, and protocols. These include sustainable finance alignment tools such as taxonomies, labels, and portfolio alignment metrics, alongside corporate strategy, and disclosure frameworks[62]. Taxonomies have become a key instrument for classifying projects, assets, and activities that support low-carbon development or are environmentally sustainable. The EU's Sustainable Finance Taxonomy stands out as one of the most ambitious frameworks, providing a comprehensive European system for categorizing environmentally sustainable investments and integrating criteria for circularity.

Although the EU taxonomy is a work in progress, substantial progress has been made in its operationalization. In 2022, the Platform on Sustainable Finance, composed of international experts, published the first set of technical screening criteria for four environmental objectives defined by the taxonomy. This report is instrumental in evaluating the impact of economic activities on the circular economy transition, a critical step in actualizing the goals of the European taxonomy. The taxonomy is grounded in science, offering a definitive classification for economic activities that contribute to climate, environmental, and sustainable goals, based on established thresholds and targets[64–66]. It serves not only to guide businesses in aligning their strategies with sustainability goals but also enables financiers to gauge the sustainability positioning of companies and investment portfolios in the context of net-zero ambitions. Taxonomies thus facilitate industry-wide performance comparisons, progress tracking, and risk and vulnerability assessments.

By promoting interoperability and comparability, taxonomies reduce obstacles to international capital flow and simplify the evaluation of assets, activities, and projects, while balancing standardization with local context and development. A shared classification system increases transparency and reliability, enabling businesses to demonstrate their ability to generate sustainable value and allowing investors to make informed decisions regarding resource allocation. It also aids financial institutions in monitoring the progress of their clients' or investees' transition processes[62]. The formulation of a sustainable finance taxonomy is a vital innovation for circular business models. It underpins market confidence, directs capital towards sustainable investments, and scales climate finance globally in an equitable manner[67].

Corporate Sustainability Reporting. In light of the EU's Green Taxonomy and the disclosure of green finance, by providing standardized information and promoting best practices in order to enhance transparency and accountability, the Directive No. 2022/2464 (Corporate Sustainability Reporting Directive - CSRD)[68] empowers stakeholders to drive positive change and accelerate the transition to a more sustainable and resilient future. It basically requires companies within the EU, including subsidiaries of non-EU companies that meet certain criteria, to disclose information about the environmental and social effects of their operations, as well as the impact of their environmental, social, and governance (ESG) practices on their business performance. In a nutshell, it ensures that companies provide clear and standardized information on the environmental sustainability of their activities. This alignment not only facilitates the identification of green investments but also enables investors to make informed decisions that contribute to the transition to a sustainable economy. The Corporate Sustainability Reporting Directive (CSRD) came into effect on January 5, 2023, and significantly broadens the scope of companies involved in sustainability reporting compared to the previous Non-Financial Reporting Directive (NFRD). The objective is to provide higher transparency to help investors, analysts, consumers, and other stakeholders better assess the sustainability performance of EU companies, as well as related business impacts and risks. Table 1 describes the companies/enterprises that must comply with the CSRD by 2025.

Large publicly traded companies	Large EU-based enterprises, whether listed or not	Third-country enterprises
• At least €350,000 EUR (€437,500*) in total assets. • At least €700,000 EUR (€857,000*) in net turnover (revenues). • At least 10 employees (on average) throughout the year.	• At least €20 million EUR (€25*) in total assets. • At least €40 million EUR (€50*) in net turnover (revenues). • At least 250 employees (on average) throughout the year.	• A large enterprise headquartered in the EU, or • A subsidiary based in the EU with securities listed on an EU-regulated stock exchange, or • A subsidiary in the EU with at least €40 million EUR in net turnover.

Table 1 – Application of CSRD

The Corporate Sustainability Reporting Directive (CSRD) represents a substantial advancement over its predecessor, the Non-Financial Reporting Directive (NFRD). Prompted by a thorough assessment revealing gaps in the NFRD framework, notably the lack of consistent data, hindering sustainability investments and consumer choices, the CSRD was developed. It aims to establish a more robust reporting framework, ensuring transparency and reliability in sustainability reporting across EU member

states. In contrast to the NFRD, the CSRD introduces additional features including mandatory assurance, digitalized sustainability information, centralized location of data, and a single reporting standard for enhanced clarity among companies. Notably, to enhance comparability, companies will adopt a single reporting standard, the European Sustainability Reporting Standard (ESRS), overseen by the European Financial Reporting Advisory Group (EFRAG).

While the CSRD and ESRS are interconnected, they serve distinct purposes. The CSRD establishes legal requirements and reporting duties, while the ESRS offers guidance on meeting those obligations. Specifically, the ESRS provides the framework for disclosed metrics and communication methods. It aims to be interoperable and compatible with GRI Standards, aligning with TCFD recommendations and reflecting EU Green Taxonomy and Corporate Sustainability Due Diligence (CSDD) Directive requirements. The ESRS consists of 12 standards, including two cross-cutting general standards and ten topical standards covering environmental, social, and governance topics: five environmental, four social, and one governance standard (Figure 16).

Regarding the environmental standard, there are five key components outlined in the **European Sustainability Reporting Standard** (ESRS). **ESRS E1** ESRS E1 focuses on Climate Change, addressing how a company's activities impact climate change and its efforts to align with the goals of the Paris Agreement. Companies must disclose historical, current, and planned actions and emissions from sources owned or controlled by the company, as well as emissions from other sources resulting from the company's operations and within its value chain, including upstream and downstream emissions, goods transportation, and travel. **ESRS E2** pertains to Pollution, encompassing disclosures related to pollution prevention and mitigation strategies. **ESRS E3** covers Water and Marine Resources, emphasizing the company's management of water resources and its impact on marine ecosystems. Biodiversity and Ecosystems are the focus of **ESRS E4**, which requires companies to disclose their actions to preserve biodiversity and protect ecosystems. Lastly, ESRS E5 addresses Resource Use and Circular Economy, highlighting the company's efforts to promote resource efficiency and adopt circular economy principles.

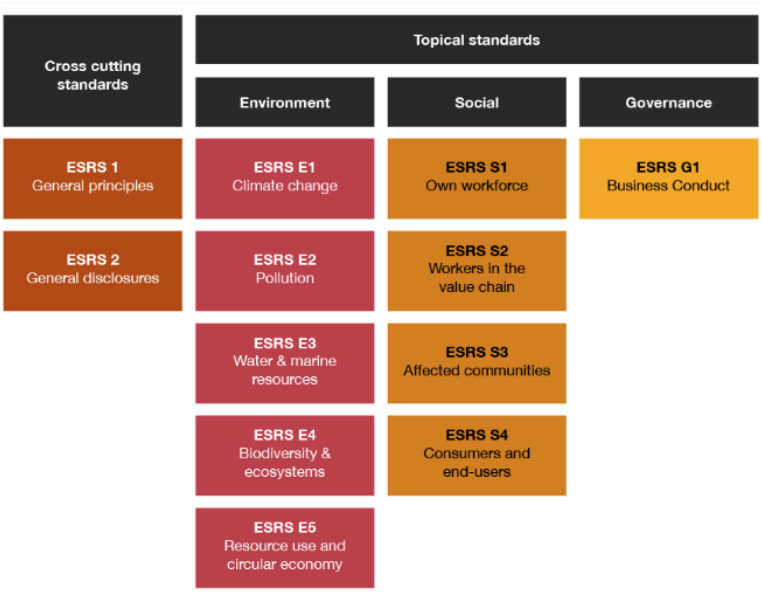

Figure 16 - The new European Sustainability Reporting Standard, ESRSs[69]

CSRD reporting will necessitate companies to provide sustainability information regarding both the impact of their activities on people and the environment, as well as how sustainability factors influence them and their financial outcomes. The "double materiality standard" involves assessing two main aspects: Impact Materiality, which considers how a company's activities affect sustainability issues internally, and Financial Materiality, which evaluates how sustainability issues impact the organization's finances externally. In summary, the Corporate Sustainability Reporting Directive (CSRD) marks a significant advancement in the EU's efforts to promote sustainability in businesses. By broadening reporting requirements and enhancing transparency, the CSRD aims to provide stakeholders with comprehensive ESG performance information. Adherence to these standards not only increases accountability but also fosters innovation and resilience. With its focus on double materiality and alignment with international frameworks, the CSRD paves the way for a more cohesive approach to sustainability reporting. As the compliance deadline nears, businesses must prioritize integrating sustainable practices to meet regulatory mandates and contribute to a greener, more equitable economy.

3.2 Business model innovation for climate services: a literature review

Introduction and scope of the analysis

Climate services play a critical role in facilitating the transition to climate-neutral and circular economies by providing essential data, analytics, and insights that enable stakeholders to make informed decisions aimed at reducing carbon footprints and enhancing sustainability. The integration of climate services into various sectors promotes the development and implementation of strategies that contribute to the mitigation of climate change impacts and the promotion of circular practices. Climate change poses both an opportunity and a challenge to the existing knowledge base across various domains, requiring decision-makers to incorporate future changes into present decision-making processes. A close connection between technology and science enables productivity growth within an innovation-driven framework[70]. Knowledge encompasses human capabilities, leadership skills, technology, information, and intellectual capital, which are harnessed through collaborative relationships[71]. Knowledge represents the ability to take action[72,73] and the capacity to initiate change. By harnessing its potential, knowledge can trigger transformative change and unlock untapped possibilities.

Climate services fall under the category of knowledge-intensive business services (KIBSs). These services rely on the expertise, knowledge, and intellectual capabilities of individuals or organizations. They involve applying specialized knowledge, information, and skills to provide value to customers. Examples of knowledge-intensive services include consulting, research and development, engineering, software development, and financial and legal services. Climate services leverage specialized knowledge and expertise in climate science, data analysis, modelling, and interpretation. They transform climate-related information into tailored knowledge, supporting policy and decision-making across geographic and functional boundaries and governance levels. Climate services as a category of KIBS pose diverse and intricate challenges due to their reliance on complex interpretation and analysis of technical concepts, data encompassing intricate weather and climate patterns, and comprehensive economic, social, and environmental impacts. They use diverse data sources such as satellites, weather stations, and climate models, requiring specialized knowledge and skills. Customized solutions are developed based on clients' specific needs and challenges, considering industry context, objectives, climate science, risk assessment, and adaptation strategies. Climate services are characterized by their dependence on human capital and knowledge, making them challenging to standardize[14]. These also play a crucial role in supporting the co-production of innovation[15]. Climate services embody these characteristics and effectively integrate them into their business models.

However, the demand for climate services remains low, and their widespread adoption has not yet been achieved. Research has pinpointed several factors contributing to this limited uptake. One key aspect is the necessity for stronger co-production processes that effectively address user needs[74,75]. Uncertainties surrounding climate simulation[76] pose some challenges in convincing potential users of the reliability and accuracy of the services. Furthermore, inadequate virtual and/or physical platforms that do not align with user expectations[77] hinder the effective delivery and utilization of climate services. Weak institutional arrangements that fail to generate usable science[78] further impede the

uptake. Lastly, inadequate business models[79] also play a role in the limited demand for climate services. By addressing these various factors, such as enhancing co-production processes, reducing uncertainties, improving platforms, strengthening institutional arrangements, and developing effective business models, the demand for climate services can be potentially increased and their diffusion maximized.

To corroborate these literature insights and **assess the level of sustainable business innovation penetration in the climate services field, we have conducted a literature review to assess the state of the art regarding innovative business models for climate services**. This review aimed to provide an overview of current research on the subject, evaluating the existence of innovative models and laying the groundwork for the creation of new and advanced business models for climate services. The objective was to contribute to identify and leverage successful models, ultimately fostering innovation in the climate services sector. Through this analysis, the study sought to gain insights into the current landscape, identify gaps, and catalyse the development of novel business strategies in the field of climate services.

Methods and tools

The literature review was conducted using the widely recognised research database Scopus, by querying the research string within the article title, abstract, and main keywords. We used the following two research strings, to compile a comprehensive overview of the topic.

TITLE-ABS-KEY ("climate service?" AND business) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "k"))

("business innovation*" OR "business model*" OR "innovation") AND ("climate service*" OR "climate knowledge" OR "climate insight*")

The research resulted in 34 and 74 papers respectively. Among these 108 articles, 10 research papers were excluded due to duplication. Subsequently, we downloaded the 97 resulting papers and generated an Excel file. This file was then utilized for title and abstract screening, and the papers were categorized based on their relevance to our research, applying the following criteria:

Classification criteria
1 = The research topic of the paper does not correspond to that of our research. This paper should be rejected.
2 = The research topic of the paper is crosscutting with our research theme (e.g. climate change impacts on economic sectors). This paper should be considered only for background information.
3 = The research topic of the paper is relevant from a theoretical point of view, but it has no practical application. This paper should be analysed, but it has a low priority.
4 = The research topic of the paper is relevant from a theoretical and practical point of view, but it does not present elements of innovation. This paper should be analysed, it has a medium priority.
5 = The research topic of the paper is in scope. It is relevant from a theoretical and practical point of view, and it includes elements of innovation. This is a crucial paper to analyse.

Table 2 - Classification criteria for literature review

Results and discussion

A key insight that emerged from this literature review is the notion that **although the landscape of climate services has witnessed significant evolution in recent years, there is still a scarcity of innovative business models available for climate services**. Out of the 97 papers analysed, 27 were considered not relevant (score 1), and 12 were only tangentially relevant to our research (score 2), focusing on the context in which climate services function and dealing with topics such as the impacts of climate change on production. Sixteen of the analysed papers addressed the research topic but only from a theoretical point of view (score 3). However, the topic was approached more practically in 16 papers, reporting case studies or concrete experiences (score 4). These papers do not directly address the topic of business model innovation for climate services but are descriptive of their context, emphasizing existing weaknesses and barriers to overcome, such as the lack of publicly accessible climate-related data and the lack of competencies for integrating these data into decision-making processes. Furthermore, the literature extensively examines enabling conditions, such as transformative technologies like AI for data analysis and manipulation. It also addresses the evolving policy context that establishes the essential environment for the operation of climate services.

Finally, out of these, 24 papers were considered completely relevant to our research. Among them, only 7 presented examples of real-world innovation, including co-generation practices, early adoption experiences, and the envisioned next generation of service delivery. For instance, the co-generation approach, involving interactive tools for visualizing climate data among end-users, has emerged as a pivotal aspect of climate service development. Dell'Aquila et al., focusing on the wine sector in Portugal's Douro Wine Region, have introduced the **MED-GOLD Dashboard**[80]. In collaboration with local vineyards, Essential Climate Variables (ECVs) and bioclimatic indicators were identified, leading to a tailored interactive platform displaying historical climate data, seasonal predictions, and climate projections. Similarly, Contreras et al. explored small hydropower plants in mountainous terrains, introducing the **SHYMAT** service[81]. This tool integrates climate forecast data with decision support procedures in the hydropower sector, emphasizing the inclusion of seasonal forecasts as supplementary information. Bolson & Broad focused on the early adoption of seasonal climate forecasts (SCFs) by the South Florida Water Management District (SFWMD)[82]. In contrast to conventional studies that emphasize barriers, this research reveals contributing factors such as in-house climate expertise, an innovative organizational culture, and strategic social networks. The findings underscore the importance of internal capacity-building and interdisciplinary collaboration in navigating the complexities of environmental decision-making, offering valuable insights for adaptive management in water resource institutions. In this regard, Jacobs & Street introduce the concept of a "partnership of networks"[83]. They advocate for a paradigm shift in climate services, proposing a "next generation" approach that goes beyond merely reducing scientific uncertainties. They highlight the necessity of transformative relationship and capacity-building strategies. This envisioned partnership aims to experiment with scalable, interdisciplinary decision-support capabilities, aligning climate services with the scale of contemporary challenges. In a way, they provide a forward-looking perspective emphasizing interactions between science, policy, and practice. In the context of institutional and sectoral boundaries, the study by Blundo-Canto et al. on scaling Weather and Climate Services (WCS) in Senegal offers a vital perspective, examining and asserting the significance of evaluating enabling conditions and future challenges[84]. Key factors facilitating WCS integration include capacity strengthening, knowledge-sharing,

and political support. Challenges, such as forecast precision and private sector involvement, underscore the need for sustained efforts in capacity and trust-building on a larger scale.

In the current state of the literature, only a limited number of research articles specifically focus on business innovation practices. Among these, two studies thoroughly analysed the concept of co-generation and development, which involve collaborative processes where multiple stakeholders, including end-users, actively participate in creating and shaping a product according to their needs. For instance, Dell'Aquila et al., focusing on wineries in Portugal's Douro Region, introduced the MED-GOLD Dashboard, a tailored and interactive climate service delivered through collaboration with local vineyards (SOGRAPE Vinhos)[80]. Based on a combined set of Essential Climate Variables (ECVs), bioclimatic indicators, and crafted compound risk indices, the platform aims not only to reconstruct the historical climate data within the winery's areas of interest but also to forecast seasonal prediction and climate projection, proving valuable for winemakers in terms of strategic planning and day-to-day management operation.

In the same vein, Contreras et al., investigating small hydropower plants situated in mountainous areas that rely on run-of-river flow, presented the technological climate service called SHYMAT (Small Hydropower Management Assessment Tool)[81]. The web user interface, which has been developed through a co-generation process between data and services providers, introduces a shift from traditional river flow management by incorporating a forward-looking, probabilistic approach based on future weather scenarios. The interactive climate service displays the "historical information" section, which presents past and real-time weather and hydrological data, while the "forecast information" component, offers insights into hydro-meteorological forecasts, seasonal predictions, and operational expectations. Tailored for hydropower managers, SHYMAT demonstrates how seasonal climate forecasts can assist in planning power generation and maintenance activities based on anticipated water availability.

Within the context of the co-design process, two studies offer interesting insights. One of these studies, conducted by Rubio-Martin et al., introduces a novel method for creating climate services, emphasizing the utilization of the business model canvas (BMC) to facilitate collaborative service design[85]. This canvas is exemplified through a case study involving the co-creation of a climate service for the urban water supply system in Valencia, Spain. The approach actively engages users in the design process to fully understand their needs, integrating local knowledge and fostering a transdisciplinary outcome. This highlights how involving users can prevent rejection of the resulting service. The methodology has proven successful in the water sector, paving the way for replication in similar conditions.

Another study by Swart et al. has employed a methodology for co-designing climate services that incorporate the elements of the business model canvas by Osterwalder and Pigneur[20,86]. This approach was systematically employed to guide the formal co-design and co-development processes of climate services. Additionally, they advocate for reframing climate services to emphasize the significance of connecting them with local challenges, integrating socio-economic factors, and redesigning stakeholder engagement processes. They conclude with recommendations to enhance the relevance and application of climate services, emphasizing the need to develop "front office capabilities" to expand the market and generate economic activity.

In the agriculture sector, the Participatory Integrated Climate Services for Agriculture (PICSA) approach, developed by Dayamba et al., serves as a novel method for extension and climate information services, specifically targeting farmers[87]. This approach utilizes historical climate records, participatory decision-making tools, and forecasts to assist farmers in identifying and planning livelihood options based on local climate conditions and individual circumstances. Implemented in Senegal and Mali, PICSA empowered farmers to strategically plan ahead of the season, resulting in various innovations such as changes in activity timing, soil and water management practices, crop selection, and adaptation of seasonal plans. The study also highlighted the potential of farmer-to-farmer extension in scaling up the PICSA approach, particularly in regions with limited extension services, through leveraging word-of-mouth and knowledge-sharing among farmers. Challenges include the availability of historical climate records and the need for contextualization in different environments. Despite these challenges, PICSA demonstrated its effectiveness in influencing farmers' behaviors and decision-making processes, offering a promising avenue for improving livelihoods in agriculture. Further research is suggested to explore decision-making processes, economic impacts, and the mainstreaming of PICSA into national-level programs.

