D5.5 A Dynamic Rural Development Model

Project	PoliRural	
Project title:	Future Oriented Collaborative Policy Development for Rural Areas and People	
Grant	818496	
Website:	www.polirural.eu	
Contact:	info@polirural.eu	
Version:	1.0	
Date:	31 May 2022	
Responsible:	CKA	
Contributing: Partners:	22SISTEMA	
Reviewers:	Laila Gercane (Vidzeme) Jakub Dvorsky (VIPA)	
Dissemination Level:	Public	X
	Confidential - only consortium members and European Commission Services	
Keywords:	Foresight; Regional Foresight; System Dynamics; System Dynamics Modelling; STELLA.	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 818496

Revision History

Revision no.	Date	Author	Organization	Description
1	30/05/2022	Patrick Crehan	CKA	First draft
2	31/05/2022	Patrick Crehan	CKA	Updated based on comments from reviewers

Table of Contents

List of Tables

List of Figures

Executive Summary

One of the key ambitions of the POLIRURAL project is to explore the application of System Dynamics Modelling[1] to regional Foresight. The only constraint was that the project should create a 'complete' model of the regional economy using the STELLA system, and use this mode and its variants, to support local Foresight initiatives in the twelve rural regions of the POLIRURAL project. A priori, the scale and scope of a 'complete' model was unknown. Nor how such models might be employed. An early task of this work was therefore to decide on good early applications of SDM to Foresight, and experiment with various model concepts to determine where best to apply SDM in Foresight, how to apply it and to what end. Subsequent tasks therefore consisted of a series of experiments in the application of SDM in Foresight, where twelve Foresight initiatives, implemented in the twelve rural regions of the project, providing living laboratories in which to test the SD modelling systems and new Foresight methods, mainly developed in WP5 of the project.

This report is the fifth of a series of project deliverables documenting progress in the design development and application of SD models to real Foresight exercises conducted as part of the project.

To provide context for the work carried out in the project, the report contains a brief introduction to SDM, current trends, and possible orientations for future work in this and other domains of possible relevance for those involved in the development of regional policy. It then describes our efforts to identify good areas of application of SDM in Foresight, bearing in mind the highly participative nature of Foresight, and its role as a support for the co-development of local policies. The report describes our efforts in the building of 'useful' SD models, starting with mini models, on paper and then in STELLA. It describes the creation of the core model, comprising 8 modules and 300 parameters, it's variants and the organisation of experiments in the use of these models in the context of the regional foresight initiatives of the project.

The report concludes with a list of key findings. The core model is not yet at the stage where it can be used by typical facilitators regional Foresight exercise. It does identify the challenges that must be addressed to achieve this goal. Nevertheless, the project has produced a number of intermediary results, such as the paper SD models, which can be used immediately, with much less preparation, and which also serve as examples of the application SDM to Foresight, although not the main one anticipated at the outset the project.

[1] Also interchangeably referred to as 'SD models' or 'SDMs'

Keywords

Foresight; Regional Foresight; System Dynamics; System Dynamics Modelling; STELLA;

1 History of SDM and Emerging New Ideas

1.1 Early History

SDM has its origins in the work of Jay Forrester, a computer scientist and systems engineer at MIT, who not only invented key computer technologies such magnetic core memory but pioneered the domain of SDM.

In 1961 he published seminal work on "Industrial Dynamics[2]." This was followed by a major publication on "Urban Dynamics" in 1969 and in 1972 by "World Dynamics," arguably the first serious attempt to model how social, economic, and environmental factors interact with each other and the natural world, evolving over time to drive population growth, resource consumption, and prosperity at the level of the entire planet. One of the most important lessons from his work was a demonstration that our usual "models" of how the world works, fail to capture important aspects of world dynamics, complex non-linear behaviours, which if left unchecked, could lead to the collapse of entire earth systems and an end to ever increasing growth and prosperity.

While all of this was going on, the Club of Rome[3] commissioning a study by a team at MIT, as an input to its "Project on the predicament of mankind." The team, led by Denis Meadows, included experts from the US, India, Germany, Norway, Turkey, and Iran, with expertise in domains such as population, pollution, agriculture, natural resources, and capital. This work relied heavily on the use of SDM, and a summary of its findings for the layman was published as "Limits to Growth" in 1972[4]. Its main finding, supported by the use of SDM, was that "even under the most optimistic assumptions about advances in technology, the world cannot support present rates of economic and population growth for more than a few decades from now."