In the hydrologic sector, specifically in water resource management, the Australian Bureau of Meteorology has introduced the Australian Water Outlook, a service that integrates historical water data, forecast products, and hydrological impact projections using the Bureau's Australian Water Landscape Water Balance model[88]. This user-cantered design aims to develop national hydrological forecasts, bridging the gap between demand and supply. To ensure the service meets user needs, 56 potential users representing 20 organizations across the water sector in Australia were interviewed. These organizations include water utilities, hydropower generators, government departments overseeing infrastructure planning and development, agriculture, water resources management, and emergency services. Identified user needs were translated into the foundational elements of the service to cater to their requirements. The goal was to assist customers with nationally modelled climate change impacts on water. Additionally, the service provides hydrological model-ready ensembles of downscaled climate inputs, enabling customers to run their own models. An intuitive user interface was developed, allowing users to explore projection information tailored to their specific region of interest. This approach aligns with the recommendation of the World Meteorological Organization's report, which anticipates increased collaboration among stakeholders at the national level to jointly develop and implement climate services in coordination with information users, aiming to provide more effective support for adaptation in the water sector[89].

The article of Bojovic et al. emphases the transformation of scientists' roles from knowledge holders to co-learners, indicating a shift in the traditional dynamics of delivering climate services[90]. The authors emphasized the necessity for a stronger connection between climate service providers, such as scientists, and users, underlining the importance of effective collaboration (co-production) based on engagement, involvement, and empowerment as key realms. They illustrate the application of this framework in the PRIMAVERA plan, a project funded by the European Union under the Horizon 2020 framework program, which focuses on the design, implementation, and testing of new high-resolution global climate models. The paper highlights the evolution of scientists' roles from skilled brains to fellow learners within this context. In summary, the framework proved valuable in overcoming challenges in traditional project structures, leading to more flexible and user-oriented outcomes. The article

concludes by advocating for a shift in perceptions, building partnerships, and embracing transdisciplinary approaches for effective climate knowledge co-production.

Visscher et al., explore the potential of climate services as a market for knowledge-intensive services and introduce a typology of climate services based on Constructive Technology Assessment (CTA)[91]. The typology includes 'Maps & Apps,' 'Expert Analysis,' 'Climate-inclusive Consulting,' and 'Sharing Practices'. These typologies aid in structuring and categorizing current and potential climate services, offering a framework for their development. The study emphasizes the necessity for a shift in focus from data and models to user demand, highlighting various climate service formats. The typology assists providers, users, and policymakers in understanding and navigating the diverse landscape of climate services, considering factors such as tailored vs. general offerings and standalone vs. integrated services. Furthermore, the study contributes to the conceptualization of climate services, suggesting a more differentiated and broader perspective. It also underscores the applicability of Customer Technology Adoption (CTA) principles in the context of emerging knowledge-intensive service markets, providing a valuable tool for stakeholders to explore supply-demand dynamics and foster productive discussions.

The work by Keele S. raises concerns about the transition from public climate information to privatized climate services, highlighting the tension between profit-oriented efficiency and public access to climate information[92]. It draws attention to the potential global shift from providing "climate information" to generating "climate services" for decision-makers, driven by the demand for timely and actionable climate knowledge. This transition implies a shift from a public good to more privatized forms of climate science. The role of consultants in climate services is analyzed, emphasizing their client-oriented nature, solutions-focused approach, resource efficiency, and self-replicating imperatives. The article also discusses the climate services paradox: how to achieve customization without exclusion, questioning the long-term sufficiency and sustainability of climate decision-making under dominant market logic. It warns of potential conflicts with public goals and emphasizes the need to balance cost-effectiveness with democratizing climate knowledge for society, linking the climate services movement to broader aims of "good" climate governance.

Simelton and McCampbell delve into the role of digital climate services in aiding agricultural decisions, particularly in navigating uncertain climatic conditions[93]. They explore the potential impact of these services on advancing what is termed as the fourth agricultural revolution. Using the Responsible Research and Innovation framework, they evaluate climate service apps based on their promotion of production systems, alignment with sustainable development goals, ecosystem restoration, and climate resilience. Focusing on Southeast Asian smallholder farming systems, the study identifies gaps in digitization efforts, highlighting the need for inclusive and sustainable practices. Recommendations include developing app intercomparison and data stewardship protocols, engaging national public actors, promoting South-South exchange on data stewardship, and establishing standards for diverse agronomic practices. The paper concludes by underscoring the limited evidence of responsible innovation criteria in current digital applications for climate services and agriculture management, urging the adoption of standardized protocols to enhance digital literacy, inclusion, and resilience-building.

The examined research articles collectively highlight the emerging trend of business innovation practices within the domain of climate services, focusing on various aspects such as co-production, co-design, and tailoring services. These innovations emphasize collaborative efforts among stakeholders,

including end-users and service providers, as essential for ensuring effective and tailored climate services. The cooperative approach underscores the importance of understanding the diverse needs of end-users through involvement in the creation and implementation processes. Co-design processes play a fundamental role in shaping features from multiple perspectives, enhancing functionalities, and overall design. **The Business Model Canvas often serves as a guide or framework for these collaborative efforts, structuring key components of the business model to ensure alignment with user needs**. The goal is to provide tailored services that are relevant, effective, and more likely to be adopted by the target audience.

However, this literature analysis highlights that business model innovation in the field of climate services is still a relatively new area of research. Currently, there is no standardized approach for business model innovation, and no widely adopted large-scale model among organizations. The existing research tends to be highly case-specific, with a predominant focus on select key elements of business models. Attention is particularly directed towards aspects such as co-production and design, which encompass key partners, key activities, customer relationships, and value propositions. Another focal point is the design of digital platforms, specifically relating to the channel element for service delivery. However, elements such as cost and revenue structures, private and public partnerships, scalability, and long-term sustainability remain inadequately explored topics.

3.3 Summary of trends in business model innovation in selected sectors from which climate services may get inspired.

3.3.1 Climate services as a tool for adaptation, mitigation, and resilience

Addressing the challenges of climate change requires a fundamental transformation of the global economy, complemented by improved decision-making capabilities. Well-informed decisions, grounded in reliable climate information, are crucial for enabling both public and private sectors to underpin effective climate adaptation, mitigation, and resilience[54,94]. The value of climate information (VOI) lies in the improved outcomes resulting from informed decisions. Effective decision-making is contingent upon the ability to interpret and act on climate forecasts and uncertainties, with the goal of minimizing impacts, optimizing response efficiency, and capitalizing on opportunities presented by the transition to a low-carbon economy[64–66].

Moreover, climate services, as defined by the World Meteorological Organization[66], extend beyond the mere data and information provision, since it involves the co-creation of information tailored to specific climate-related needs through user engagement and iterative dialogue. These services transform climate data into actionable insights, bridging the divide between science, technology, and policy, and aiding in the formation of climate-smart societies[95]. In Europe, climate services are recognized as instrumental in driving economic growth, job creation, and competitiveness. They support decision-making on critical issues such as mitigation policies, resilient infrastructure, business innovation, and investment planning[65].

Investments in climate information and early warning systems yield significant economic returns. The prevention of losses alone could save up to USD 66 billion globally, while optimization in weather-sensitive sectors could lead to annual gains of approximately USD 96 billion. Moreover, such investments enable better long-term strategic responses to climate challenges[96].

A wide array of organizations and individuals is engaged in producing and utilizing climate information. Although data from the WMO[97] indicates advancements in climate services governance, there is a notable deficiency in the functional capacities dedicated to monitoring and evaluating the outcomes and benefits derived from the application of climate services. There is an explicit need to track and evaluate the impact of climate services on socio-economic factors. In this regard, public sector entities, including city governments, seek this data to assess local risks and vulnerabilities, plan adaptively, and enhance resilience. For businesses, incorporating climate risks into strategic investments and operations is increasingly vital, leading to a growing demand for specialized climate tools and information[64,65].

The growth of green economies necessitates robust climate services, particularly in weather-dependent sectors like renewable energy and climate-smart agriculture. For instance, accurate climate forecasts enable farmers to optimize water use and improve crop yields, while renewable energy generation can be enhanced through precise weather data[96]. Additionally, the insurance and financial sectors require detailed climate risk information to develop innovative financial products and strategies, enhancing resilience and opening new market opportunities, especially in traditionally uninsured regions[96]. Although the climate service market is still in its infancy, with both demand and supply sides evolving, its potential to catalyse the transition to a climate-resilient and low-carbon society is immense.

Climate Service Market: State of The Art

The climate service market, still in its nascent stages, is expanding as the recognition of climate change impacts begins to profoundly influence both corporate and individual decision-making. Typically, climate service providers are small-scale enterprises founded by climate scientists and often affiliated with National Meteorological Services. Nevertheless, a shift is underway, with major consultancies incorporating climate impact analyses into their services, and large corporations developing in-house climate competencies that extend beyond traditional risk assessment roles found in reinsurance companies[65,98].

Public entities are also increasingly using climate data in their operations, driven by regulatory mandates and a growing recognition of the importance of climate information for effective adaptation, risk mitigation, and securing funding. A key impediment to the growth of the climate services market is the lack of standardized business models, which are crucial for fostering innovation and addressing economic, political, and institutional barriers to climate services adoption action[95].

Business models for climate services (BM4CS) involve strategic decisions that co-create value with users to promote sustainability and transform climate data into tailored knowledge services[22,95]. These models can find synergies with natural assurance schemes, as both focus on risk reduction and the generation of social, environmental, and economic co-benefits[99]. **Despite efforts, a universally recognized taxonomy for climate services is yet to be established**. Such a taxonomy would clarify communication among stakeholders, enhancing market transparency and stimulating investment. It would

organize knowledge and present new frameworks for innovating business practices within the climate service market.

A taxonomy for climate services (CSs) would also facilitate stakeholder co-creation, aligning service offerings with user needs, developing user capacity, and leveraging existing capabilities[66]. Usability is critical—it ensures that climate services align with the knowledge and needs of users to support diverse decision-making scenarios. These scenarios can range from immediate to multi-decade planning, such as setting insurance rates, evaluating long-term loans, or planning infrastructure projects[100]. Ultimately, climate data and information must be customized to user needs and delivered in a timely manner, enabling smooth integration into organizational logic and decision-making processes.

Climate Service Enablers

The advent of technology is a primary driver in expanding the climate service market. Technological progress, particularly in AI and ML, has revolutionized climate modelling and forecasting by enabling the handling of big data and complex variables[98]. IoT advancements have led to innovative applications like advanced smart hybrid public warning systems, enhancing the ability to warn specific populations of climatic disasters[96].

These technological strides facilitate the efficient collection and analysis of climate information, laying the groundwork for new solutions across various sectors. They have allowed for the advancement of hazard modelling, geo-mapping of assets, and the creation of detailed exposure datasets, expanding the role of private enterprises in the climate service production chain[64,100].

The integration of climate-related risk forecasts into private-sector decision-making processes is increasingly common, affecting areas such as underwriting, credit rating, and infrastructure resilience. As technology evolves, so does the relationship between the stakeholders in the climate and weather value chain.

Policy also plays a significant role in advancing the climate service market. Initiatives like the EU's Data Space, launched in 2022, aim to create a common European data space to enhance data sharing for strategic sectors in the green transition. This project prioritizes interoperability, quality standards, and transparency to reduce fragmentation and integration costs, acknowledging data as a crucial resource in the future economy[101].

The EU Commission recognizes data sharing as essential for improving supply chain efficiency and fostering innovative product development. Companies have multiple incentives to share data, including increased access to the data of others, analytical results, predictive maintenance services, and faster product marketing[101]. Furthermore, the European Commission's DestinE initiative seeks to create a highly accurate digital model of Earth. This Digital Twin will monitor and simulate natural phenomena, anticipate environmental disasters, and assist in devising precise adaptation and mitigation strategies[101,102].

International projects like SPHERE and the Digital Urban European Twins (Duet3) contribute to the Digital Twin's development, aiming to optimize building life cycles and assist city management by creating digital replicas for better decision-making and citizen engagement[101,102]. The CReDo project

instead looks specifically at the impact of flooding on energy, water, and telecoms networks, helping the operators to mitigate the effect of flooding on network performance and ser-vice delivery[98].

Private initiatives also play a fundamental role in this landscape, fostering climate service market growth. Platforms like SatVu leverages the power of public accessible climate-related data enhancing climate solutions in the public and private sectors, as well as in geospatial defence and intelligence. In the private sector, targeted services may also be developed to respond to specific market needs. For instance, the enterprise Symphony creative solution (Singapore) has developed a maritime innovation platform to help shipping & logistics companies to become more productive.[103]

Technological advancements and supportive policies are shaping the climate service market, driving it towards greater precision, efficiency, and integration, ultimately aiding the transition to a more resilient and sustainable future.

3.3.2 Business Model Innovation for Climate Services: How to Make the Market Grow

To accelerate the growth of the climate service market and unlock its potential in addressing the urgent challenges of climate change, a critical focus must be placed on developing innovative business models for climate services and a tailored taxonomy. As previously discussed, business model innovation serves as a pivotal tool to revolutionise traditional approaches to creating, delivering, and capturing value, moving beyond the conventional business-as-usual paradigm. Additionally, taxonomies play a vital role in establishing widely recognized standards, and enhancing transparency and comparability, thereby positively influencing the trust of investors and peers.

Given the relatively modest development of these aspects within the climate service domain, insights from mature markets sharing similarities and robust synergies with the climate service sector can be analysed. By doing so, best practices can be gleaned and - with thoughtful consideration - applied to the development of innovative business models and a specialised taxonomy for climate services.

In the following section, the results of an exhaustive examination of scientific and grey literature on this subject will be outlined. This analysis covers key markets and sectors, such as data, public goods, knowledge-intensive businesses (KIBS), as well as weather and climatic data markets. Furthermore, the paragraphs will delve into research exploring sustainable business models and their role in innovation, along with the few available studies specifically focused on the climate service market.

Sustainable business models: the patterns for a green innovation

Sustainable business model (SBM) innovations are defined as innovations that bring about substantial positive impacts and/or notably decrease negative effects on the environment and society. These innovations drive change by modifying how organisations, along with their value networks, generate, deliver, and capture value. In essence, they redefine value propositions, contributing to a more sustainable and positive relationship between organisations and their broader environmental and societal contexts[56].

The value created by Sustainable Business Models (SBMs) extends beyond the economic boundaries typically considered by business-as-usual (BAU) business models, encompassing environmental and

social dimensions as well. In this perspective, there are strong synergies between sustainable business models and those tailored for climate services. The utilization of climate-related data is aimed at optimizing decision-making processes, thereby supporting various stakeholders in adapting to climate variability and change. The resulting impact from these decision-making processes transcends the boundaries of individual organizations and generates value across the three pillars of sustainability: economy, environment, and society.

The economic benefits of climate services are substantial. Accurate climate information aids industries in making informed decisions, optimizing production processes, and minimizing losses caused by weather-related disruptions. Businesses can enhance efficiency, mitigate operational risks, and explore new opportunities based on reliable climate forecasts. The economic value also extends to job creation and overall economic growth, as climate services support sectors heavily dependent on weather conditions. Additionally, climate services provide valuable information that enhances societal resilience and preparedness. Early warning systems and accurate climate predictions contribute to public safety by assisting communities in anticipating and responding to extreme weather events. This social value includes saving lives, minimizing injuries, and reducing the overall societal impact of climate-related disasters.

Finally, climate services contribute to environmental sustainability by facilitating informed decision-making that incorporates ecological considerations. By enabling better management of natural resources, such as water and energy, climate services support environmentally responsible practices. Additionally, they assist in monitoring and mitigating the impact of climate change on ecosystems, biodiversity, and overall environmental health[104].

The value created is delivered to users and captured by organizations through the combination of different strategies that encompass diverse business models. These models vary depending on the specific challenges actors need to address and the combinations of problem-solution set in place. In literature, the systematic and general description of the combination of a problem and a corresponding solution, which can be repeatedly applied in different situations, is known as a pattern. Specifically, in the realm of sustainability, the Sustainable Business Model (SBM) pattern describes ecological, social, and/or economic problems and their corresponding solutions. Moreover, it contains information about the design principles, value-creating activities, and their arrangements required to provide a useful problem-solution combination[55].

Patterns may also describe a solution for only a certain part of a company's business model; hence, complete business models of companies are often a combination of several patterns[105]. Their systematisation helps in organising knowledge and identifying gaps thus innovating and enabling businesses to gain a competitive advantage.

According to the analysis conducted by Lüdeke-Freund et al.[55], classifying business model patterns is important and useful for the following reasons:

Information Retrieval for Understanding:

- Enables storing and retrieving information on value creation, delivery, and capture the logic of diverse organisations.
- Aids researchers and practitioners in understanding through classifications that order and compare different SBMs/BMs.

Simplified Cognition and Communication:

- Classifications simplify cognition and enhance communication in collaborative SBM/BM development.
- Well-ordered knowledge streamlines cognitive processes, allowing parsimonious capturing and communication of rationales across organizations.

The basis for Midrange Theorizing:

- Well-organized knowledge forms the basis for midrange theorizing, helping formulate and test contingent hypotheses about business models.
- Facilitates understanding forces within specific business models.

Inspiration for Innovation:

- SBM/BM classifications inspire managers and entrepreneurs to creatively develop or imitate solutions by recombining existing patterns.

Guidance for Sustainable Innovations:

- Well-organized knowledge about SBMs guides managers and entrepreneurs toward the next wave of sustainable innovations.
- Helps identify existing SBMs, and understand their functions, problem-solving capabilities, and limitations, akin to criteria for design or 'knowledge for action'.

All the considerations above may be applied in the realm of climate service business models since they are not case-specific but rather refer to a systematic approach to knowledge management, communication techniques, and innovation mechanisms.

Lüdeke-Freund et al.[55] have identified in their study **45 patterns for SBM**, resulting from bringing together the results of an extensive literature review on the subject enriched by the opinions of various international experts. The first basics of taxonomy for sustainable business models have been developed by the authors in collaboration with experts, by clustering the 45 patterns into 11 groups based on similarities of problem-solution combinations and using the ecological, social, and economic dimensions of sustainability as a guide to creating meaningful groups. A visual representation of the groups based on their expected value effect in economic, environmental, and social terms has been made to easily visualize the current gaps in the market and the possible innovation areas.

These patterns may provide a starting point for crafting tailored approaches in the climate service market. Their formulation is grounded in criteria applicable to climate services as well, this involves addressing ecological, social, and economic sustainability issues by business model innovation. However, not all these patterns are relevant, given the dematerialized and predominantly online nature of climate services[106]. Patterns that specifically refer to sustainable services and those associated with generic pricing, revenue, and finance strategies are instead noteworthy. Examples include pattern 1.1 “differential pricing”, 1.2, the "freemium model, 1.4, the "Subscription model", 5.4, "physical to virtual", and 5.5 “produce on demand”. Furthermore, the authors' methodology holds potential for application in the climate service (CS) context for developing customized patterns. Their approach combines qualitative and quantitative methods, along with both theoretical and empirical techniques. This encompasses a systematic literature review and expert consensus obtained through the Delphi card sorting technique. This balanced approach integrates theoretical insights with practical considerations, showcasing its adaptability and relevance in diverse contexts, including climate services.

In the specific realm of climate services, recent advancements have led to the identification of tailored Business Models for Climate Services (BM4CS). Notably, the REACHOUT project, funded by H2020, has pioneered a Climate service business model architecture organized in three distinct layers: Data, Infrastructure, and Intelligence. The Data layer focuses on upstream services supporting data acquisition and is associated with a Data-As-A-Service business model, which can use various revenue models such as per-quantity pricing, type-led pricing, and per-click pricing. The infrastructure layer incorporates brokers facilitating the storage and processing of raw data and is associated with business models including Platform or Infrastructure as a Service, featuring revenue models like periodic fees, advertising, partnerships, and lump-sum contributions. The Intelligence layer encompasses advanced and operational climate services that convert information into knowledge, offering business models for analytics, insights, and applications. Associated business models are Software/Insights/Analytics as a service, while revenue models involve software subscriptions, consulting, and pay-per-use licensing.

REACHOUT has specifically collaborated with city hubs, defined as cities along with their broad stakeholder network comprising local communities, local and national authorities, the private sector, and civil society. The initiative begins by assessing climate adaptation tools already utilized in these city hubs, such as thermal assessment tools and Community Flood Resilience Support Systems, to analyze the climatic risks facing the cities. Subsequently, goals are established (ambition), and actions to achieve them are defined (triple-A approach). The SWOT-PESTLE framework is then applied to reconstruct the existing business model within the city hub, enriching the initial business model archetypes developed.

The approach crafted by REACHOUT stands as a valuable instrument for expediting business model innovation within the realm of climate services. Its practical and collaborative methodology ensures a dynamic and adaptable framework that can be effectively applied across diverse sectors. This versatility not only enhances its applicability but also extends the potential to broaden the spectrum of business models available for climate services. By embracing a flexible and collaborative approach, the REACHOUT model becomes an invaluable tool, facilitating and accelerating innovation in CS business models. The REACHOUT approach emerges as a valuable tool for accelerating business model innovation in climate services. Its practical and collaborative methodology offers a dynamic framework adaptable to various sectors, enhancing its applicability and broadening the spectrum of available business models. Embracing flexibility and collaboration, the REACHOUT model becomes an invaluable instrument, expediting innovation in climate service business models.

3.3.3 Elements of innovation for climate service business model

The following paragraph will explore key innovation elements essential for shaping tailored business models in the domain of climate services. Focusing on three critical components—data and tools, partnerships and relationship networks, and user-centric value delivery structures—it aims to address fundamental aspects of climate service provision and utilization. This includes managing extensive climate data, fostering collaborative partnerships among stakeholders, and developing customized delivery structures to meet the diverse needs of end users, reflecting the inherent challenges of standardizing climate services.

Data and tools

According to the World Bank Report, few World Meteorological Organization (WMO) Members have fully open data policies. Typically, data access is restricted, not freely available for use and republishing without constraints like copyright or patents. The international data sharing requirements set by WMO Members tend to be conservative, limiting access for certain users and producers. Additionally, data availability in most countries represents only a small portion of the total[100,103]. Moreover, most of the raw weather and climate data are freely downloadable, but "cutting-edge" and aggregate data useful for mapping hazards, like satellite-generated maps, may not be.

Data generated by municipal infrastructure and corporate supply chain are even more likely to require specific licenses, furthermore, no standardisation for data extraction and elaboration exists, which poses significant problems in terms of transparency. The impossibility of overseeing the scientific rigour of the data and model used by stakeholders is known in the literature as the "black box model" [100]. Data, methods, and metrics become hard to compare, and their reliability is thus called into question.

In addition, even a small error in data generation and modelling may provoke profound effects - which is also known as the butterfly effect - since it will propagate and amplify in the subsequent models used by other stakeholders, eventually degrading forecast skills and consequently decision-making processes on a large scale[96]. One of the ways to avoid the butterfly effect is to guarantee shared quality standards and transparency along the value chain. This, in turn, will have a positive influence on stakeholders' confidence and trust, essential elements for the CS market innovation and growth.

Data policies and more generally shared data management initiatives can contribute to achieving these goals, ensuring equitable access to high-value data, free of restrictions for businesses, governments, and citizens[107]. Many European and non-European, public, and private initiatives are moving in this direction in addition to the previously mentioned European Common Data Space Policy. The Data Act was launched in February 2022 to harmonise rules on fair access and use of data generated by the Internet of the things in the public and private sectors. For instance, data held by the private sector will be made accessible to the public bodies for necessary public interest purposes. Data may be used to develop insights and quick response strategies to address climate hazards and ensure citizens safety.

The DIAS projects (Data and Information Access Service), funded by the EC for the deployment of five cloud-based platforms will be dedicated to the provision of centralised access to Copernicus data and information, as well as to processing tools. The platforms will also give access to additional commercial satellite or non-space data sets and give users the possibility to run their applications in the cloud, facilitating data collection and processing.

The Hub Ocean Foundation, currently affiliated with the Centre for the Fourth Industrial Revolution Network, aims to develop a new Ocean Data Platform dedicated to data, applications, and tools to pilot new approaches to ocean governance. The platform will cluster open data - publicly funded, made available by governments and scientific institutions - private data, and dispersed data and make them accessible by scientists, government, and industries to help create science-led and data-driven solutions.

Who will bear the cost?

Collecting, storing, and processing climate-related data necessitates significant investments in infrastructure, including local sensor networks for data collection, national datasets, data manipulation tools, and highly skilled human resources capable of performing these tasks[98].

Based on the collective opinion of multiple experts[100,103,108], climate services ought to be recognized as a public service. This acknowledgment is rooted in their pivotal function in ensuring citizen safety from climate-related hazards, promoting the sustainable and responsible utilization of common natural resources, and nurturing the development of a low-carbon economy. This vision is reflected in today's reality, since climate services are mostly produced by public entities, within the constraints of international development assistance including being funded and implemented through short-term and pilot projects[108]. As a consequence, when public funds run out, the project lacks additional financial resources to cover the costs of maintenance and operations, leading to frequent failures[109,110].

Furthermore, regulations in many countries seem to be designed to strengthen the public sector's monopoly (monopsony) over the creation and sale of club goods, such as observational data, and private goods, like customized forecasting services[103]. Public organizations are thus primarily responsible for providing climate services at the national level, yet they often lack the necessary resources for production. This underfunding significantly affects their ability to deliver high-quality services. The reliability of these services depends largely on the quality and quantity of data collected, including factors such as temporal and spatial resolution, time horizon, and geographical coverage[100]. Indeed, spatial resolution plays a crucial role in providing accurate simulations at a local level, as global models often operate at scales too broad for precise local decision-making. While downscaling techniques can be employed for hazard assessment, they may not suffice for calculating total risk for specific communities. An effective assessment of climate risk also involves understanding a municipality's capacity to recover from disasters, considering factors such as community vulnerability, sensitivity, and exposure. Therefore, local data are essential for generating valuable climate information for local decision-making processes.

Until now, many underdeveloped and some developed countries have struggled due to deficiencies in cutting-edge technologies, infrastructure, and highly skilled human resources within their public national organizations. This limitation has hampered their capacity to collect and generate vital climatic data, information, and forecasts. Consequently, the quality of climate-related data and services has suffered, resulting in underutilization, even within the private sector. This challenging situation, often described as a "low-quality trap[103]," highlights the imperative for innovation to spur growth in the climate services market.

Outsourcing, collaboration, and co-production

Outsourcing certain activities in the production of climate services can help public organizations reduce operational costs, enabling them to focus their limited human resources on core functions. For instance, the National Meteorological and Hydrological Service (NMHS) may maintain its essential observational network while obtaining additional data from external vendors. However, restrictions on data reuse may be necessary to protect its value as private goods. Careful evaluation of outsourced activities is vital to safeguard the organization's future management capacity and maintain public accountability, ensuring that critical functions are not compromised by external involvement[103].

Private businesses can collaborate with public entities by sharing the data collected through their infrastructure networks in exchange for publicly produced data. This public-private data collaboration fosters innovation and allows the public sector to harness the expertise of the private sector in finding data-driven solutions to various public issues, ranging from climate change and public health to job creation[111]. Outsourcing and close collaboration with external partners increase the complexity of the value chain and thus transaction costs. To lower this risk, business models for data marketplace often adopt standardise contract conditions which increase efficiency and lower variable costs, simplifying stakeholders' interactions[112].

Contracts may vary depending on data ownership considerations, as the pricing structure and sharing arrangements are contingent upon this factor. Ownership of data can differ, ranging from data marketplaces owned privately by a single company, multiple companies, or an independent third party[112]. However, in the specific context of climate services, public organizations should retain control over data crucial for the public interest and offer the majority of it free of charge to encourage both usage and market expansion.

Partnerships Network

Climate service business model innovation, akin to sustainable business model (SBM) innovation, is systemic and involves numerous interdependencies among diverse actors within a shared complex architecture. The climate-weather value chain entails multiple organizations collaborating closely, pooling complementary assets and resources[107]. Hence, formal, and informal partnerships between entities in the public and private sectors are essential for value production, capture, and delivery.

Public-private engagement (PPE) and public-private partnership (PPP) represent the primary modalities of collaboration utilized or attempted for hydrometeorological service production. Given their similarities, the considerations addressed by various studies on hydrometeorological services can also be applied to the field of climate services. While there is no universally agreed-upon definition of Public-Private Engagement (PPE), it can generally be described as an inclusive partnership involving the public, private, academic, and civil society sectors at global, regional, and national levels. According to Frei[113], PPE facilitates the provision of better and sustainable solutions for modernizing public infrastructure and improving access to high-quality hydrometeorological services essential for the national economy and citizens. In contrast, Public-Private Partnership (PPP) is a concept introduced in the 1990s, referring to formal arrangements between public and private entities to share risks and rewards in delivering public services and infrastructure. Exemplary partnerships at a global level are the National Centre for Atmospheric Science, the Joint Weather and Climate Research Partnership, the World Weather Research Programme, and the European Centre for Medium Range Weather Forecasts (ECMWF)[114].

To facilitate a successful public-private partnership, researchers from various countries and sectors have identified several common critical factors. These factors can be categorized into seven groups: (1) equitable distribution of risks, (2) robust private sector involvement, (3) balanced government oversight, (4) transparent and efficient procurement procedures, (5) economic viability of projects, (6) establishment of a suitable legal framework and stable political environment, and (7) access to financial markets[113].

As discussed in earlier sections, the establishment of a shared taxonomy and the standardization of data and methodologies for climate service production enhance transparency and efficiency throughout the value chain. This fosters the growth of financial markets and strengthens the private sector's involvement. Moreover, progressive policies and regulations concerning data accessibility, storage, and technology diffusion contribute to building the necessary framework for fostering climate services market expansion. However, despite these facilitating factors, the success of public-private partnerships (PPPs) may be hindered by misallocated risks, lack of trust among stakeholders, and inadequate data ownership agreements. As highlighted by Mazzucato (2013), PPPs often stumble due to imbalanced risk distribution and a failure to recognize the public sector's innovative role, hindering the achievement of mutually beneficial outcomes. Additionally, many potential PPP initiatives face challenges related to the reluctance to share intellectual property rights (IPR), potentially granting one party undue control over the product. To mitigate conflicts and ensure PPP success, fostering trust and clearly delineating responsibilities are essential.

From the perspective of the public sector, academia, in addition to National Research Institutions (NRI), can significantly contribute to Public-Private Partnerships (PPP) and Public-Private Engagement (PPE). Academic institutions play a crucial role in the Research to Operation (R2O) processes, contributing to the development of innovative methods, tools, and products. These outputs can then be operationalized by the private sector, leveraging their expertise and financial resources to bring these innovations to fruition[107]. Additionally, academia can address capacity gaps in developing countries by providing training opportunities for users, producers, or other trainees [113,114]. In this context, acknowledging the crucial contribution that academia can make to PPP and PPE in climate service development, it's imperative to ensure sufficient public and private funding. This is essential to prevent the occurrence of the low-quality trap, a challenge already prevalent in other national research institutions and public entities.

User profile and delivery structure

The careful definition of user profiles and relationship types, along with the design of an efficient value delivery structure, are critical aspects of the business model design process. In the realm of climate services, specific considerations must be made. Users of climate services should be categorized based on their level of expertise and skills to ensure the service meets their needs effectively. For instance, small municipalities and organizations may have limited knowledge of climate forecasting compared to larger cities or institutional investors engaged in international projects involving climate scientists.[86,100]

According to this principle, climate service (CS) users are classified into three groups[86]: self-sufficient users, transitional climate service users, and potential climate service users. The first two users differ in their ability to utilize climate information independently, with self-sufficient users being able to do so and transitional users requiring external assistance. Conversely, potential users are not yet aware of the relevance of existing climate risks and the role of climate-related information in their decision-making processes.

The demand for services also varies based on the level of user awareness. In the top-down approach, where users are highly aware of the role of climate information, they independently identify the target

users and develop and deliver the service. Conversely, in the bottom-up approach, users have a lower level of awareness and may contact a climate service provider based on their own experiences and knowledge to address their needs[86]. The World Meteorological Organization (WMO) recommends shifting from a top-down approach to a co-production process. This process involves actively engaging all end-users throughout the entire development of information[97].

In addition to these classifications, another distinction can be made between clients and direct and indirect beneficiaries[99]. In the context of climate services, clients are the purchasers of the service, while beneficiaries are those who directly or indirectly benefit from the value generated by the service. This concept is easily understandable in the context of municipalities, where the municipality itself may be identified as the client, purchasing or co-developing a tailored climate service for the local territory. The citizens then become the direct beneficiaries of the benefits produced by the service, such as the reduction of climate hazard risks. Indirect beneficiaries are those who benefit from the positive externalities of the applied service, such as private businesses that are not directly exposed but benefit from avoided losses and risk reduction.

Providers should select the most appropriate type of provider-user relationship and service delivery channel based on the differentiations mentioned above. Regarding the nature of relationships, they are categorized according to the frequency of interaction between the parties. Users may require either continuous or occasional personal assistance, like counselling, or interactions may be transactional, limited to a single point of purchase. In situations where there is an ongoing, close relationship between the providers and the users, opportunities for co-development and co-creation can be established[99]. Relationships may also be automated, allowing for independence between both parties.

In the realm of counselling, similar to other Knowledge Intensive Business Sectors (KIBS), Climate Service (CS) providers impart knowledge to users. This knowledge aims to enhance the users' overall understanding of the service's potential value within their specific contexts. Additionally, providers assist users in applying this knowledge and various tools to cultivate new expertise and forge bespoke innovations, thereby crafting novel solutions for specific user challenges. Relationships, in general, are fluid and adapt over time, tailored to the users' distinct needs, capacities, and the type of service required. The provision of climate services is not the end of the user-developer relationship. Rather, it can be the beginning of a sustained engagement built on mutual trust and a shared commitment to innovation.

The user’s profile and the type of relationship they have with the provider influence the choice of distribution channel for climate services. E-marketplaces, due to the intangible nature of climate services, have become the most favoured channels. They facilitate communication, automate transactions, coordinate brokerage, and integrate processes. Digital channels also offer user assistance, demonstrations, and consultations. However, when face-to-face interaction is essential, physical channels are more appropriate for effective engagement.

Data management through digital channels introduces several challenges not seen with physical ones. A notable issue is the lack of robust legislation regarding data property rights, data security, and privacy, which can raise significant concerns about the security and confidentiality of user data, thereby affecting their trust in the service. Moreover, the lack of standardized data management rules and practices can lead to inconsistent data handling across various platforms. This inconsistency can cause data fragmentation, diminishing the usability of data for users and reducing the likelihood of integrating

complementary services due to compatibility issues. Furthermore, infrequent data updates can affect the service's continuity and reliability. These factors collectively can constrain the efficiency of climate services in delivering relevant information and impair the decision-making process. In this context, it is crucial to reemphasize the necessity for an innovative legal and policy framework, complemented by newly established shared standards for data access and management. This is essential to ensure quality, transparency, security, ownership, and interoperability, thereby fostering market growth and increasing financial support for climate services.

4 Review of strategies applied by selected climate services

4.1 Introduction

The theoretical background presented and discussed in chapters 2 and 3 provides the basis for reviewing the business model strategies applied to selected climate services. For this review, several case studies across different products, sectors, and funding schemes were selected for in-depth investigation of the business models applied, the values generated, and the success and/or failures of the climate services. Five project-wide case studies were chosen from those selected for an analysis across all work packages of the project: MED-GOLD, Valencia Water (a case study within the context of the INNOVA project), SMHI climate projections, S2S4E, and Focus Africa.

The analysis in this section is based on desk research of public web-based information and documents, additional feedback, and interviews mostly from the provider side. For each case study, a standard set of information is provided (if available). This encompasses:

- A short overview of the climate service (CS) including motivation, topics, sector(s), actors & collaboration, data & products/results, value (aimed & accomplished), funding.
- Exploring the strategies of the CS including business model (BM) used, value generated, sustainability and equitability, product alignment, reasons for success or failure of the BM, and options for improvement or revitalization of the CS's BM.

In the following section, the examples are presented in alphabetical order. A summary of all climate services investigated in this study can be found in Table 3 - Selected case studies. For each case study, the information is mapped on a standard business canvas, which is available in Appendix B of this report. A summary of the findings based on the selected case studies is provided in section 4.3.

4.2 Results from individual case studies

4.2.1 ADAPT TERrestrial systems

Brief description of the service

The aim of the ADAPTER (ADAPT TERrestrial systems) project[115–117] was to develop and provide innovative simulation-based information products for weather- and climate-resilient agriculture in Germany. This means that ADAPTER provided daily updated ("ground") weather and comprehensive long-term climate change information for agriculture and all interested parties as digital climate data products and information free of charge.

In the area of measurements and forecasts, the focus was on the current state and development of the water balance, including groundwater. For optimized soil management, Forschungszentrum Jülich uses forecast simulations with the hydrological numerical model ParFlow and the regional earth system model Terrestrial Systems Modelling Platform (TSMP) in conjunction with observation data.

For climate adaptation measures, the Climate Service Center Germany (GERICS) derived prototypical climate products from a variety of data sources. The ADAPTER products were co-developed right from the start with key practice partners and users. The project ended in 2023.

Knowledge-holders

The service was jointly developed between research teams from the Forschungszentrum Jülich (Institut für Bio- und Geowissenschaften (IBG-3, Agrosphäre)) and Climate Service Center Germany (GERICS) and key practice partners from different agriculture-related agencies and organisations.

Summary of business model and values

Business Model (BM) used: The project developed a publicly accessible web-based information system. The short-term predictions (FZ Jülich) as well as the climate-related part (GERICS) are prototype climate service products financed by public resources.

Asset dimension: Short-term (3-10 day) high-resolution forecasts for soil-meteorological conditions relevant to agriculture (in particular soil moisture) to climate projections (different scenarios) with climate indicators relevant to agriculture.

Type of value generated: Short-term predictions can have economical value, e.g. determining an optimal timing for seeding, grazing, irrigation or harvesting. Long-term effects are changes in cultivation such as type of crops, vegetables or fruits, planning of irrigation or planning of new (cattle) stables. The products can also be used for raising awareness for climate change issues relevant to agriculture.

Sustainability and equity of the BM: The information provided by the climate service is publicly available. Funding was limited to the project duration, thus only prototypes could be developed and implemented.

Alignment of customers and product: The products were developed in close interaction between providers and users. The co-production process encompasses interaction via multiple

communication channels and methods to ensure to meet user needs. In addition, an evaluation study including semi-structured interviews was conducted to find out by whom and for what the climate-data products are and will be used.

Reasons for success or failure: Although the co-production process was closely related to user needs, the final evaluation study showed that there were still deficiencies due to the complexity of the information. In particular, individual farmers indicated that the products are not interesting for them due to the long timescales and the lack of recommendations for actions. Agricultural agencies found the information suitable for educational purposes and to raise awareness for climate change.