The use of SDM showed that only "a concerted attack on all the major problems at once can man achieve the state of equilibrium necessary for his survival." At that time, this statement came as a shock to mainstream thinkers in economics and economic development, yet it was highly influential in helping to establish on the basis of the best science available, the basic ideas about what is required for "sustainability" and establishing "sustainability" as the state to which all who work in economic and social development need to aspire. It will come as no surprise that the report was seen as controversial and even bitterly opposed by vested interests.

---

[2] Jay W. Forrester, "World Dynamics" first published in June 1971, ISBN: 978-1-935056

[3] https://www.clubofrome.org/

[4] "Limits to Growth" 1972, by Denis and Donella Meadows, Jorgen Randers, and William W. Behrens III, with ISBN 0 330 241699, available for download from the Club of Rome website at http://www.donellameadows.org/wp-content/userfiles/Limits-to-Growth-digital-scan-version.pdf

Nevertheless, and despite various shortcomings of the SDM approach and the modelling technology available at the time, follow-up reports showed that it was in fact very accurate in its ultimate insight that "human beings and the natural world are on a collision course.[5]".

The first SDM was created two decades before the internet was invented. "Limits to Growth" was published half a decade before the age of personal computing started, in 1977 with the creation of the Apple II, the TRS-80 and the Commodore PET.

We have come a long way since then in terms of a tremendous increase in the power of computing, the availability of data, and ease of access to sophisticated tools and communication platforms.

So, it is time to make SDM tools and the explanatory power of the SDM approach ore widely available to those involved in policy development processes, ultimately that means citizens and stakeholders involved in regional development processes.

This story provides much of the inspiration behind our efforts to adapt the SDM approach for application as a support for the stakeholder intensive processes that characterize a typical Foresight exercise.

It is worth pointing out that the team commissioned by the Club of Rome to carry out the Limits to Growth study in 1972, comprised not only pioneers in the development of SDM, but also some of best scientists in the world in areas of economics and geography, and the modelling of industrial and y-urban systems. The models were designed, run, and interpreted by some of the best minds in the world and published in book form. In our work we are aiming at providing a system where 'concerned citizens' are invited to interact with complex models, asking sophisticated questions of the system, with a view to understanding the impact of policy choices on regional economies, to the point where they are able to take part in the design of policy interventions responding to key challenges that their region will face.

This raises a wide range of issues that must be addressed in the system design, which are quite different from those that had to be addressed in the time of Jay Forrester. Part of the work of the project is effectively to understand what these 'other' questions are, and adapt the work being conducted with the partners, to address these other issues using the regional Foresight exercise as a living laboratory in which experiments in the use of SDM applied to Foresight could be conducted.

Before telling the story of what we did, how we did it and the results obtained, it is useful to provide some context in the form of a brief survey of recent trends in the application of SDM, as well as some new and emerging ideas which may one day help to achieve the

[5] "Limits to Growth - The 30-year Update" by Donnella and Denis Meadows and Jurgen Randers, published in 2004 with ISBN 1-931498-51-2.

breakthroughs needed for it large scale adoption at the level of regional and sub-regional policy design and development.

1.2 Recent Trends

1.2.1 SDM in the Horizon Programme

There are two different approaches in the use of SDM in European projects, related to rural issues. One relies on the extraction of qualitative insights. The other is more overtly scientific in that it focuses on quantitative results. Some projects combine elements of both of these approaches.

POLIRURAL lies in the first group, in that it does not aspire to making quantitative predictions. It takes a qualitative approach and in doing so hopes to help users of the models to gain a deeper understanding of how the dynamics of a region is impacted by policy decision. Another example of the qualitative approach is RURALIZATION[6]**.** Although this project does not explicitly refer to SDM. Its approach is highly relevant for the application of SDM. It contains a section called ‘Rural Trends’ and has produced a repository of 60 Trend Cards featuring 10 megatrends, 20 trends and 30 weak signals. The cards contain an explanation of the trend, description of drivers and impacts, and some statistical manifestations signaling the trend. In many ways this resemble work done independently by POLIRURAL in the production of its STEEPV Inventory of Drivers, which also served as a test bed for the application of Text Mining in Foresight based on the production of CRLs or Curated reading Lists.