Financial dimension: The knowledge transfer project received third party (public) funding through the Helmholtz Initiative and Network Fund. Usage of the service is free, thus, **no revenue by users of the service**.

Options to improve or re-vitalize the BM: The project would need funding to maintain, update and improve the products. A commercialization of the product is regarded to be difficult as the market for the products is very limited. Individual farmers, even if they would be interested in the product, are reluctant to spend money as the potential economic profit is (if at all) very limited. Potential customers would be insurance and breeding companies (for agricultural plants).

For further details, see business model canvas in the appendix.

4.2.2 ANYWHERE

Brief description of the service

The principal objective of ANYWHERE (Enh**AN**cing emergency management and response to extreme **W**eat**HER** and climate **E**vents) is to enable society as a whole and the main civil protection agencies to respond more rapidly than today to extreme climate and weather events, and to better cope with the high social, environmental and economic impacts related to these extremes.

The Project will establish a pan-European platform on extreme climate risks that will enable to identify, in a number of geographic regions, critical situations that could lead to loss of life and economic damages. Such early-warning should enable us to improve protection measures and, in case of catastrophic situations, ameliorate the coordination of rescue operations.

The platform will be adapted to provide early warning products and locally customizable decision support services proactively targeted to the needs and requirements of the regional and local authorities, as well as public and private operators of critical infrastructures and networks. It will be implemented and demonstrated in four selected pilot sites to validate the prototype that will be transferred to the real operation. The market uptake will be ensured by the cooperation with a SME and Industry Collaborative Network, covering a wide range of sectors and stakeholders in Europe, and ultimately worldwide. The project ended in 2019.

Knowledge-holders

In total 34 partners across Europe, coordinated by the Universitat Politècnica de Catalunya (UPC), Spain. Partners encompass climate research institutes, SMEs and industrial partners (e.g., AIRBUS) across Europe plus a collaborative network of associated enterprises.

Summary of business model and values

Business Model (BM) used: The products developed in ANYWHERE (early warning platforms and self-preparedness and self-protection tools) should be transferred to users through a business hub. Pilot studies were implemented for all products on a prototype level to showcase their practical usability.

Asset dimension: Multihazard early warning platforms (A4EU) on different level (prototypes implemented on EU, national, regional and municipal level), self-preparedness and self-protection tools (http://anywhere-h2020.eu/services/self-preparedness-and-self-protection-tools/) for different applications

Type of value generated: Economic as well as societal values (protection and mitigation against severe events and raising of self-awareness and self-protection)

Sustainability and equity of the BM: The project design supported the transition of platforms developed in the ANYWHERE project into commercial applications.

Alignment of customers and product: The products were developed and tested in close cooperation with users in multiple test areas across Europe, ranging from municipal to national level.

Reasons for success or failure: The Business Hub development and test were performed according to the initial DoA requirement. It complies with the Consultancy Centre purpose that allows analyses, development, customization and roll-out of the ANYWHERE products and tools, to be directly implemented into the users and suppliers' platforms and applications. It has been developed as a tool dedicated for the function of marketing, administration and pre and after-sales support, as a self-administrated entity. Nevertheless, the collaborative tool by itself was sparsely used only by a few partners. Despite this situation, the Hub has been maintained operational and accessible for the partners all along the ANYWHERE project.

Financial dimension: The project received third-party (public) funding from the European Union (Horizon 2020). Total costs: 14.8 Mio. €, of which 12 Mio. € from the EU).

Options to improve or re-vitalize the BM: Continuation would either require further public funding or commercialization of the services.

For further details, see business model canvas in the appendix.

4.2.3 Blue Action - Winter Tourism in Finland

Brief description of the service

BlueAction (Arctic Impact on Weather and Climate is a Research and Innovation action) has been an EU-funded Horizon 2020 research project (2016-2021) investigating the effect of a changing Arctic

on weather and climate. It involved over 120 experts from 40 organizations in 17 countries, pooling expertise to improve how to model and predict the impact of warming in the Arctic region.

Within BlueAction the case study "Winter Tourism in Finland"[118,119] has been conducted which focused on developing a decision support tool (DST) providing relevant predictions on snow cover for the partner ski resort Ruka to allow preparation for the winter season. Ruka is a Northern Finnish ski resort that welcomes around 400,000 skiers annually. It is in the business strategy of Ruka ski resort to be the most snow secure resort in Europe. A consistent snow base is a key resource for Ruka that has around 200 skiing days from early October to early May, and it relies heavily on machine-made and stored snow to ensure the slopes can be opened early and maintained through the winter. The project ended 2021.

Knowledge-holders

Scientific partners for this study are the University of Lapland.

Summary of business model and values

Business Model (BM) used: Decision-support tool (SnowApp) for ski resort management based on seasonal climate forecasts. With the output of the DST briefings for the local community and ski business in Ruka were provided. Note that the DST is only a prototype.

Asset dimension: Skilful seasonal forecasts (4-weeks in advance) provide the sound basis for optimized snow management of a ski report. Saving can be up to 30% of energy (and emissions as long as the energy production is not by renewable energy) required for snowmaking.

Type of value generated The CS has potentially economic value for skiing tourism (see above), depending on the quality of forecasts.

Sustainability and equity of the BM: The prototype has shown that the DST has potential to improve the winter tourism in Northern Finland. Long-term skilful forecasts would provide a better basis for snow production and extending the skiing season. The information is mostly suitable for private companies (ski resorts).

Alignment of customers and product: The CS was developed in close cooperation with the user (ski resort management).

Reasons for success or failure: Success of the project critically depends on the quality of forecasts. As there was no sustained funding available and the financial risk for a start-up where too high and no investor could be found, the DST remained on the prototype level.

Financial dimension: The project received third-party (public) funding through Horizon 2020.

Options to improve or re-vitalize the BM: 1. Improved forecasts, 2. Sustained funding or commercialization. The project coordinator tried to assess the willingness-to-pay to such a service. According to her estimate, it is questionable that such a business would provide enough revenue for a successful commercialization.

For further details, see business model canvas in the appendix.

4.2.4 CLIMANOMICS

Brief description of the service

S&P Global Climanomics[120] puts a price on the impact of physical climate risk using standardised so-called "one-click scenario analysis". The commercial climate scenario analysis from S&P Global provides actionable insights about potential future outcomes and is recommended by the TCFD for reporting purposes. A set of scenarios, Shared Socioeconomic Pathways (SSPs), focuses on projecting socioeconomic changes and when used alongside the RCPs capture both physical and socioeconomic factors. The company uses mainly publicly available data e.g., from NASA, NOAA, and IPCC in their scenarios. Customers can pick out of about 300 different asset types to estimate financial risks due to climate change based on different RCP scenarios until 2100.

Knowledge-holders

S&P is a globally operating company developing (amongst other branches) solutions on climate risk assessment for the financial sector.

Summary of business model and values

Business Model (BM) used: S&P Global Climanomics uses a standardized software tool based on Shared Socioeconomic Pathways (SSP) and Representative Concentration Pathway (RCP) for financial risk assessment for the financial sector. The product is based on about 300 different asset types, the user can select and adopt and interpret for their purposes.

Asset dimension: The products provide decision support for climate risk of financial related assets. S&P Global Climanomics offers a growing library of proprietary impact functions that model the vulnerability of about 300 different asset types to climate-related hazards, based on a wide range of factors specific to each one.

Assessments of hazards and of vulnerabilities can be considered for each asset to estimate the average annual loss associated with climate risk to provide an informative evaluation of exposure. This can be disaggregated by type of hazard and, within each hazard, by type of expense. The loss data is provided for each decade out to 2100 under the four standard RCP scenarios.

Type of value generated: Economical / financial values can be generated, or losses mitigated respectively based on the risk assessment tools.

Sustainability and equity of the BM: Applying climate risk assessments can contribute towards an equitable transition to a low-carbon economy.

Alignment of customers and product: S&P Global Climanomics is trying to provide their customers solutions which are efficient and easily applicable to climate risk assessment of their assets.

Reasons for success or failure: S&P Climanomics has more than 100 customers, mostly larger financial institutions.

Financial dimension: The revenue for the company is generated through sales of their software-based solutions.

Options to improve or re-vitalize the BM: The increasing demand for climate risks assessments and the TCFD framework provides potential to sustain and expand the S&P Global Climanomics service. The number of assets of the standardized product is continuously increasing.

For further details, see business model canvas in the appendix.

4.2.5 ClimApp

Brief description of the service

ClimApp[121,122] is an EU project funded by the European Research Area for Climate Services (ERA4CS) (2017-2021) and three participating countries: Sweden, Denmark, and The Netherlands. The overall aim of this project is to develop an advanced mobile phone App that integrates weather forecast data into human heat balance models. The personalized App takes individual factors into account and predicts body responses, provides health risk warning and advice for individuals, public and private sectors, to support decision-making to cope with heat and cold stress when facing extreme weather events such as heat waves and cold spells.

Knowledge-holders

The service was developed by a consortium of Lund University, Sweden, University of Copenhagen, Denmark, Technical University of Denmark, Denmark and Vrije Universiteit Amsterdam, The Netherlands.

Summary of business model and values

Business Model (BM) used: ClimApp's business model provides personalized health risk warnings based on open-source weather data from openweathermap.org in a mobile phone app. The app is freely available.

Asset dimension: The provider developed a freely available mobile phone app (iOS and Android, 10 language versions). The CS uses weather forecast data for human heat balance models. Individual factors are taken into account to predict body responses, health risk warning and advice for individuals, public and private sectors.

Type of value generated: User can avoid or reduce health risks due to thermal stress, e.g. by adopting their (outdoor) activities or clothing according to the weather conditions.

Sustainability and equity of the BM: The product is freely available and is maintained after the end of the research project. **No revenue by users of the service**.

Alignment of customers and product: The climate service addresses the general public, in particular users sensitive to extreme temperatures. The developers performed extensive tests with users and compared the results of their app with the commonly used Universal Temperature Climate Index (UTCI).

Reasons for success or failure: The app is freely available but not advertised widely. Therefore, the current number of users is not very high (2,500 in 176 countries). The language versions have some limitations and in part special knowledge (e.g. clothing specs (air, vapour permeability)) is

required for correct personalization. No warning mode, i.e. you have to run the app to obtain warnings due to thermal stress.

Financial dimension: The CS was financed through public funding (in total about 1.1 M€) by:

- European Research Area for Climate Services (ERA4CS), European Union
- FORMAS, a Swedish Research Council for Sustainable Development, Sweden
- Innovationfonden (IFD), Denmark
- Dutch Research Funding (NWO), the Netherlands

Options to improve or re-vitalize the BM: For a commercial use, a warning mode would be helpful (by alarm or push-messages). The personalization is at least in parts too complex, and the language localization should be improved.

For details, see business model canvas in the appendix.

4.2.6 European Forest Fire Information System (EFFIS)

Brief description of the service

The **European Forest Fire Information System** (EFFIS) is an operational information and alert system on forest fires in Europe. The EFFIS network is made up of experts on forest fires from countries and international organizations (e.g. FAO, UNECE). Its main role is to provide advice for the implementation and further development of EFFIS and recommendations for improved forest fire prevention in the European and Mediterranean regions.

The Joint Research Centre (JRC) of the European Commission (EC) set up in 1998 a research group to work specifically on the development and implementation of advanced methods for the evaluation of forest fire danger and mapping of burnt areas at the European scale. These activities led to the development of the European Forest Fire Information System (EFFIS) which became operational in 2000.

EFFIS was created through cooperative efforts of the countries and the EC Services and is open to all European countries.

Knowledge-holders

EFFIS has partners in 32 European and Mediterranean countries: https://effis.jrc.ec.europa.eu/partners.

Summary of business model and values

Business Model (BM) used: EFFIS is an operational public-funded service. Products are freely available via a web portal.

Asset dimension: EFFIS provides a number of web-based service products including short-term to seasonal forecasts for temperature and precipitation based on ECMWF model runs, wildfire risk viewer and data sets for download. Furthermore, historical data and reports[123] are freely available.

Type of value generated: The service provides information for risk assessment for wildfires based on meteorological data and prediction for Europe. Authorities as well as individuals can obtain warnings in real-time in order to do emergency and rescue planning.

Sustainability and equity of the BM: The information is freely available via a public website.

Alignment of customers and product: The products are improved continuously in exchange with the European partners.

Reasons for success or failure: The service already exists for more than 20 years in operational mode. It provides usable and freely accessible products which are continuously maintained and upgraded.

Financial dimension: The service receives long-term sustained funding by the EU.

Options to improve or re-vitalize the BM: Warnings apps for mobile devices could be a useful extension to the service.

For further details, see business model canvas in the appendix.

4.2.7 Fathom - Climate risk / flood management

Brief description of the service

Fathom is an SME founded in 2013 as a start-up of scientists from the University of Bristol. The aim of the company was to create a data-driven, research-led enterprise, providing transparent world-leading methods of understanding water risk. Today, the company works with a variety of users from small organizations to government agencies to multinational corporations, across industries including humanitarian aid, insurance, international development, engineering, conservation, and financial markets. As of December 2023, Fathom is a subsidiary of Swiss Re.

Fathom's products are designed to support customers to understand flood risks both now and in the future. Products encompass global flood maps, catastrophe modelling and terrain data.

Knowledge-holders

Scientific expertise at Fathom encompasses climate scientists, coastal, hydrological and catastrophe modellers and software engineers. In addition, Fathom has several scientific partners such as University of Bristol, NASA, MetOffice, GfZ, NCAR etc.

Summary of business model and values

Business Model (BM) used: Fathom provides primarily B2B services for a variety of users from small organizations to government agencies to multinational corporations, across various sectors such as humanitarian aid, insurance, international development, engineering, conservation and financial markets.

Asset dimension: The overall assets of Fathom are 3-fold: High resolution flood modelling in coastal and river areas, catastrophe modelling (with respect to flooding events), high resolution terrain data.

Type of value generated: Climate related (due to extreme events) flood risk estimates and impacts and planning support in flood risk areas[124,125]. Thus, there is a financial impact but also a benefit for society by reducing the risks and potential impacts of flooding events.

Sustainability and equity of the BM: Applying flood risk management will reduce impact of climate-related extreme events and safeguard people and assets.

Alignment of customers and product: Fathom is working closely with their customers in order to optimize the impact of the services.

Reasons for success or failure: The proven and transparent (documented by scientific publications) scientific background and high-quality data provides a sound basis for developing high-quality products and services. After 10 years at the market, Fathom has developed to a successful global leader in the area of flood risk assessment which is also documented through the transition to a globally operating reinsurance company (Swiss Re).

Financial dimension: The revenue of the company comes through sales of mapping products, data, and consultancy.

Options to improve or re-vitalize the BM: The transition of Fathom to Swiss Re could provide new opportunities and markets.

For further details, see business model canvas in the appendix.

4.2.8 FOCUS-Africa

Brief description of the service

FOCUS-Africa (Full-value chain Optimised Climate User-centric Services for Southern Africa) is an EU H2020 funded project (2021-2024), with 13 partners, who aims to develop tailored climate services in the SADC (Southern African Community Development) region. The full value chain of climate services is being demonstrated by piloting eight case studies in five countries (Tanzania, Mozambique, South Africa, Malawi, and Mauritius), involving a wide range of stakeholders and following a co-production approach. The case studies illustrate how the use of climate science, forecasts and projections can maximise socio-economic benefits in the targeted countries and potentially in the whole of Africa. To provide a range of examples where climate service delivery can be successfully implemented, four key sectors are targeted: agriculture, water, energy, and infrastructure. The project develops and/or improves the following climate services for each respective case study:

- Climate projections for the agriculture in South Africa
- Tailored climate forecasting information for the agricultural sector of Tanzania
- Climate projections for the infrastructure sector in Tanzania
- Seasonal forecasts for the hydropower, solar and wind energy sectors in Tanzania
- Seasonal forecasts for the agricultural sector of Malawi
- Climate projections for the hydropower sector in Malawi
- Tailored climate forecasting information for the agricultural sector of Mozambique
- Seasonal forecasts for water management in Mauritius

Knowledge-holders

Knowledge holders differ depending on each case study. Climate information and background are provided by several research and industrial partners: CSIR (Council of Scientific & Industrial Research), WMO (World Meteorological Organisation), BSC (Barcelona Supercomputing Centre), WEMC (World Energy & Meteorology Council), TARI (Tanzania Agricultural Research Institute), TMA (Tanzania Meteorological Authority), UK Meteorological Office, DCCMS (Department of Climate Change and Meteorological Services Malawi), INAM (Mozambique National Meteorology Institute), MMS (Mauritius Meteorological Services).

End users are involved in the co-production process from the beginning and include: South African Land Bank, Small-holder farmers using the climate services, TANESCO (Tanzania Electric Supply Company), EDF (Electricité de France), WRU (Mauritius Water Resources Unit), FAREI (Mauritius Food and Agricultural Research and Extension Institute).

Summary of business model and values

Please note that the following points are preliminary and / or tentative as the project is still running.

Business Model (BM) used: Different approaches are applied as products are derived from seasonal forecasts as well as from climate change predictions. Products are jointly developed with the user groups from different sectors.

Asset dimension: Users receive targeted information which can be applied to their purposes. These range from seasonal forecast products[126] e.g. for agriculture or energy to climate change scenarios for adaptation. Based on the climate information and background relevant to the sectors, individual assets are created by interaction with the various user groups and applying the services to different sectors.

Type of value generated Beyond building of knowledge and trust the results from seasonal forecasting and climate projections may lead to higher yields, more efficient power production and improved water management. Thus, the CS have potential of economic value. In addition, the studies are expected to also have some social impact due to knowledge transfer and educational impact.

Sustainability and equity of the BM: As many users of climate services in Africa are limited in financial but also educational resources, the availability of the services including training and knowledge transfer for low or no costs are essential for sustainable and equitable CS.

Alignment of customers and product: The climate services in Focus Africa are built in close cooperation with the users. The co-design process of the products is key in this project to build mutual understanding and trust.

Reasons for success or failure: The success of the climate services in Focus Africa crucially depends on the ability to build up trust to the various user groups. In addition, access to the services and lack of downscaled information can hinder the success at least in some areas. The interpretation and understanding of results are another key item in particular in rural areas. Quality measures for the various products of the project.

Financial dimension: The project received third-party (public) funding through Horizon 2020. Total EU-funding is 7 Mio. €.

Options to improve or re-vitalize the BM: 1. Long-term funding perspectives beyond the end of the project to sustain the availability of the climate services for low or no costs for the user side. 2. Further develop interaction with local users to build knowledge and understanding of results including uncertainties and limitations.

For further details, see business model canvas in the appendix.

4.2.9 INDECIS

Brief description of the service

INDECIS, "Integrated Approach for the Development across Europe of user-oriented climate indicators for GFCS (Global Framework for Climate Services) high-priority sectors: agriculture, disaster risk reduction, energy, health, water and tourism"[127], constitutes a pan-European effort focused on the development and production of climate indices, specifically targeting the priority sectors of the GFCS plus tourism and their conversion into climate services by engaging stakeholders in their definition and communication. The main objective of the project is to develop historical high quality and dense climate networks across Europe based on long-perspective time series of different stations-based meteorological variables from which accurate and robust climate indices can be calculated to create user-oriented climate products and services.

Knowledge-holders

In total 16 partners across Europe, coordinated by the Universitat Rovira i Virgili, Spain. Partner encompass National Weather Services and climate research institutes across Europe.

Summary of business model and values

Business Model (BM) used: Online tool for 125 sector-oriented (Agriculture and Food Security, Disaster Risk Reduction, Energy, Health, Water and Tourism) climate indices based on historical data (from 1950 onwards) and trends. A more detailed study was conveyed for the tourism sector[80].

Asset dimension: Information about many climate indices of historical data (1950-2019) relevant for different sectors can be displayed through two online tools: https://indecis.csic.es and https://ectaci.csic.es/ (European Climatology and Trend Atlas of climate indices). Data can be obtained through a separate data portal (http://www.indecis.eu/data.php). In addition, INDECIS has created or supports different software suites for climate data quality control and homogenisation, indices calculation, datasets inter-comparison and climate indices visualization (http://www.indecis.eu/software.php).

Type of value generated: Although the portals do not provide information on future climate developments, the analysis of historical data can provide insights into changes of climate parameters relevant for different sectors.

Sustainability and equity of the BM: The tools are freely available but not maintained after the end of the project.

Alignment of customers and product: For the use case for the tourism sector (Barnet et al., 2021) a comprehensive co-development process was applied. The indices portal follows a more scientific focused approach.

Reasons for success or failure: Due to the limited project funding, further developments of applications were not possible. The tourism case study has enrolled some potential applying the results to a practical example.

Financial dimension: The project received third-party (public) funding from different sources as FORMAS (SE), DLR (DE), BMWFW (AT), IFD (DK), MINECO (ES), ANR (FR) with co-funding by the European Union (Horizon 2020).

Options to improve or re-vitalize the BM: To re-vitalize the tool, sustained funding would be required. In the present form, a commercialization is not very likely as the products are too scientific and usable. The use case in the tourism sector showcased some potential for commercialization.

For further details, see business model canvas in the appendix.

4.2.10 MED-GOLD

Brief description of the service

MED-GOLD (Turning climate-related information into added value for traditional MEDiterranean Grape, OLive and Durum wheat food systems)[80,128,129] (EU H2020 funded project, 2017-2022, 16 partners, see https://doi.org/10.3030/776467) aims to develop novel pilot climate services focusing on three staples of the Mediterranean food system: grape, olive, and durum wheat. The long-term objective of MED-GOLD is to make European agriculture and food systems more resilient, sustainable, and efficient in the face of climate change, by using climate services to minimize climate-driven risks/costs and seize opportunities for added value. Rather than the usual web portal, MED-GOLD was deliberate in generating an ICT ecosystem for climate services in agriculture as a final result (see infographics https://doi.org/10.5281/zenodo.7928703) which is being further developed and used in both research and industry contexts, see detailed info on the Horizon Results Platform.

Knowledge-holders

Climate information and background provided by several research partners (BSC, CNR, MetOffice, NOA, UNMG, U Leeds, and UTH), matched with expertise in the above-mentioned agricultural sector from a number of companies (Barilla, DCOOP, SOGRAPE). Advanced decision support systems and digital platforms were developed by HORTA, EC2CE, BEETOBIT, GMV. Thus, in this project an attempt was made to provide (scientific) knowledge about seasonal climate variations and long-term climate change and to combine it with knowledge in the (commercial) agricultural sector to increase economical value (and trust) to users.

Summary of business model and values

Business Model (BM) used: MED-GOLD's business model revolves around providing tailored climate services in agriculture, enhancing decision-making and productivity in the agro-food sector.

Asset dimension: The provider consortium developed a decision dashboard on the basis of seasonal forecasts products. Scientific expertise on climate predictions plus expertise in the development of software tools was brought in by several (private) partners. The dashboard was specifically tailored to the needs of companies active in the agriculture sector.

Type of value generated: The project primarily generates economic value by improving agricultural productivity and decision-making efficiency. Additionally, it may contribute to environmental and social value through sustainable agricultural practices and enhanced food security.

Sustainability and equity of the BM: The business model appears sustainable, focusing on long-term climate services and promoting resilience in agriculture. The emphasis on open data and transparent data treatment suggests a commitment to equitable access to information.

Alignment of customers and product: MED-GOLD's services are aligned with the needs of its customer segments, which include public administrations, agribusiness companies, and farmers' associations, focusing on their specific climate-related decision-making needs.

Reasons for success or failure: The success of MED-GOLD's business model likely hinges on its ability to provide accurate, tailored climate services that meet the specific needs of its target market. Challenges may include market penetration and the complexity of integrating climate services into existing agricultural practices.

Financial dimension: The project received third-party (public) funding through an EU Horizon 2020 project. A planned commercialization was not implemented after the end of the project. The total EU-funding is in the order of 5 Mio. €.

Options to improve or re-vitalize the BM: Potential improvements could include expanding customer segments, enhancing user-friendliness of climate services, and continuous innovation in climate data analysis and prediction accuracy. Strengthening partnerships and community engagement might also contribute to its revitalization.

For further details, see business model canvas in the appendix.

4.2.11 REACHOUT

Brief description of the service

REACHOUT is an EU-funded research and innovation project to advance user-oriented climate services to support the implementation of the Green Deal. Therefore, research partners, climate service providers and city stakeholders are co-developing a coherent set of services for seven city hubs across the EU. These services support cities to **A**nalyse hazard, exposure and vulnerability to climate change, formulate **A**mbitions for Climate Resilient Urban Development, and identify, evaluate and select adaptation **A**ctions for implementations. This so-called Triple-A toolkit builds upon and utilizes existing tools and services to ensure sustainability beyond the lifetime of the project.

Knowledge-holders

The consortium of REACHOUT is co-led by Deltares and CAS (Climate adaptation Service) and comprises 10 partners.

Summary of business model and values

Business Model (BM) used: The Triple-A toolkit brings together stand-alone tools, guidance, fit-for-purpose visualizations and tailored climate services to engage policymakers with Triple-A climate adaptation tools, which cover all steps of the adaptation cycle to provide cities with the necessary resources to accelerate urban adaptation to climate change. Examples for tools used in REACHOUT are: Climate Resilient City Tool, FloodAdapt Tool, Thermal Assessment Tool (see https://reachout-cities.eu/tools/ for more information).

Type of value generated: The use of the tools will enable cities to better adapt to climate change. This can lead to substantial economic savings (due to risk reductions) but also to social benefits by increasing awareness and ability to adapt and mitigate climate change.

Sustainability and equity of the BM: The project uses existing tools (see above) that are integrated in the Triple A-toolkit.

Alignment of customers and product: For the development and implementation of the tools in the selected cities of REACHOUT, transdisciplinary co-production processes are applied.

Reasons for success or failure: The project is still active and will end in 2025.

Financial dimension: The project received funding through the EO Horizon 2020 project. The total funding by the EU is in the order of 5 Mio. €.

Options to improve or re-vitalize the BM: not applicable: the project is still active and will end in 2025.

For further details, see business model canvas in the appendix.

4.2.12 RECEIPT (Climate stories)

Brief description of the service

RECEIPT (**Re**mote **C**limate **E**ffects and their **I**mpact on European sustainability, **P**olicy and **T**rade) is an EU-funded project that will map the sensitivity of five European socio-economic sectors to climate change features that occur outside its borders. The aim is to provide quantitative information on the European risks from remote climatic events. The project's key deliverables include a map of global hotspots of remote areas with climatic features relevant for Europe, and scientific narratives (climate stories) describing the impact on Europe's food security, financial sector, international development, and coastal infrastructure. It will deliver a Europe-wide socio-economic risk assessment showing the differences between high-end and moderate climate change conditions. The project finished at the end of 2023.

Knowledge-holders

The consortium of RECEIPT is led by Deltares and comprises 17 partners from 9 countries.

Summary of business model and values

Business Model (BM) used: The central product of RECEIPT is the "Climate storyline visualiser" (www.climateimpactstories.eu) which builds and shows climate change impact stories that occur far away from European borders, and their direct or indirect consequences on the European Union. This is done by a bottom-up approach and a sector-oriented perspective. The sectoral 'storylines' contain narratives of consistent and plausible chains of events, stories and data that illustrate risk-oriented cause-effect interactions. The storylines evaluate drivers and impacts of specific events, and map changing climatic and socio-economic drivers onto the cause-effect chains, in order to illustrate the implications of climate change. Outreach material in the form of policy briefs (https://climatestorylines.eu/policy-briefs/) and quiz (http://www.quiz.climatestorylines.eu) is produced.

Type of value generated: RECEIPT is a research project focused on the development of the storyline approach to explore complex impact transmission pathways now and in the future. Its main products are research papers and policy briefs. The storylines showcase possible linkages between remote areas and European economic sectors. Considering for instance historic hurricanes, their devastating impacts in the Caribbean and the subsequent consequences for European insurance: a storyline shows how would the chain of events can look like when the hurricanes follow different pathways. It also explores what global warming does to their intensity, or frequency. The project investigated what would be the effects for the EUSF insurance system if it would need to cover multiple events, at different locations, but in a short period of time. Constructing plausible storylines, rooted in historic events introduces a novel approach to explore the implications of a warming planet.

Sustainability and equity of the BM: The project does not have a Business Model in terms of economic features. Together with the sister project CASCADES (https://www.cascades.eu), a strong community of users and developers of approaches that deals with cascading and cross-border climate change impacts was built.

Alignment of customers and product: The storylines were developed in close cooperation with users and the scientific community.

Reasons for success or failure: As the project did not aim to produce commercial values but raise societal awareness for teleconnection of climate risks it was a successful endeavour.

Financial dimension: The project received funding through the EU Horizon 2020 project in the order of 7 Mio. €. The project does not have a Business Model in terms of economic features, thus no revenue of the costs.

Options to improve or re-vitalize the BM: The products can in this form presumably not be commercialised.

For further details, see business model canvas in the appendix.

4.2.13 RECONECT

Brief description of the service

RECONECT[130] aims to rapidly enhance the European reference framework on Nature-Based Solutions (NBS) for hydro-meteorological risk reduction by demonstrating, referencing, upscaling and exploiting large-scale NBS in rural and natural areas.

RECONECT will stimulate a new culture of co-creation of 'land use planning' that links the reduction of hydro-meteorological risk with local and regional development objectives in a sustainable and financially viable way.

To do that, RECONECT draws upon a network of carefully selected demonstrators and collaborators that cover a wide and diverse range of local conditions, geographic characteristics, institutional/governance structures, and social/cultural settings to successfully upscale NBS throughout Europe and Internationally.

To achieve these ambitious goals, RECONECT brings together an unprecedented transdisciplinary partnership of researchers, industrial partners (SMEs and large consultancies) and authorities/agencies at local and watershed/regional level fully dedicated to achieving the desired outcomes of the project.

Knowledge-holders

In total 37 partners across Europe and beyond (Brazil, Malaysia, Thailand), coordinated by IHE Delft, The Netherlands. The RECONECT Consortium is a transdisciplinary partnership between researchers, industry partners (SMEs and large consultancies) and responsible agencies at the local and watershed/regional level.

Summary of business model and values (requires additional input)

Business Model (BM) used: Core of the project is the RECONECT Services Platform which is an ICT (Information & Communication Technology) ecosystem supporting the demonstrators and collaborators in terms of data storage, analysis, and visualisation. The central element of the platform is the so-called TeleControlNet, a SaaS (Software as a Service) used to collect in-situ data and connected with the other platform components.

Asset dimension: Various processes contributing to NBS, such as: data collection, monitoring, evaluation, modelling, operation, and training.

Type of value generated: Nature-to-nature and nature-to-people non-commercial values have been shown (Viti et al., 2022), potential economic value by applying NBS for risk reduction purposes, potential commercial value by commercialization of the RECONECT platform.

Sustainability and equity of the BM:

Alignment of customers and product: demonstrator projects were developed in close cooperation between providers and users.

Reasons for success or failure: The project is still active and will end 08/2024.

Financial dimension: The project received funding through the EO Horizon 2020 project (EU contributions: 13.4 Mio. €, total 15.4 Mio. €).

Options to improve or re-vitalize the BM: The project is still active and will end 08/2024.

For further details, see business model canvas in the appendix.

4.2.14 REPATH - Climate risk management

Brief description of the service

Management of climate risks will be one of the most important challenges as a consequence of climate change. As more than 60% of companies are already suffering financial losses due to climate risks which will substantially increase in the coming years and decades even if emissions decrease rapidly. Nevertheless, many forward-looking decisions still do not consider climate risks. In addition, mandatory climate risk reporting obligations are emerging globally.

The repath GmbH is a German start-up that provides B2B solutions for climate risk management in particular for energy providers. The core of the service is a software product which empowers businesses to identify, understand and effectively manage global climate risks. The company, which was co-founded by former scientists from the Climate Service Center Germany (GERICS), uses publicly available high-resolution model results (max. 12x12 km) from CORDEX climate change projections (RCPs 2.6, 4.5, 8.5). Repath solutions uses 13 climate indices, categorized into temperature-related hazards, wind-related hazards, and water-related hazards.

Knowledge-holders

Repath is a German start-up of climate scientists and software developers that provide solutions for climate risk management based on publicly available data and a customized software product.

Summary of business model and values

Business Model (BM) used: Repath developed a standardized software product for climate risk assessment for energy providers to facilitate decision making for climate change adaption and mitigation issues.

Asset dimension: The provider developed a software-based solution using model output of high-resolution climate change scenarios. The overall goals of Repath are 3-fold: Climate Risk Transparency, Resilient Investment Decisions, Climate Risk Reporting

Type of value generated: Economical / financial values can be generated, or losses mitigated respectively based on the risk assessment tools.

Sustainability and equity of the BM: Applying climate risk assessments can contribute successfully towards a transition to a low-carbon economy.

Alignment of customers and product: Repath is trying to provide their customers solutions which are efficient and easily applicable to climate risk assessment of their assets.

Reasons for success or failure: Repath has a strong scientific background as the founders worked for the Climate Services Center Germany before. They were successful acquiring funds from investors to support their start-up, founded in 2021. There is demand on the market, in particular in the financial and energy sector, nevertheless Repath has to compete with globally

operating consulting companies. Their niche could be their proven scientific expertise and regional networks for German customers.

Financial dimension: The revenue for the company is generated through sales of their software-based solutions.

Options to improve or re-vitalize the BM: The increasing demand for climate risks assessments and the TCFD framework provides potential to sustain and expand the climate service provided by Repath.

For further details, see business model canvas in the appendix.

4.2.15 RESPONSE

Brief description of the service

RESPONSE (Integrated Solutions for Positive Energy And Resilient Cities) aims to establish a strategic vision for Smart Cities Energy Transition[131,132]: Climate-neutral cities by 2050. RESPONSE aims to turn energy sustainability into a do-able vision by solving the energy trilemma (security, equity/affordability, environmental sustainability) at building, block and district levels in smart cities. The project builds upon intelligent integrated and interconnected energy systems coupled with demand-oriented city infrastructures, governance models and services that foster energy sustainability.

RESPONSE supports the lighthouse cities (LH) of Dijon (FR) and Turku (FI) and their fellow cities (FH) Brussels (BE), Zaragoza (ES), Botosani (RO), Ptolemaida (GR), Gabrovo (BU) and Severodonetsk (UA) to facilitate them deliver positive energy blocks and districts. It will attract the interest of various stakeholders by generating innovative business models enabling the upscale and replication of the solutions forming a validated roadmap for sustainable cities across Europe and beyond. The overall focus of the project is to create resilient and safe cities whilst increasing the quality of life and lowering the impacts of climate change.

Knowledge-holders

The consortium of RESPONSE is led by European Institute for Energy Research (EIFER) Germany, being technically supported by Centre for Research and Technology Hellas, CERTH, Greece, and comprises a total of 53 partners.

Summary of business model and values

Business Model (BM) used: RESPONSE aims to generate novel and sustainable business solutions and suitable BMs to support and stimulate the market deployment of the smart city solutions in the lighthouse and fellow cities, while recognizing and eliminating barriers and/or risks; and identifying potential non-energy services to generate new revenue streams. Investors and citizens' perspective will be analysed, to promote replication of BMs. BMs developed will be applied in the LH cities and adapted in the FCs, with a special focus on governance aspects in view of accelerating the smart economy of the cities involved but also act as exemplars for EU cities beyond the RESPONSE.

Type of value generated: RESPONSE will support the two LH cities and the six FCs in delivering positive energy blocks and districts. Specifically, it will aim to achieve a local renewable energy systems penetration of 11.2 GWh/y, energy savings of 3,090 MWh/y and an emission reduction of 9,799 tons CO2 eq/y within the districts of the two Lighthouse Cities. The focus will be on heating and cooling systems, optimising energy flows with novel storage systems and linking with existing applications and other digital infrastructure.

Sustainability and equity of the BM: The BMs derived in the RESPONSE Project for Smart City Solutions and Governance Capacity aims to assist smart cities and stakeholders to capture value, by ensuring sustainable and replicable strategies.

Alignment of customers and product: Products are developed in close cooperation with users in LH and FCs.

Reasons for success or failure: The project is still active until September 2025.

Financial dimension: The project received funding through the EO Horizon 2020 project in the order of 20 Mio. € (Total costs 23.5 Mio. €). All BMs in the Turku BM Portfolio are profitable when evaluating them on the basis of non-monetary revenues, as they are addressing the challenges of the city (e.g., climate change mitigation and adaptation, citizens well-being, social equity and accessibility). For the Lyon BMs several are actually non-profitable, or only profitable in the **mid to long-term.**

Options to improve or re-vitalize the BM: The project is still active until September 2025.

For further details, see business model canvas in the appendix.

4.2.16 S2S4E

Brief description of the service

S2S4E (Sub-seasonal to Seasonal Climate Predictions for Energy) was an EU H2020 funded project (2017-2020) with 12 partners, who aimed to provide more reliable and usable climate forecasts for renewable energy (solar, wind and hydropower) production, with the long-term goal to make the European energy sector more resilient to climate variability and extreme events. Within the S2S4E project, a novel Decision Support Tool (DST) was developed to facilitate the usage of climate predictions tailored to user needs. The project ended in 2020.

Knowledge-holders

Stakeholders from the energy sector, scientists within climate physics and psychology (user interactions with the tool) and CS providers (Capgemini, Nnergix and TCDF) were involved in the project. The number of users involved in the project was limited compared with the ambitious objective of the project to provide useful information for the operation of several renewable energy sources in different parts of Europe. The team concluded by the end of the project that they still lacked knowledge on how to commercialise the CS. In response a specialist was hired to help facilitate the commercialisation of the CS. The tool is no longer operational after the end of 2020.

Summary of business model and values

Business Model (BM) used: The business model is the transfer of (subseasonal to seasonal) weather & climate information for planning processes in the renewable energy sector via a specially designed decision support tool (DST). The plan was to commercialize the product with an annual subscription fee. The business model is based on the provision of tailored climate predictions (sub seasonal and seasonal forecasts) for the energy sector. The operational forecasts would be distributed upon subscription, through a user-friendly tool that supports decision-making for different clients in the energy market (for example: energy producers, TSOs, and energy traders). High resolution forecasts can be provided globally.

Asset dimension: The provider consortium developed a decision support tool on the basis of subseasonal to seasonal forecasts products[133]. Scientific expertise on climate predictions plus expertise in the development of software tools is brought in by several (private) partners. The DST was specifically tailored to the needs of companies active in the renewable energy sector. Part of the information is also available to the public via the S2S4E website.

Type of value generated: Building of mutual understanding and trust are assets as an outcome of the project. Nevertheless, the value of the forecast itself is critically dependent on the end-user's risk preferences and risk-management goals. Although the product was usable free of charge, the DST has potential for a commercialization. Open question is whether there would be a willingness to pay for the service, although the trust in the present forecast products is limited. S2S4E direct impact is the optimisation of the decision-making processes of its users, which can potentially lead to economic benefits for the business. By helping renewable energy companies in coping with climate variability, S2S4E was expected to contribute to the increase of renewables in the energy mix, leading to a decrease in GHG emissions.