Other relevant projects include

- AGRICORE[7] which is building a tool using an agent-based approach where each farm is to be modelled as an autonomous decision-making entity which individually assesses its own context and makes decisions based on its current situation and expectations. This approach allows the modeler to simulate the interaction between farms and their context at geographic scales ranging from the regional to the global. One of the examples it has developed includes an ABM developed at NUTS2 level for Andalucía, where it tries to measure the impact of directive 2014/99/EU on the olive oil sector, with a focus on its environmental and climate impacts.
- BESTMAP[8] will design and develop a new Policy Impact Assessment Model framework, which relies on modern socio-economic, behavioural, and biophysical approaches to capture the environmental, social, and economic variability of individual farms and EU

[6] https://ruralization.eu/
[7] https://agricore-project.eu
[8] https://bestmap.eu/

regions. It has produced five regional case studies with different agricultural, socio-economic, and political backgrounds.
- MINDSTEP[9] aims at improving the exploitation of available agricultural and biophysical data based on the integration of individual decision-making units in policy models. This approach tries to take account of the behaviour of individual decision-making units in agriculture and the rural society.

These last three models all address the issue of 'policy impact' in the areas of agriculture. They make extensive use of big data and statistical sources, and they employ ABM techniques. Models are built by experts using a top-down approach. The starting point tends to be the passing of new legislation and they proceed to model the impact of legislation on the sector or issue in question.

By contract the POLIRURAL approach has been on bottom-up approaches where the models are to some extent co-designed by users who are not experts, but members of local communities. In this sense it is useful to distinguish between high level global models and local models. Arguably, both are important, and both have a place in the new and emerging EU model of democracy. An important topics for future study may be the intersection of these two approaches, and how they can support and complement one another, for the benefit of both expert users and grass roots communities, 'actors' and 'beneficiaries' in the language of the POLIRURAL project, whose immediate priorities and interests can differ greatly.

Other H2020 projects using SDM, or related approaches include the following:
- VALUMICS[10] which attempts to better understand food value chains and their network dynamics.
- SIM4NEXUS[11] which addresses sustainable integrated management approaches in the water-land-food-energy-climate nexus for a resource-efficient Europe.
- IMPREX[12] which explores prediction and management of hydrological extremes
- Nature4Cities[13] examines nature-based solutions for the re-naturing of cities. It has developed a knowledge diffusion and decision support platform using 'collaborative' models.
- MIDAS[14] looks at the challenge of the Meaningful Integration of Data, Analytics and Services
- The SEYMOUR project does not yet have a website. It intends to apply to suicide prevention.

[9] https://mind-step.eu
[10] https://valumics.eu/
[11] https://sim4nexus.eu/
[12] https://www.imprex.eu/
[13] https://www.nature4cities.eu/
[14] http://www.midasproject.eu/

- eLTER[15] addresses he issue of developing long-term ecosystem and socio-ecological research infrastructure
- CO-CREATE does not yet have a website. It intends to explore the engagement of youth in the co-creation of policies to confront the problem of obesity.
- Problem Shifting[16] is a project funded by the European Research Council. It explores the shifting of problems between International Environmental Treaty Regimes, looking at their causes, and examining the impact of such shifts in terms of solutions and other consequences.

It would be interesting at some stage in the near future, to survey the variety of modelling environments employed for example in the H2020 projects listed above, and compare the performance of such systems in terms of their ability to model complex socio-economic systems at the level of the regions and sub-regions of Europe, as well as the ease with which such models can be created, the ease with which general users can learn how to use such systems and use them to explore the dynamics of regions, to learn lessons that will inform their policy choices.

1.2.2 Stella software, community and code sharing platform

For various reasons, POLIRURAL has chosen to use the STELLA software system as a basis for all of its SD modelling[17]. The system was created and is maintained by a company called ISEE Systems and it is intended to help modellers create and implement SD models. It is marketed as a tool that helps users to understand complex systems using simple models and in doing so create solutions to the problems they face. It has been a pioneer in the space in the sense that it was the first company to provide an icon-based model building and simulation tool. In 1989 ISEE Systems and the creator of the STELLA software was awarded the Jay Wright Forrester Award by the System Dynamics Society for this achievement, which was considered to have played an important role in introducing computer simulation-based SD model building to a mass market. ISEE Systems continuously evolves its software and is credited with being among the first to introduce the idea of an interactive management 'flight simulator.'

In the early stages of the project, extensive use was made of this of this material, in the provision of training to initiate the Foresight teams and introduce them to SD modelling principles and to the use of the STELLA tool.