Sustainability and equity of the BM: The service itself was limited to the usage of partners and ended because the service was not commercialized by the end of the project. It was expected to provide environmental benefits (greater resilience for energy systems and improved viability of renewables) and social benefits (partners collaborate with honesty and transparency to bring scientific research into practical use).

Alignment of customers and product: The project has shown that in practice social bonds of trust have more influence on how decisions are taken than technical metrics of forecast performance. The co-production of the DST with energy sector users that were part of the project guaranteed the alignment with customer needs.

Reasons for success or failure: By end of the project, the DST had more than 1,000 registered users. Although the users were involved in the development of the CS, they still need to develop trust in the forecasts to make decisions. Users were not yet ready to make real time decisions based on the service. The DST needs to be accompanied by technical support and customer service.

Financial dimension: The project received third-party (public) funding through an EU Horizon 2020 project in the order of 4.8 Mio. €. A planned commercialization was not implemented after the end of the project.

Options to improve or re-vitalize the BM: The quality of the forecasts has to be improved to fulfil the requirements of the users. To support the maintenance of development of the DST

sustained funding and / or commercialization of the product is required. Many of the communication and dialogue initiatives have been broad and targeting a wide audience within climate and energy policy and research, and it is not clear how the more direct and focused co knowledge production with renewable energy sector in terms of the industry has been going on, and on the outcomes of these interactions.

For details, see business model canvas in the appendix.

4.2.17 SMHI Climate Change Scenario Service

Brief description of the service

The Swedish Meteorological and Hydrological Institute (SMHI) has developed an interactive scenario-based climate service (https://www.smhi.se/en/climate/future-climate/future-climate) that allows users to view the effects of the IPCSS's Representative Concentration Pathway scenarios (RCPs) on the entire country of Sweden. The service is split into Basic and Advanced functionalities. The "Basic Service" shows the effects of the RCP scenarios (RCP 2.6, RCP 4.5, and RCP 8.5) on temperature and precipitation in Sweden. The model outputs are shown in an interactive map format and the user can select the time frame the model should run on (2011-2040, 2041-2070, or 2071-2100). The "Advanced Service" considers extreme climate events as well as gradual climate change. The user can select the same parameters as for the "Basic Service" but can further specify the season they are interested in as well as choose between model outputs for meteorology, hydrology, or oceanography. The model results are presented in a map, graph, and table format. All the presented data is downloadable. The SMHI also offers tailored climate services using their climatic models for industry and professional users as well as for national and international projects.

Knowledge-holders

The service is developed based on results from the SMHI research department at Rossby Centre.

Summary of business model and values

Business Model (BM) used: The SMHI climate service provides information about climate change scenarios for Sweden in different modes of complexity via an interactive webpage. This information is freely available. More tailored information for industry and professional users is provided via a commercial branch of SMHI.

Asset dimension: Users can access climate change information of different physical parameters and indicators on an interactive webpage based on high-resolution model experiments using different climate change scenarios The domain is limited to Sweden. Additional educational material for climate change adaptation is provided.

Type of value generated: Users can get an impression about the climate change expected in Sweden according to different scenarios.

Sustainability and equity of the BM: The service is maintained by the SMHI on a semi-permanent basis (funding gets renewed on a yearly basis). The information is available free of charge via a public webpage.

Alignment of customers and product: SHMI had a long-lasting and well-established dialogue with county and city climate adaptation officers in order to provide usable information on a regional level. Nevertheless, as the service is publicly available, it will not be able to fulfil everybody's requirements. Although background information and explanations are provided, the products are best suitable for well-educated users. The information is split in a basic and an advanced section, the knowledge level required to understand the results is similar. Individual products are available separately on request.

Reasons for success or failure: The service is well established and used in particular by regional administrative bodies such as climate adaptation officers.

Financial dimension: The service is maintained by the SMHI through public funds. Fundings get renewed on a yearly basis.

Options to improve or re-vitalize the BM: The Rossby Centre developed the high-resolution (grid cells of 4 km^2) HARMONIE-Climate regional climate model, which is able to represent extreme weather events, and they are planning to expand on this model, coupling it with ocean models and vegetation processes. They are further working together with the European Centre for Medium Range Weather Forecasts (ECMWF) on developing an updated version of their global climate EC-Earth model, which will be used for international projects on climate change. SMHI is taking part in the EURO-CORDEX initiative.

For details, see business model canvas in the appendix.

4.2.18 Urban Water in Valencia (case study of INNOVA)

Brief description of the service

In the metropolitan area of Valencia, the water use is intense, and the region suffers from frequent droughts due to climate conditions. Valencia is surrounded by an agricultural landscape with a multi-sectoral structure in which irrigated agriculture plays an important role in the consumption of water.

Within the framework of the INNOVA project[85,86] a climate service was developed to explore the effects of climate change and potential requirements to adapt to these changes in order to ensure the availability and distribution of potable water in this region.

A chain of models was designed, validated and developed, consisting of 1) Global and regional climate models to obtain future projections of temperature and precipitation in the region; 2) Hydrological models of the system's sub-basins to obtain water inflows; 3) Water management model that simulates the operation of the water resource system to obtain the water inflows to the reservoir and its storage under climate change; 4) Reservoir model to simulate the water quality dynamics in the new climate scenarios[134].

The collaboration between the research team from the Universitat Politècnica de València and the managers from the water utility company Global Omnium began by establishing the research goals and objectives of the company with regards to the potential impact of climate change on the water service they provide.

Knowledge-holders

The service was jointly developed between the research team from the Universitat Politècnica de València and the managers from the water utility company Global Omnium.

Summary of business model and values

Business Model (BM) used: The business model for Urban Water in Valencia provides custom made information for the water management in the Valencia area.

Asset dimension: The provider and user consortium co-developed a solution to optimize water supply in the Valencia areas using a chain of models from climate models to hydrological and water management applications. Scientific expertise on climate predictions plus expertise on water management by private partners matched successfully.

Type of value generated: Building of trust is the major asset as an outcome of the project. Although there is no immediate economic value, the plans for water management developed in the project have potential for savings of the water supplier and users (e.g. through optimization of water supply or better water quality).

Sustainability and equity of the BM: A better water management supports a sustainable water supply in the Valencia area. The BM can in principle be applied to other cases/regions. The data used in the project was transparent to the user.

Alignment of customers and product: The climate service was very much aligned with the needs of users. The co-design process of the product building mutual understanding and trust was central in this project.

Reasons for success or failure: The success of the business model crucially depends on the quality of the model results. Close interaction and collaboration between users and providers helped to improve the quality of the product substantially. The method is in principle applicable to other regions but clearly depends on local knowledge, willingness for collaboration and mutual understanding.

Financial dimension: The project received third party (public) funding through an ERA4CS (https://jpi-climate.eu/programme/era4cs/) project.

Options to improve or re-vitalize the BM: The project achieved the goals in Valencia. A second project phase with the goal to operationalize such a type of service was not funded.

For further details, see business model canvas in the appendix.

4.3 Summary and outlook

A variety of climate services examples (see Table 3 - Selected case studies) were analysed extensively using publicly available information as well as direct communication with project partners or companies. Five of these cases were pre-defined by the selected common case studies of Climateurope2. The selected climate services cover a broad range of sectors (see Figure 17 - Sectors covered by CS selected for this study.), with many services providing information on climate risks due to climate change that affect multiple sectors.

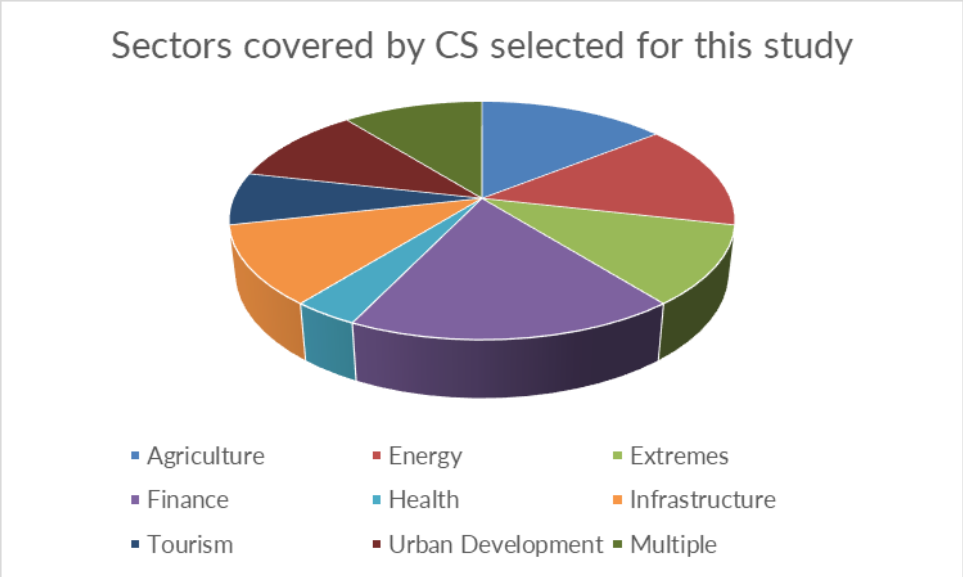

Figure 17 - Sectors covered by CS selected for this study.

The goal of this exercise was to collect more detailed information about business models (BM), values and innovation, impact, costs and revenues, success or failures of BM and potential to improve or revitalize CS.

Most of the examples (15 out of 18) in this chapter concentrate on publicly funded projects (EU or national sources), as there is still limited information from the private sector available. Reaching out to commercial services is often not as successful as for the public sector. On the other hand, services developed in the public sector are often prototypes without specific intention and/or perspective for commercialization. Although containing innovative ideas, many services would probably not be successful on the private market. Reasons for that are manifold, e.g., not enough customers, products are very specific and application / transformation for other customers is difficult to accomplish, funding is only limited for prototype development, expertise for commercialization, launch of start-ups and rising of venture capital is not existing or supported to name some reasons that many prototype climate services fail to be sustained and / or to be commercialized.

The values applying climate services are often not directly accountable: e.g., savings vs. costs for climate adaptation and mitigation applications because of long timescales or uncertainties or the increase in mutual understanding and trust which are important societal values.

In particular, publicly funded projects often encompass the development of custom-made individual solutions which are on one hand optimal for the customer but on the other hand too expensive from a commercial point of view. Thus, commercial providers often prefer to develop standardised products

which are able to capture most of the needs of their customers at reasonable costs and are capable of delivering information in a timely fashion fitting customers' needs.

Services funded by public sources often have a limited lifetime (project funding) and do not aim to produce a product which has the potential to be commercialized. Nevertheless, even in cases where a commercialization is explicitly formulated in the project goals the commercialization was successful (e.g. S2S4E). Reasons for this failure are different ranging from legal problems (who is the owner of a service?), market problems (sufficient customers), product deficiencies / lack of innovation, to financial issues (willingness to pay versus costs). Two of the examples from the private sector (Repath and FATHOM) build on a sound scientific basis and were able to allocate financial resources for a start-up. In contrast, the Climanomics service is a commercial product provided by a large consultant company (S&P) with a clear focus on a rapidly emerging market segment (climate risk assessment for financial assets) that provides sufficient revenue for the product investment.

Within the public funded services, only the European Forest Fire Information System (EFFIS) and the Swedish Meteorological and Hydrological Service receives funding which is not limited to the lifetime of a project.

Project-funded services often develop a prototype service with custom-made high-quality products, but these are often not suitable for commercialization as either the potential market is not sufficient or substantial additional efforts are required for transformation and adaptation for other applications. On the other hand, research projects are often asked to include transfer of innovative knowledge and / or technology but the development of a functionable business model for future commercialization is not included. As a consequence, a large pool to prototype climate services which are developed are often not continued after the end of the project and are either phased-out or remain available without or little support and maintenance (e.g. Indices, S2S4E).

In this sense, many public climate services are not sustainable, as substantial resources were allocated to develop the products, but they cannot be used or transferred beyond the lifetime of the project. The advantage of public-funded projects is that the use is normally free of charge even though their use might be restricted to a limited audience. In this sense, commercial products cannot be as equitable as the provider needs a revenue for the investment.

What makes up a successful business model of a climate service versus reasons for failure?

1. **Idea / product that meets user needs**. The probability that an idea or product is successful which is developed without investigating that there is a need, a market for such a product is low. Thus, market evaluation and interaction with users are essential. Thus, co-designing a fit-for-purpose product is very helpful but it must fit not only for one or a small group of potential customers but for a wider market segment.
2. **Costs vs. revenue**. To be commercially successful, the revenue for selling the product have to be higher than the costs. This sounds obvious and simple but in particular for businesses that develop as start-ups of science the calculation of real costs (including maintenance, distribution, etc) are often lacking behind the development of innovative ideas for the product.
3. **Willingness-to-pay**. How much revenue can be received from a customer? An individual vineyard owner can make some savings due to a successful seasonal forecast, but he/she has also

to take failures into account. A larger cooperative might be willing to pay more but distribute the information to many others, thus reducing the market potential. In particular, in a non-developed emerging market the pricing has to be adjusted according to the willingness-to-pay for the product.

4. **Payment model**. Depending on the product, different payment models can be applied. Section xx provides an overview on the suite of business models that can be applied. The examples investigated in this study mostly use either subscription or receive their revenue e.g. for consulting by invoice to customers. For any type of software products, the payment model can be crucial, e.g. receiving a continuous revenue via a subscription vs. paying for a (lifetime) licence for a software.
5. **Competition**. Some parts of the market for climate services are emerging rapidly. E.g. the demand for risk assessments for the financial sector or climate adaptation plans for cities is continuously growing. Here, in particular, private companies offer more and more services in competition. Beside the quality of products also other instruments, like advertisements, pricing or optimizing of processes are required to compete with other actors in the market. Standards can help customers to better compare products on the market and increase trust and transparency.

Thus, the success or failure of commercializing a climate service depends on several factors and requires expertise beyond scientific quality of data or an appropriate co-design process. Many climate services, even with high quality products, will not be suitable to be commercialized but fulfil important and necessary needs for society to adapt to climate change. Thus, in this sense publicly funded climate services will also be required to cover a part of the market for climate services besides commercial applications. Public funding can initiate new areas, push innovation and, where needed, maintain societal important services through long-term sustained funding.

Table 3 - Selected case studies

Project / CS	Sectors	Scope[1]	BM / Tools	User scope	Funding / Revenue	Sustained funding / Revenue	Potential for commercialization
Adapter	Agriculture	ST & CC	Modelling, web-based maps	Open	Public (Helmholtz, national, D)	No, free product	Yes, but limited to users and willingness to pay
Anywhere	Div. / Multi - hazard	CC	Warning tools	Limited	Public (EU)	No, pilot projects only	Yes, Business Hub created, commercialization of products envisaged
Blue Action	Tourism	SP	Consultancy based on seasonal prediction	Limited	Public (EU)	No, prototype developed	Limited (due to forecast quality, user, willingness to pay
CLIMANOMICS	Risk assessment / Finance	CC	Digital assets (indices) / Consultancy	Limited	Private	Yes	Commercial service
ClimApp	Health	ST	Mobile phone app, free based on weather data	Open	Public (EU)	No	Limited (willingness to pay)
EFFIS	Extremes / Fire	ST & SP	Warning tools based on ST & SP	Open (partly limited)	Public (EU)	Yes (Public service)	Yes, but free by EU regulation
Fathon	Extremes / flooding	CC	Flood risk maps/data	Open	Private	Yes	Commercial service
FOCUS Africa[2]	Multiple sectors	SP & CC	Different tools & approaches	Limited	Public (EU)	No	Limited (willingness / ability to pay)

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Project / CS	Sectors	Scope[1]	BM / Tools	User scope	Funding / Revenue	Sustained funding / Revenue	Potential for commercialization
Indecis	Multiple sectors	HD & CC	Maps of climate indices	Open	Public (EU)	No	Yes, but product improvement required / willingness to pay
MED-GOLD[2]	Agriculture	SP and CC	Dashboard	Limited	Public (EU)	No	Yes, but willingness to pay / revenue
REACHOUT-CITIES	Urban planning	CC	Tripe A-Toolkit (different tools)	Limited	Public (EU)	No	Partially, some tools used have potential
RECEIPT	Multiple sectors	CC	Storylines (toolkit)	Open	Public (EU)	No	No, product not suitable
RECONECT	Nature based solutions	CC	Demonstrators (Software tool)	Limited	Public (EU) & Private	No	Yes, but willingness to pay / revenue
repath	Risk assessment	CC	Software product based on CC projections	Open	Private	Start-up	Commercial service
RESPONSE	Urban planning, renewable energy	CC	Master plans for demo cities	Limited	Public (EU)	No	Yes, business models part of the project

Project / CS	Sectors	Scope[1]	BM / Tools	User scope	Funding / Revenue	Sustained funding / Revenue	Potential for commercialization
S2S4E[2]	(renewable) Energy	SP & CC	Decision support tool	Open	Public (EU)	No	Commercialization planned but not implemented
SMHI[2]	Multiple sectors	CC	Interactive web-based maps	Open	Public (national)	Yes	No, product not suitable
Urban Water in Valencia[2]	(urban) Water	CC	Consultancy based on modelling	Limited	Public (EU)	No	Limited due to transferability, revenue

[1]Scope abbreviations: HD: Historical data, ST: Short-term (weather) prediction, SP: Seasonal prediction, CC: Climate Change

[2] Project-wide case studies within CE2

5 Conclusion and further work

This report offers an initial assessment of the business innovation theories, frameworks, and practices within the domain of climate services, aimed at facilitating the transition to climate-neutral and circular economies. While the deployment of these services is progressing, their full potential has yet to be realized. Addressing current challenges can enhance their user orientation and specific applicability. Developing sustainable business models is vital for ensuring the financial viability of climate services, leading to increased demand, wider adoption, and optimal benefit realization.

A review of business model frameworks for climate services revealed several insights: the prioritization of societal and environmental values alongside financial viability, the necessity of user-centric models for service success, and the need for traditional business models to evolve to meet broader sustainability goals. While traditional frameworks provide a solid starting point, tailored adjustments are often required for climate services' unique goals. Despite progress in climate services, literature on sustainable business model innovation showed mixed results. Research on business strategies and mechanisms supporting the long-term viability of climate services is less developed compared to other sectors. However, the field benefits from a range of incentives from sustainable finance, such as risk disclosures and sustainability reporting, which promote the adoption of sustainable practices. This review also extracts innovation elements from other fields to inform the development of tailored business models for climate services.

In exploring the practices of climate service providers, a detailed analysis uncovers essential beliefs and approaches needed for service development and deployment. Understanding user needs through market evaluation and engagement is crucial for product relevance across diverse market segments. Financial sustainability through cost-effective strategies, responsive pricing in emerging markets, and diverse payment models are fundamental for commercial success. Despite the fact that some services may not be commercially feasible, they fulfil vital societal functions. Publicly funded climate services complement commercial efforts, driving innovation and guaranteeing the continuation of essential services.

The future work will focus on several priorities. Firstly, although more than 260 business models have been identified, not all have been analysed for the purposes of this report. The analysis will continue to identify key common elements and combine them into a coherent taxonomy-like framework to establish a foundation for further advancements in business innovation for climate services. Building upon the identified elements, the business choices will be further detailed and accompanied by patterns of innovative choices leading to better outcomes. Secondly, the analysis of specific climate services, which serve as a pool of prevailing practices and identified opportunities, will be continued. This analysis will provide the opportunity for testing the business innovation patterns and choices identified previously, ultimately contributing to extending a compendium of good practices and recommended principles. By working with specific services, the analysis will provide additional insights into the decisions made by providers and the requirements advanced by the users of climate services. It will also be instrumental in providing tailored assistance for advancing the innovation strategies of the selected services, through coaching or counselling, which is another objective of WP3 and a priority for future work.

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6 References

1. Hanel, P. H. P., Litzellachner, L. F. & Maio, G. R. An Empirical Comparison of Human Value Models. *Front. Psychol.* **9**, (2018).

2. Smith, J. B. & Colgate, M. Customer Value Creation: A Practical Framework. *J. Mark. Theory Pract.* **15**, 7–23 (2007).

3. Woodruff, R. B. Customer value: The next source for competitive advantage. *J. Acad. Mark. Sci.* **25**, 139–153 (1997).

4. Zeithaml, V. A., Verleye, K., Hatak, I., Koller, M. & Zauner, A. Three Decades of Customer Value Research: Paradigmatic Roots and Future Research Avenues. *J. Serv. Res.* **23**, 409–432 (2020).

5. Shafer, S. M., Smith, H. J. & Linder, J. C. The power of business models. *Bus. Horiz.* **48**, 199–207 (2005).

6. Falloon, P., Fereday, D., Stringer, N., Williams, K. & al Gornall J, et. Assessing skill for impacts in seasonal to decadal climate forecasts. 1–4 (2013) doi:10.4172/2329-6755.1000e111.

7. Tikkanen, H., Lamberg, J., Parvinen, P. & Kallunki, J. Managerial cognition, action and the business model of the firm. *Manag. Decis.* **43**, 789–809 (2005).

8. Doganova, L. & Eyquem-Renault, M. What do business models do? *Res. Policy* **38**, 1559–1570 (2009).

9. Geissdoerfer, M., Vladimirova, D. & Evans, S. Sustainable business model innovation: A review. *J. Clean. Prod.* **198**, 401–416 (2018).

10. Bocken, N. M. P., Short, S. W., Rana, P. & Evans, S. A literature and practice review to develop sustainable business model archetypes. *J. Clean. Prod.* **65**, 42–56 (2014).

11. Gassmann, O., Frankenberger, K. & Sauer, R. Exploring the field of business model innovation: New theoretical perspectives. in *Exploring the field of business model innovation: New theoretical perspectives* 1–118 (Springer International Publishing, 2016). doi:10.1007/978-3-319-41144-6.

12. Lüdeke-Freund, F., Carroux, S., Joyce, A., Massa, L. & Breuer, H. The sustainable business model pattern taxonomy—45 patterns to support sustainability-oriented business model innovation. *Sustain. Prod. Consum.* **15**, 145–162 (2018).

13. Rashid, A., Asif, F. M. A., Krajnik, P. & Nicolescu, C. M. Resource Conservative Manufacturing: an essential change in business and technology paradigm for sustainable manufacturing. *J. Clean. Prod.* **57**, 166–177 (2013).

14. Miles, I. *et al.* Knowledge-intensive business services: Users, carriers and sources of innovation. *EIMS Publ.* **15**, (1995).

15. Amara, N., Landry, R. & Traoré, N. Managing the protection of innovations in knowledge-intensive business services. *Res. Policy* **37**, 1530–1547 (2008).

16. Larosa, F. & Mysiak, J. Business models for climate services: An analysis. *Clim. Serv.* **17**, (2020).

17. Krumeich, J., Werth, D., Burkhart, T. & Loos, P. Towards a component-based description of business models: A state-of-the-art analysis. in vol. 1 266–277 (2012).

18. Andersson, B. *et al.* Towards a Reference Ontology for Business Models. in *Conceptual Modeling - ER 2006* (eds. Embley, D. W., Olivé, A. & Ram, S.) vol. 4215 482–496 (Springer Berlin Heidelberg, Berlin, Heidelberg, 2006).

19. McCarthy, W. E. The REA Accounting Model: A Generalized Framework for Accounting Systems in a Shared Data Environment. *Account. Rev.* **57**, 554–578 (1982).

20. Osterwalder, A. & Pigneur, Y. *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. (Modderman Druckwerk, Amsterdam, 2010).

21. Osterwalder, A., Pigneur, Y. & Tucci, C. L. Clarifying Business Models: Origins, Present, and Future of the Concept. *Commun. Assoc. Inf. Syst.* **16**, (2005).

22. Shafer, S. M., Smith, H. J. & Linder, J. C. The power of business models. *Bus. Horiz.* **48**, 199–207 (2005).

23. Remane, G., Hanelt, A., Tesch, J. F. & Kolbe, L. M. The business model pattern database — A tool for systematic business model innovation. *Int. J. Innov. Manag.* **21**, 1750004 (2017).

24. Osterwalder, A., Pigneur, Y. & Clark, T. *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. (Wiley, Hoboken, NJ, 2010).

25. CASE - Competencies for a sustainable socio-economic development. Sustainable Business Model Canvas. (2018).

26. Flourishing Business. Flourishing Business Canvas. (2024).

27. Joyce, A. & Paquin, R. L. The triple layered business model canvas: A tool to design more sustainable business models. *J. Clean. Prod.* **135**, 1474–1486 (2016).

28. Business Model Toolbox. Social Business Model Canvas. (2024).

29. Maurya, A. What is a Lean Canvas? (2024).

30. Usabilis. EMPATHY MAP (OU CARTE D'EMPATHIE) : QU'EST-CE QUE DIT, PENSE, FAIT ET RESSENT L'UTILISATEUR ? (2018).

31. Prelicz-Zawadzka, Zawadzki. user centered design canvas. (2023).

32. Osterwalder. The Mission Model Canvas: an adapted The Business Model Canvas for mission driven organizations. (2016).

33. Harvard Business Review. What Is Disruptive Innovation? (2015).

34. Sarafin, G. What business ecosystem means and why it matters. (2021).

35. James, C. *Theory of Change Review*. (2011).

36. Center for Theory of Change. What is Theory of Change? (2023).

37. De Reviers, B. *Repères Sur Les Théories Du Changement*. (2012).

38. Schuetz, Förch, Thornton, Vasileiou, T., Wiebke, Philip, Ioannis. *Pathway to Impact: Supporting and Evaluating Enabling Environments for Research for Development*. https://link.springer.com/chapter/10.1007/978-3-319-43702-6_4 (2017).

39. Tarver, E. Subscription Business Model Defined, How It Works, Examples. (2022).

40. Bloomenthal, A. E-commerce Defined: Types, History, and Examples. (2023).

41. Lefe Mary John, A. Freemium Business Model: Definition, Examples, Tips, Pros & Cons. (2023).

42. Ganoe, P. The Marketplace Business Model: Everything You Need to Know.

43. Cuofano, G. What is a business model ? (2024).

44. CFI Team. Transaction Costs. (2024).

45. Cuofano, G. What Is The Razor And Blade Business Model? Apple's Reversed Razor And Blade Strategy. (2023).

46. Cuofano, G. Pay-as-you-go Business Model. (2023).

47. Hayes, A. What Is a Franchise, and How Does It Work? (2023).

48. Alpha JWC Ventures. B2B Model Business: How It Works, and The Examples. (2023).

49. Pereira, D. What Is Business-to-Consumer (B2C)? Types and Examples. (2023).

50. Learning Loop. Open Business Model.

51. Deloitte. Platform Business Model explained…in under 100 words. (2024).

52. Opendatasoft. Data-as-a-Service / Data Service. (2024).

53. IPCC. Summary for policymakers. in *Contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change* (eds. Pörtner, H. O. et al.) 3–33 (Cambridge University Press, Cambridge, UK and New York, NY, USA, 2022).

54. Calvin, K. *et al. IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (Eds.)]. IPCC, Geneva, Switzerland.* https://www.ipcc.ch/report/ar6/syr/ (2023) doi:10.59327/IPCC/AR6-9789291691647.

55. Lüdeke-Freund, F., Carroux, S., Joyce, A., Massa, L. & Breuer, H. The sustainable business model pattern taxonomy—45 patterns to support sustainability-oriented business model innovation. *Sustain. Prod. Consum.* **15**, 145–162 (2018).

56. Bocken, N. M. P., Short, S. W., Rana, P. & Evans, S. A literature and practice review to develop sustainable business model archetypes. *J. Clean. Prod.* **65**, 42–56 (2014).

57. Evans, S. *et al.* Business Model Innovation for Sustainability. *Bus. Strategy Environ.* **26**, (2017).

58. Barrie, J., Schröder, P. & Sherman, S. *Making Sustainable Finance Taxonomies Work for the Circular Economy: Lessons from the EU Taxonomy*. https://chathamhouse.soutron.net/Portal/Public/en-GB/RecordView/Index/203206 (2023) doi:10.55317/9781784135690.

59. Gillabe, J., Manshoven, S. & Grossi, F. *Business Models in a Circular Economy*. (2021).

60. Ellen MacArthur Foundation. *Towards the Circular Economy: Economic and Business Rationale for an Accellerated Transition*. (2013).

61. World Economic Forum & Ellen MacArthur Foundation. *Towards the Circular Economy: Accelerating the Scale-up across Global Supply Chains*. (2014).

62. IPSF. International Platform on Sustainable Finance transition finance report - November 2022. (2022).

63. EC. Piano d'azione per finanziare la crescita sostenibile. (2018).

64. American Meteorological Society, A. *Weather-Water-Climate Value Chain(s): Giving VOICE to the Characterization of the Economic Benefits of Hydro-Met Services and Products*. (2021).

65. Directorate-General for Research and Innovation. *A European Research Innovation _ Roadmap for Climate Services*. (2015).

66. WMO. Step-by-step Guidelines for Establishing a National Framework for Climate Services. **1206**, (2018).

67. United Nations Environment Programme. *Common Framework of Sustainable Finance Taxonomy: For Latin American and the Carrabien*. (2023).

68. Corporate sustainability reporting - European Commission. https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en.

69. PricewaterhouseCoopers. Corporate Sustainability Reporting Directive. *PwC* https://www.pwc.nl/en/topics/sustainability/esg/corporate-sustainability-reporting-directive.html.

70. EBRD. *Introducing the EBRD Knowledge Economy Index*. (2019).

71. Shapira, P., Youtie, J., Yogeesvaran, K. & Jaafar, Z. Knowledge economy measurement: Methods, results and insights from the Malaysian Knowledge Content Study. *Res. Policy* **35**, 1522–1537 (2006).

72. Kragulj, F. A knowledge perspective on needs as a foundation for organisational learning processes. in *Theory and applications in the knowledge economy* (ed. Eduardo Tomé) (Aveiro, 2016).

73. Nonaka, I. & von Krogh, G. Perspective—Tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory. *Organ. Sci.* **20**, 635–652 (2009).

74. Vaughan, C. & Dessai, S. *Climate Services for Society: Origins, Institutional Arrangements, and Design Elements for an Evaluation Framework. WIREs Clim Change*. (2014).

75. Bremer, S. *et al.* Toward a multi-faceted conception of co-production of climate services. *Clim. Serv.* **13**, 42–50 (2019).

76. Cavelier, R. *et al.* Conditions for a market uptake of climate services for adaptation in France. *Clim. Serv.* **6**, 34–40 (2017).

77. Alexander, M. & Dessai, S. What can climate services learn from the broader services literature? *Clim. Change* **157**, 133–149 (2019).

78. Dilling, L. & Lemos, M. C. Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy. *Glob. Environ. Change* **21**, 680–689 (2011).

79. Brasseur, G. P. & Gallardo, L. Earth ' s future climate services : Lessons learned and future prospects. *Earths Future* 79–81 (2016) doi:10.1002/2015EF000338.Received.

80. Dell'Aquila, A. *et al.* Monitoring climate related risk and opportunities for the wine sector: The MED-GOLD pilot service. *Clim. Serv.* **30**, 100346 (2023).

81. Contreras, E. *et al.* Advances in the Definition of Needs and Specifications for a Climate Service Tool Aimed at Small Hydropower Plants' Operation and Management. *Energies* **13**, 1827 (2020).

82. Bolson, J. & Broad, K. Early adoption of climate information: Lessons learned from south florida water resource management. *Weather, Climate, and Society* vol. 5 266–281 (2013).

83. Jacobs, K. L. & Street, R. B. The next generation of climate services. *Climate Services* vol. 20 (2020).

84. Blundo-Canto, G., Andrieu, N., Soule-Adam, N., Ndiaye, O. & Chiputwa, B. Scaling weather and climate services for agriculture in Senegal: Evaluating systemic but overlooked effects. *Climate Services* vol. 22 (2021).

85. Rubio-Martin, A. *et al.* Structuring Climate Service Co-Creation Using a Business Model Approach. *Earths Future* **9**, e2021EF002181 (2021).

86. Swart, R. *et al.* Reframing climate services to support municipal and regional planning. *Clim. Serv.* **22**, 100227 (2021).

87. Dayamba, D. S. *et al.* Assessment of the use of Participatory Integrated Climate Services for Agriculture (PICSA) approach by farmers to manage climate risk in Mali and Senegal. *Climate Services* vol. 12 27–35 (2018).

88. Wilson, L. *et al.* A national hydrological projections service for Australia. *Climate Services* vol. 28 (2022).

89. WMO. *2021 State of Climate Services: Water*. 46 https://library.wmo.int/idurl/4/57630 (2021).

90. Bojovic, D. *et al.* Engagement, involvement and empowerment: Three realms of a coproduction framework for climate services. *Global Environmental Change* vol. 68 (2021).

91. Visscher, K. *et al.* Matching supply and demand: A typology of climate services. *Climate Services* vol. 17 (2020).

92. Keele, S. Consultants and the business of climate services: implications of shifting from public to private science. *Clim. Change* **157**, 9–26 (2019).

93. Simelton, E. & McCampbell, M. Do digital climate services for farmers encourage resilient farming practices? Pinpointing gaps through the responsible research and innovation framework. *Agriculture (Switzerland)* vol. 11 (2021).

94. United Nations Environment Programme. Adaptation Gap Report 2020. *UNEP - UN Environment Programme* http://www.unep.org/resources/adaptation-gap-report-2020 (2021).

95. Larosa, F. & Mysiak, J. Business models for climate services: An analysis. *Clim. Serv.* **17**, 100111 (2020).

96. Alliance for Hydromet developement. *Hydromet Gap Report*. (2021).

97. WMO. *2019 State of Climate Services: Agriculture and Food Security*. 44 https://library.wmo.int/idurl/4/56884 (2019).

98. Thorpe, A. The global weather enterprise, part 3: an evolving picture. *Weather* **78**, 74–78 (2023).

99. Mayor, B. *et al.* Natural Assurance Schemes Canvas: A Framework to Develop Business Models for Nature-Based Solutions Aimed at Disaster Risk Reduction. *Sustainability* **13**, 1291 (2021).

100. Condon, M. Climate Services: The Business of Physical Risk. SSRN Scholarly Paper at https://doi.org/10.2139/ssrn.4396826 (2023).

101. EC. COMMISSION STAFF WORKING DOCUMENT on Common European Data Spaces. (2022).

102. EC, JRC. *Destination Earth: Survey on "Digital Twins" Technologies and Activities, in the Green Deal Area.* (Publications Office, LU, 2020).

103. Rogers, D., Bogdanova, A.-M., Tsirkunov, V. & Suwa, M. *Public and Private Engagement in Hydromet Services: From Rivalry to Coproduction in Meteorological and Hydrological Service Delivery*. (2021).

104. WMO. *2022 State of Climate Services: Energy*. (2022).

105. Remane, G., Hanelt, A., Tesch, J. & Kolbe, L. The Business Model Pattern Database — A Tool For Systematic Business Model Innovation. *Int. J. Innov. Manag.* **21**, 1750004 (2017).

106. Pereira, Á. & Vence, X. The role of KIBS and consultancy in the emergence of Circular Oriented Innovation. *J. Clean. Prod.* **302**, 127000 (2021).

107. Thorpe, A. The global weather enterprise, part 1: the jigsaw pieces. *Weather* **77**, 349–351 (2022).

108. Webber, S. & Donner, S. D. Climate service warnings: cautions about commercializing climate science for adaptation in the developing world. *WIREs Clim. Change* **8**, e424 (2017).

109. Rogers, D. P., Tsirkunov, V., Bogdanova, A.-M., Suwa, M. & Kootval, H. *Innovation in Public and Private Weather Services*. (2021).

110. Rogers, D. P., Staudinger, M., Tsirkunov, V., Suwa, M. & Kootval, H. *Affordability of National Meteorological and Hydrological Services*. (2022).

111. Kazantsev, N., Islam, N., Zwiegelaar, J., Brown, A. & Maull, R. Data sharing for business model innovation in platform ecosystems: From private data to public good. *Technol. Forecast. Soc. Change* **192**, 122515 (2023).

112. Bergman, R., Abbas, A. E., Jung, S., Werker, C. & de Reuver, M. Business model archetypes for data marketplaces in the automotive industry. *Electron. Mark.* **32**, 747–765 (2022).

113. Frei, T. Public–private engagement (PPE) in hydromet services and the role of the academic sector. *Meteorol. Appl.* **28**, e2025 (2021).

114. Thorpe, A. The global weather enterprise, part 2: fitting the pieces together. *Weather* **77**, 424–427 (2022).

115. Bathiany, S. *et al.* Increasing interannual climate variability during crop flowering in Europe. *Environ. Res. Lett.* **18**, 044037 (2023).

116. Belleflamme, A. *et al.* Hydrological forecasting at impact scale: the integrated ParFlow hydrological model at 0.6 km for climate resilient water resource management over Germany. *Front. Water* **5**, 1183642 (2023).

117. Rechid, D., Bathiany, S., Belleflamme, A., El Zohbi, J. & Goergen, K. Produkte für eine klimaresiliente Landwirtschaft | Bildungsserver Agrar. https://www.bildungsserveragrar.de/fachzeitschrift/produkte-fuer-eine-klimaresiliente-landwirtschaft/.

118. Mettiäinen, I., Coath, M., Grist, H. & Harvey, W. SnowApp climate service for winter tourism centres. (2020) doi:10.5281/zenodo.4159295.

119. *CS4SkiTourism - The SnowApp climate service prototype for Finnish ski resorts - Ilona Mettiäinen*.

120. S&P Global Climanomics | S&P Global. https://www.spglobal.com/esg/solutions/climanomics.

121. Eggeling, J., Rydenfält, C., Kingma, B., Toftum, J. & Gao, C. The usability of ClimApp: A personalized thermal stress warning tool. *Clim. Serv.* **27**, 100310 (2022).

122. Eggeling, J. *et al.* Validating an advanced smartphone application for thermal advising in cold environments. *Int. J. Biometeorol.* **67**, 1957–1964 (2023).

123. Joint Research Centre (European Commission) *et al. Advance Report on Forest Fires in Europe, Middle East and North Africa 2022*. (Publications Office of the European Union, LU, 2023).

124. Bates, P. D. *et al.* A climate-conditioned catastrophe risk model for UK flooding. *Nat. Hazards Earth Syst. Sci.* **23**, 891–908 (2023).

125. Gutenson, J. L. *et al.* Comparison of estimated flood exposure and consequences generated by different event-based inland flood inundation maps. *Nat. Hazards Earth Syst. Sci.* **23**, 261–277 (2023).

126. Zampieri, M. *et al.* Seasonal forecasts of the rainy season onset over Africa: Preliminary results from the FOCUS-Africa project. *Clim. Serv.* **32**, 100417 (2023).

127. Barnet, A. *et al.* Climate services for tourism: An applied methodology for user engagement and co-creation in European destinations. *Clim. Serv.* **23**, 100249 (2021).