In particular we used examples that dealt with:

---

[15] https://elter-ri.eu/
[16] https://problemshifting.org/
[17] https://www.iseesystems.com/store/products/stella-architect.aspx

- Ski resort dynamics which presents options to be explored by a ski resort manager that wants to address problems related to over-crowding
- The impact of COVID policies in different contexts in terms of deaths and economic activity. In particular the impact of vertical isolation policies on infection and mortality rates in Brazil, as well as the impact of the Cares Act on business survival rates in the US.
- An online MIT developed model of the impact of factors such as humidity, crowdedness, use of filters, and exposure times, on the spread of infection in a closed room.

Give the challenges we faced in developing user-friendly interfaces, even for the simplest of our in-house models, we participated in 'Leadership' training offered by Ken Thompson on December 8, 2020, which has since been made available on YouTube[18]. Thompson is the Managing Director of 'Business Simulations' and has specialized in the use of STELLA for creating simulators that help managers explore the tactics and strategies they might employ when faced with change management or strategy development challenges. His simulations have won prizes and he claims that they are used by "leading corporations, consultancies, and business schools." We were especially interested in his 'interface', which appeared to depend on technology that is quite different from that available in the bare bones STELLA environment.

One of the advantages of using STELLA is that the use of their system is supported by an online community of users and a platform for model sharing. We have subscribed to this and found it instructive. Nevertheless, we quickly discovered limitations of the system which became quite significant for the project, given the scale of the model we were trying to build.

Our first issue is that the models available on the sharing platform tend to be small models. Our impression is that these models correspond to learning exercises. Perhaps they are the result of small project carried out by students of SD modelling as a way to reinforce their learning of the basic principles. Although this is very useful, it is far from the kind of large integrated model that we needed to build in the POLIRURAL project. It meant that we had to work alone to build such models, with no outside experience to build upon. The field would benefit from a small number of large model development projects, where the results are put out into the public domain, so that the work can be distributed and managed, and more ambitious modelling goals can be reached. Perhaps using some kind of open-source modelling approach.

The second issue that we faced was the limitations of the STELLA environment for building use interfaces. We found it very hard to work with this. We see it as a key enabler for

[18] https://www.youtube.com/watch?v=rGWj5DP7q2s

engagement with large groups of stakeholders, most of whom have little or no technical understanding of modelling, or any of the fields underlying model construction.

The 'implementation' of a model for use in Foresight, in an open process of stakeholder engagement, requires not only model building, and the population of that model with relevant data, but also the calibration and testing of the model, based on clear ideas of the basic phenomena it is expected to reproduce.

It also requires the creation of good user interfaces that allow a novice user to navigate the model and run simulations with a minimum of preparation and visualize the results in ways that are meaningful.

In this project we found a work-around to this and solutions were provided by AVINET working with 22SISTEMA. Instead of relying on the STELLA environment to support user interaction with the model, we used STELLA to run the model, as the back end of online environment, which ran the user interface allowing users to select policy options, and the visualization engine that allowed the user to see the impact of its choices on selected KPIs. We refer to this system as the Policy Options Explorer, explained in detail later on.

This work lead to a second wave of experimentation on the use of SDM in Foresight, but this time connected to another key area of interest of the project, namely rural attractiveness.

This lead to the development of a second system allowing the user to select policy options observe the impact over time of its choice on rural attractiveness. We refer to as the Rural Attractiveness Explorer. Our work on this system is ongoing and is explained in more detail further on.

1.2.3 MIT course in system dynamics for management

Management and Leadership training appears to be an important rea of application for SD modelling. We note that MIT, the pioneer in the development of SD modelling, based on the early work of Jay Forester, trying to understand complex industrial and urban systems, continues to develop the application of SD modelling.

MIT has recently advertised new courses on the application of SD modelling in its Management and Leadership track at the MT Sloan School of Management. One course in particular is entitled "Business Dynamics: MIT's Approach to Diagnosing and Solving Complex Business Problems[19]."

The course is offered on the premise that "the most vexing problems facing managers arise from the unanticipated side-effects of their own past actions," that "organizations struggle to

[19] https://executive.mit.edu/course/Business-Dynamics/a056g00000URaMkAAL.html#program-details

increase the speed of learning and adopt a more systemic approach" and that the "challenge is to move beyond outdated slogans about ... thinking systemically..." to implementing "practical tools that help managers design better operating policies, understand complexity, and guide effective change."

The only difference between this and what we set out to achieve with SD modelling in POLIRURAL is that we are not really addressing need of top management, but a need of local agents of change, who may be far removed from top management. It is reminder that the use of SD modelling in Foresight should be extended beyond support for grass roots decision making based on the use of SD models to explore policy options. Tools are also needed that are explicitly intended for use by top management in regional and sub-region and also national government.

Using the flight simulator analogy beloved of management schools all over the world, we have been working on a flight simulators here we put 50 or100 untrained pilots in the cockpit. We believe that this is the right thing to do. But it may be useful to extend these efforts in future, to the creation of flight simulators intended for the pilots, that is for those who govern at national, regional, and sub-regional level, and which reflect their interests, which though related to the interests of those operating at grass roots level, is nevertheless significantly different.

1.2.4 Other tools for use by the general public

There is an increasing number of online interactive tools and games intended to help either experts or the genal public explore the impact of various policy scenarios on society, the economy and on the natural world including the climate.

Arguably the one too that most closely resembles what we are trying to achieve in POLIRURAL is EN-ROADS, an accessible online simulation that allows users to design their own policy scenarios to limit carbon emissions, and in doing so, limit global warming[20]. It is designed to be used in policy workshops and its creator offers training on facilitation. It was created by Climate Interactive working with MIT. Apparently, it has been used by individuals, small community groups, the US Congress and the UN secretary-general's office.

But there are many others. Some aimed at kids, others at experts (policy makers) and others at the general public. Climate Game[21] by Games for Sustainability is an interactive online game in which the player lives on a deserted island covered by trees and forests. The player is able

[20] https://en-roads.climateinteractive.org/scenario.html
[21] https://games4sustainability.org/gamepedia/climate-game/

to harvest, use and plant trees, as well as manage its income to develop infrastructure. Bad choices may end up in bankruptcy for the player or natural disasters for the island.

The Climate Center has created a wide variety of games covering many different aspects of climate change and resilience[22]. So has the Climate Institute[23]. The Game On[24] initiative funded by the EU DEAR program for 'Development Education and Awareness Raising' was set up to activate youth groups, using a gamification approach to mobilize them to tackle issues relate to Biodiversity Conservation, Adaptation and Mitigation, and Climate Justice. Climate Kids is an educational initiative funded by NASA[25] that uses gaming as part of its pedagogical approach, and Games for Change or 4C[26] using gaming for social impact.

The Guardian newspaper has created the Fossil Fuel Interactive[27]. This system allows users to visualize the amount of coal, oil and gas consumed every day, as part of its 'Keep It In the Ground' campaign, which aims to educate users, and provoking a reflection on what needs to be done to avoid catastrophic climate change.

The FT Climate Game[28] is one where the player must keep global warming to under 1.5^{C} by cutting energy-related carbon dioxide emissions to net zero by 2050. The game is based on published scientific research. It uses models of global emissions developed by the International Energy Agency in 2022. It uses the IEA 'World Energy Model' and its 'Energy Technology Perspectives' model, along with a model for the 'Assessment of Greenhouse Gas Induced Climate Change' to recalculate Net Zero scenarios based on choices made by the user. All these models are state of the art and used by scientists in so-called Integrated Assessment Models[29] or IAMs.

The EU funded LOCOMOTION project[30] is working on the design of a new more sophisticated set of IAMs intended to help assess the socioeconomic and environmental impact of different policy options in order to make more informed decisions about the transition to net zero. The models are not ready yet. But the project has been funded on the basis that "existing models are not enough" and it has been featured in the newsletter of the European Environmental Bureau[31].

Another project called MEDEAS is currently creating an open-source energy model to guide policy makers in the transition to a low carbon European socio-economy. This too has been

[22] https://www.climatecentre.org/priority_areas/innovation/innovation_tools/climate-games/
[23] http://climate.org/climate-games/
[24] https://climategame.eu/index.php
[25] https://climatekids.nasa.gov/
[26] https://www.gamesforchange.org/
[27] https://www.theguardian.com/environment/ng-interactive/2015/apr/10/how-much-fossil-fuel-are-we-using-right-now
[28] https://ig.ft.com/climate-game/
[29] https://en.wikipedia.org/wiki/Integrated_assessment_modelling
[30] https://www.locomotion-h2020.eu/
[31] https://meta.eeb.org/2022/03/28/locomotion-interactive-use-of-data-for-people-and-planet/

featured by the EEB, which remarked that it felt "sorry for the policymakers who will use this toy to test the outcomes of their plans... the truths it generates about the climate and our global economy are way more inconvenient than those once produced by a certain Al Gore. The bottom-line message is that "greening capitalism is just not going to cut it."

1.3 Alternative and adjacent new ideas

1.3.1 Community Based System Dynamics

The early work on SD modelling, based on its emergence from the work of Jay Forester and colleagues at MIT on the modelling of industrial, urban and world systems, was mainly intended for use by researchers.