128. Terrado, M. *et al.* Co-production pathway of an end-to-end climate service for improved decision-making in the wine sector. *Clim. Serv.* **30**, 100347 (2023).

129. Dell'Aquila, A. MED-GOLD Final Showcase 2022. *MED-GOLD* https://www.med-gold.eu/med-gold-final-showcase-2022/.

130. Viti, M. *et al.* Knowledge gaps and future research needs for assessing the non-market benefits of Nature-Based Solutions and Nature-Based Solution-like strategies. *Sci. Total Environ.* **841**, 156636 (2022).

131. Kourtzanidis, K., Angelakoglou, K., Apostolopoulos, V., Giourka, P. & Nikolopoulos, N. Assessing Impact, Performance and Sustainability Potential of Smart City Projects: Towards a Case Agnostic Evaluation Framework. *Sustainability* **13**, 7395 (2021).

132. Skarga-Bandurova, I., Kotsiuba, I. & Biloborodova, T. Cyber Security of Electric Vehicle Charging Infrastructure: Open Issues and Recommendations. in *2022 IEEE International Conference on Big Data (Big Data)* 3099–3106 (IEEE, Osaka, Japan, 2022). doi:10.1109/BigData55660.2022.10020644.

133. Manrique-Suñén, A., Gonzalez-Reviriego, N., Torralba, V., Cortesi, N. & Doblas-Reyes, F. J. Choices in the Verification of S2S Forecasts and Their Implications for Climate Services. *Mon. Weather Rev.* **148**, 3995–4008 (2020).

134. Rubio-Martin, A. *et al.* Climate services for water utilities: Lessons learnt from the case of the urban water supply to Valencia, Spain. *Clim. Serv.* **29**, 100338 (2023).

Appendix

Business Model Canvas — **ADAPTER**

Key Partners

Partner:

- Forschungszentrum Jülich
- Climate Service Center Germany (GERICS)/Helmholtz-Zentrum Hereon

Networks:

- NPZ Innovation GmbH
- Gemeinschaft zur Förderung von Pflanzeninnovation e.V. (GFPi)
- Zukunftswerkstatt Pflanzenbau (ZWP) Schleswig-Holstein
- Landwirtschaftskammer Nordrhein-Westfalen
- Kreisverwaltung Segeberg

Key Activities

- Short term predictions of soil water content.
- Observed and projected climate change parameters relevant to agriculture

Key Resources

- Observational data from the German Weather Service (DWD)
- Climate projections from EURO-CORDEX (Jacob et al., 2014)
- ECMWF forecasts (short-term) TSMP & ParFlow simulations

Value Propositions

- Short-term (3-10 day) high-resolution forecasts for meteorological conditions relevant to agriculture (in particular soil-moisture)
- Climate projections (different scenarios) with climate indicators relevant to agriculture

Customer Relationships

- Periodic meetings and email/phone communications
- Public Website
- Reports and presentations
- Evaluation and feedback

Channels

- Web-based products for short-term and climate products

Customer Segments

Targeted Market (of customers)

- Local
- Regional

Targeted customer / client / user

- Agriculture managers and educational staff

Targeted sectors:

- Agriculture
- Water management in rural areas

Cost Structure

- Personnel
- Hardware & Software costs
- In kind: Hardware & Software costs, material costs, partly personnel, Computational costs (modelling, big data analyses) (provided by Jülich Super Computing Center (JSC) and GERICS

Revenue Streams

No revenue,
costs covered by Research funds (National, Germany)

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101056933.

Business Model Canvas | **ANYWHERE**

Key Partners

Partner:

- 34 partners across Europe plus a collaborative network of associated enterprises.

Key Activities

- Develop early warning tools and products for extreme weather and climate events
- Develop self-preparedness and protection tools

Key Resources

- Computer and other hardware
- Software tools

Value Propositions

- Observed changes of climate variable of the past 70 years in Europe

Customer Relationships

- Web-products
- Publications
- Training material

Channels

- Web-based interfaces for emergency authorities & organizations

Customer Segments

Targeted Market (of customers)

- Europe
- National
- Regional
- Local

Targeted customer / client / user

- Various sectors affected by extreme events primarily authorities concerned with emergency issues but also for end-users (self-protection and awareness tools)

Targeted sectors:

Emergency planning

Cost Structure

- Personnel
- Programming and maintaining web portals
- Development of training material

Revenue Streams

No revenue,
costs covered by different public funding sources

Business Model Canvas		Blue Action		
Key Partners **Partner:** • U. Lappland	**Key Activities** • Seasonal forecasts **Key Resources** • Computer and other hardware • Software tools	**Value Propositions** • Recommendations for ski business based on seasonal forecasts (snow production)	**Customer Relationships** • Seasonal forecasts • Consultancy **Channels** • Consultancy	**Customer Segments** Targeted Market (of customers) • Local Targeted customer / client / user • Local authorities, local business Targeted sectors: • Tourism
Cost Structure • Personnel • Modelling		**Revenue Streams** No revenue, costs covered by EU-funded project		

Business Model Canvas | **Climanomics**

Key Partners

Partner:

NASA, NOAA, IPCC

Key Activities

- Risk assessment due to climate change for the financial sector

Key Resources

- SSPs and climate scenarios from IPCC and other public sources

Value Propositions

- Climate Risk Analysis
- Climate Risk Reporting

Customer Relationships

- Consultancy
- Decision support tools (Standardized software products)

Channels

- Standardized software solution

Customer Segments

Targeted Market (of customers)

- Global

Targeted customer / client / user

- B2B (companies)

Targeted sectors:

- Finance

Cost Structure

- Personnel
- Data analysis tools

Revenue Streams

Fees for use of products

Business Model Canvas

European Forest Fire Information System

Key Partners

Partner:

- Partner in 32 countries
- ECMWF and Copernicus Service

Key Activities

- Wildfire information and advisory services
- Monthly forecasts
- Seasonal forecasts
- Data provider

Key Resources

- Seasonal forecast products from ECMWF

Value Propositions

- Fire risks and warnings to protect against and/or control wildfires

Customer Relationships

- Seasonal forecasts
- Web-based products

Channels

- Web-interfaces, consultancy

Customer Segments

Targeted Market (of customers)

- Local
- Regional
- National

Targeted customer / client / user

- Local authorities, local business

Targeted sectors:

- Environmental risks (Fire)

Cost Structure

- Personnel
- Modelling

Revenue Streams

Sustained EU-funding

Business Model Canvas | **Fathom**

Key Partners

Partner:

- U. Bristol
- Metoffice
- NASA

and many others:
https://www.fathom.global/research-partners/

Key Activities

- High resolution flood modelling
- High resolution terrain data

Key Resources

- Terrain data from different sources merged to own product
- Climate data: e.g. UK Climate Projections 2018 (UKCP18) climate simulations

Value Propositions

- Flood risk estimates and impacts
- Planning in flood risk areas

Customer Relationships

- Flood risk maps
- Catastrophe modelling
- Consultancy
- Scientific publications

Channels

- Delivery of flood and terrain maps
- Consultancy

Customer Segments

Targeted Market (of customers)

- Local
- Regional
- Global

Targeted customer / client / user

- B2B (companies), government agencies

Targeted sectors:

- Health, insurance, international development, engineering, conservation and financial markets

Cost Structure

- Personnel
- Modelling

Revenue Streams

Fees for consultancy and provision of custom-made maps and data services

Business Model Canvas | **FOCUS Africa**

Key Partners

Partner:

- BSC
- CSIR (Council of Scientific & Industrial Research)
- DCCMS (Department of Climate Change and Meteorological Services Malawi)
- INAM (Mozambique National Meteorology Institute)
- MMS (Mauritius Meteorological Services).
- TARI (Tanzania Agricultural Research Institute)
- TMA (Tanzania Meteorological Authority)
- UK Meteorological Office
- WEMC (World Energy & Meteorology Council)
- WMO

Key Activities

Seasonal forecasts and climate projections

Key Resources

Scientific expertise on climate variability and change

Value Propositions

- Climate predictions
- Publications
- Social impact

Customer Relationships

- Meetings
- Website
- Publications
- Consultancy

Channels

- Pers. Communication
- Web-based applications
- Publications

Customer Segments

Targeted Market (of customers)

- Regional
- National

Targeted customer / client / user

- South African Land Bank
- Small-holder farmers
- TANESCO (Tanzania Electric Supply Company)
- EDF (Electricité de France)
- WRU (Mauritius Water Resources Unit)
- FAREI (Mauritius Food and Agricultural Research and Extension Institute)

Targeted sectors:

- Agriculture
- Water
- Energy
- Infrastructure

Cost Structure

- Personnel
- Computational costs (forecasting)

Revenue Streams

- Research funds (EU)
- Potential revenue by fees for usage of CS

Business Model Canvas | **INDICES**

Key Partners

Partner:

- 16 partners across Europe, co-ordinated by the Universitat Rovira i Virgili, Spain

Key Activities

- Develop a comprehensive set of climate indices

Key Resources

- Climate data sets based on the European National Meteorological and Hydrological Services

Value Propositions

- Observed changes of climate variable of the past 70 years in Europe

Customer Relationships

- Web-products
- Consultancy

Channels

- Web-based interface (Indices)
- Consultancy (Tourism use case)

Customer Segments

Targeted Market (of customers)

- Europe
- Regional (Tourism)

Targeted customer / client / user

- General
- Tourism customers (case study)

Targeted sectors:

- Tourism (case study)
- Div. (Indices)

Cost Structure

- Personnel
- Data assembly and indices calculation
- Programming and maintaining web portals

Revenue Streams

No revenue,
costs covered by different public funding sources

Business Model Canvas | **MED-GOLD**

Key Partners

Partners (Project)

Public:

- BSC, CNR, MetOffice, NOA, UNMG, U Leeds and UTH

Private (users):

- Barilla, DCOOP, SOGRAPE

Private (support):

- HORTA, EC2CE, BEETOBIT, GMV

Key Activities

- Modelling: Seasonal forecasts & Climate change prediction
- IT services (application programming)
- Consultancy services

Key Resources

- Scientific expertise on climate variability and change
- Competence on IT-applications

Value Propositions

- Advisory service, risk assessment, decision support tool
- Climate predictions
- Capacity building/training
- IT-applications
- Publications

Customer Relationships

- Workshops, meetings
- Website
- Publications (Policy briefs, documentation, deliverables and scientific papers)

Channels

- Web-based applications
- Publications
- Pers. communication

Customer Segments

Targeted Market (of customers)

- Local
- Regional
- National
- Transnational

Targeted customer / client / user

- Private companies
- Cooperations/industries

Targeted sectors:

- Agriculture / Food
- (ev. water management)

Cost Structure

- Personnel
- Computational costs (modelling)
- Development of IT-applications

Revenue Streams

No revenue,
costs covered by Research funds

Business Model Canvas | **REACHOUT**

Key Partners

Project:

- 10 partners across Europe lead by DELTARES and CAS

Partner:

- European commission
- Data providers

Key Activities

- Software development
- Training modules
- Workshops

Key Resources

- Hard- and Software for products

Value Propositions

- Triple A-Toolkit: analyze ambitions, actions. Support cities to *Analyze* hazard, exposure and vulnerability to climate change, formulate *Ambitions* for Climate Resilient Urban Development, and identify, evaluate and select adaptation *Actions* for implementation
- Develop and implement applications in 7 European cities
- Recommendations for adaptation and risk reduction against extreme events and changes due to climate change.

Customer Relationships

- Web-products
- Publications
- Consultancy
- Training material

Channels

- Web-based interfaces
- Publications
- Trainings

Customer Segments

Targeted Market (of customers)

- Europe
- Regional
- Local

Targeted customer / client / user

- Citizen
- Private Sector
- (local) Governments

Targeted sectors:

- Urban development / Cities
- Finances

Cost Structure

- Personnel
- Programming and maintaining web portals
- Development of training material

Revenue Streams

No revenue,
costs covered by EU funding (H2020)

Business Model Canvas | **RECEIPT**

Key Partners

Partner:

- 17 partners across Europe lead by DELTARES.

Key Activities

- Climate storyline visualiser that shows the impact of climate extremes on economy and finances

Key Resources

- Software tool / Quiz
- Training modules

Value Propositions

- Indirect impact of climate change (due to remote events) on EU.

Customer Relationships

- Web-based interface
- Meetings
- Publications
- Videos

Channels

- Web-based interface (Climate storyline visualizer)
- Publications (Policy briefs)
- Videos

Customer Segments

Targeted Market (of customers)

- Global
- Europe
- National

Targeted customer / client / user

- Governments
- Research
- Industry/traders
- Banks/investors
- Citizen

Targeted sectors:

- Agriculture
- Finances
- Manufacturing chains
- Coastal infrastructure

Cost Structure

- Personnel
- Programming and maintaining web portal
- Development of videos

Revenue Streams

No revenue,
costs covered by EU funding (H2020)

Business Model Canvas | **RECONECT**

Key Partners

Partner:

- 37 partners across Europe plus number of international partners.

Key Activities

- Develop and implement NBS in demonstrator projects and areas
- Develop software tools to facilitate and support the development of NBS
-

Key Resources

- Software tools for data storage, analysis and visualization
- Training modules

Value Propositions

-

Customer Relationships

- Web-products
- Publications
- Training material

Channels

- Web-based interfaces
- Publications
- Trainings

Customer Segments

Targeted Market (of customers)

- Europe
- National
- Regional
- Local

Targeted customer / client / user

- Various sectors affected by climate change, in particular extreme events. Depending on method, aera and sector ranging from local authorities to international stakeholders

Targeted sectors:

- Different sectors, e.g., water, urban development, environmental issues

Cost Structure

- Personnel
- Programming and maintaining web portals
- Development of training material

Revenue Streams

No revenue,
costs covered by EU funding (H2020)

Business Model Canvas		repath		
Key Partners **Partner:** • CORDEX data provider (Copernicus)	**Key Activities** • Analysis of regional climate change projections with respect to more than ten climate indices • Integration of model results in a software solution **Key Resources** • Global and regional climate projections from the Copernicus open repository and EURO-CORDEX	**Value Propositions** • Climate Risk Transparency • Resilient Investment Decisions • Climate Risk Reporting	**Customer Relationships** • Software distribution • Consultancy **Channels** • Software tool	**Customer Segments** Targeted Market (of customers) • Local • Regional Targeted customer / client / user • B2B (companies) Targeted sectors: • (renewable) energy and private equity and infrastructure investors
Cost Structure • Personnel • Software development & data analysis tools		**Revenue Streams** Subscription or fee for use of service		

Business Model Canvas | **RESPONSE**

Key Partners

Partner:

The consortium of RESPONSE is led by European Institute for Energy Research (EIFER) Germany, being technically supported by Centre for Research and Technology Hellas, CERTH, Greece, and comprises of a total of 53 partners

Key Activities

- Smart energy transitions in cities

Key Resources

-

Value Propositions

- Support renewable energy production in lighthouse cities

Customer Relationships

- Consultancy
- Master plans
- Publications
- Training material

Channels

- Web-based interfaces
- Publications
- Trainings (Hackathons)

Customer Segments

Targeted Market (of customers)

- Local

Targeted customer / client / user

- Private sector (Energy) but also local governance and reaching out to citizens

Targeted sectors:

- Energy
- Cities

Cost Structure

- Personnel
- Software development
- Development of training material

Revenue Streams

No revenue,
costs covered by EU funding (H2020)

Business Model Canvas | **S2S4E**

Key Partners

Partner:

- **Science:** BSC, CICERO, U Reading, SMHI, ENEA
- **Energy:** edf, edp, EnBW
- **Industry:** Capgemini, Nnergix, TCDF, LGI

Key Activities

Subseasonal to seasonal prediction for energy provider

Key Resources

Scientific expertise on climate variability and change

Value Propositions

- Climate predictions
- Publications

Customer Relationships

- Decision support tool (no longer operational)
- Website
- Webinar
- Publications (scientific papers)

Channels

- Web-based applications
- Publications

Customer Segments

Targeted Market (of customers)

- Regional
- National
- Multinational

Targeted customer / client / user

- Renewable energy companies

Targeted sectors:

- Energy

Cost Structure

- Personnel
- Software development (DST)
- Computational costs (forecasting)

Revenue Streams

No revenue,
costs covered by Research funds

Commercialization planned but not implemented

Business Model Canvas | **SMHI**

Key Partners

Partner:

- ECMWF

Networks:

- IPCC
- EURO-CORDEX

Key Activities

Modelling: Climate change prediction on regional scale

Key Resources

Scientific expertise on climate variability and change

Value Propositions

- Climate change scenarios with high resolutions, climate indices, data,
- Publications

Customer Relationships

- Website
- Publications (scientific papers)
- Consultancy (commercial branch of SMHI only)

Channels

- Web-based applications
- Publications

Customer Segments

Targeted Market (of customers)

- Local
- Regional
- National

Targeted customer / client / user

- Climate adaptation on local community level
- General public

Targeted sectors:

- Div., not specified

Cost Structure

- Personnel
- Computational costs (modelling)

Revenue Streams

No revenue (except fees for consultancy & data for business sector)
costs covered by research funds

Business Model Canvas | **INNOVA-Valencia**

Key Partners

Partner:

- **Universitat Politècnica de València**
- **EMIVASA** / Global Omnium as the final user of the climate service

Networks:

- **EURO-CORDEX & Copernicus** (regional and global raw climate projections data)
- **Confederación Hidrográfica del Júcar**: water authority of the basin, main data providers for hydrological information.
- **Comunidad General de Usuarios del Canal Jucar-**Turia (information about the Jucar-Turia channel configuration and its operation)
- **Valencian municipality** (data of water quality for the Tous reservoir and the Jucar-Turia Channel)
- **AEMET** (Spanish National Meteorological and Climate Agency) (precipitation and temperature data in the region)

Key Activities

- Data gathering and processing
- Downscaling and bias-correction for climate projections.
- Development of hydrological model of the Jucar River basin at the sub-basin scale
- Scientific literature revision for the creation of the water resource management and the water quality model
- Development of a basin-scale water resource management simulation model
- Periodical meetings with the final user
- Results processing.
- Design and construction of a scaled-down model of the water treatment plant (done by EMIVASA)
- Operation of the testing plant under the scenarios provided by the models (done by EMIVASA)

Key Resources

- Global and regional climate projections from the Copernicus open repository and EURO-CORDEX
- Historical data of natural inflows, reservoir storage, water

Value Propositions

- Assessing the effect that climate change will have on the future raw (untreated) water available in the Valencia region in terms of both quality and quantity.
- Assist EMIVASA into finding the best strategies to treat and manage this resource and calculate the cost of the adaptation strategies.

Customer Relationships

- Periodic meetings and email communications (early stages)
- Reports and presentations submitting (mid stages)
- Periodic visits to the water treatment plant (late stages)
- On-demand consulting (after project completion)

Channels

- Reports with the predicted state of the system in terms of water quantity and
- water quality for current and future climate change scenarios

Customer Segments

Targeted Market (of customers)

- Local
- Regional

Targeted customer / client / user

- Water resource manager

Targeted sectors:

- Water management

	• demands and main users of the system, water quality parameters • Scientific publications • Data on the water infrastructures that affect the user segment operation • Physical resources for the construction of a testing scaled-down model of the plant by Aguas de Valencia •		• Counseling on the best treatments strategies for the future water • Final report to EMIVASA and the water authorities including cost	

Cost Structure	**Revenue Streams**
• Personnel (2 professors, 2 postdocs, 1 pre-doc student and additional support of EMIVASA employees during the late stage of the project) • Data costs • Hardware & Software costs • In kind: Computational costs (modelling) (provided by Euro-CORDEX and Copernicus	No revenue, costs covered by research funds