Nevertheless an important trend started in the 1980s referred to as Community Based System Dynamics by P. S. Hovmand. This is described in an excellent survey of the history of this field, that he provides in a book of the same name[32]. Hovmand points out that there are many definitions and interpretations of what community base SD means, and many ways of doing it.

Unknowingly, our work on the application of SD modelling to Foresight, in the POLIRURAL project, is a contribution to this trend. It will be useful in future to make contact with those who are thinking about community-based SD, to learn what is already known, and provide inputs to their process of reflection based on the experience we have gained in the POLIRURAL project.

1.3.2 Low-code no-code development paradigms

The creation of software systems and software-based applications is a difficult and expensive task, made more difficult by constant changes to the hardware and bigger software universe in which applications are embedded. The software industry has reacted to this by developing what are known as low-code and no-code platforms intended to simplify the development process and yield useful results at a fraction of the cost and in a fraction of the time normally needed[33].

[32] P.S. Hovmand, Community Based System Dynamics, DOI 10.1007/978-1-4614-8763-0_2, ISBN: 978-1-4614-8762-3, © Springer Science + Business Media New York 2014.

[33] https://www.techtarget.com/searchsoftwarequality/definition/low-code-no-code-development-platform

As a general rule, 'low-code' refers to a development paradigm aimed at software developers themselves, intended to ease the burden of development and increase their productivity. It also lowers the barrier to entry for would be developers in many domains. It has been avidly embraced and is actively promoted by most mainstream software providers such as Microsoft.

'No-code' refers to a paradigm where the developer is dispensed with, and users take direct control over the creation and deployment of new applications. This is not only about saving time and money. It is also about 'unleashing creativity' by tapping the needs and insights of users, by giving them direct control over the development process.

These are paradigms from which the further development of SD modelling can benefit. Such systems typically rely on the use of drag and drop interfaces, where users develop systems by assembling bricks, linking them, with all of the plumbing being done in the background by the platform.

Arguably, the STELLA system goes some way in this. It can be seen as a low-code environment. Nevertheless, there is a long way to go before significant breakthroughs will be possible before such systems can easily be put in the hands of experts in economic and social development, or the facilitators of meetings intended to explore easily and fully, the impact of policy options.

1.3.3 Lessons from commercial gaming environments

Lessons may be earned from advances in modern gaming. Modern games are already of great complexity and playing them requires the systematic development of skills needed to fully take part. This is true of FPS or first-person shooter games[34] such as Call of Duty[35] as well as of complex community base games such as Eve Online[36]. In the case of Eve Online thousands of gamers take part at the same time. They interact with each other in virtual worlds, where they buy and sell, build, and destroy, and find partners to plot and execute their shared strategies. They use virtual currencies and there is even the equivalent of the 'economist magazine which analyses the internal economy of the game looking at growth and decline, the prices of commodities and other market behaviours.

The emergence of game such as these seem to provide a continuation of game concepts such as Sim City and approach the complexity of small and medium sized real-life communities. It is tempting to think that the world of gaming can provide lessons of use to SD modellers, especially those intent on building large life-like models such as we have attempted to do in POLIRUAL, in terms of

[34] https://en.wikipedia.org/wiki/First-person_shooter
[35] https://en.wikipedia.org/wiki/Call_of_Duty
[36] https://www.eveonline.com/

- Studying, describing, and modelling large complex socio-economic systems, comparable in size to those of the regions and sub-regions of the EU
- Tactics for on-boarding or initiating novice users of complex simulations such as those of modern games, whose complexity far surpasses that of the SD model interfaces we have tried to build in this project.

1.3.4 Digital Twins, Agent Based Modelling and AI

There is some interest in the EU in the use of Digital Twins. Although some academics are of the view that a 'twin' is not a 'model', it nevertheless lives in silico and requires code, models, and simulations.

First developed as an approach to understanding and controlling complex machinery[37], the development of digital twins for social economic and environmental systems presents many challenges. Nevertheless, progress is being made in the use of digital twin technologies by cities to help address management and policy challenges with which they are faced[38]. Arguably, rural regions or more generally regions and their sub-regions, would also benefit from access to such tools. In which case it would make sense to explore the role of SD modelling applied to digital twin design and implementation.

Many experts are of the view that the field of economics is in dire need of overhaul. The traditional approach based on the 'rational man' has been thoroughly debunked by such as Michael Hudson writing in "J is for Junk Economics,"[39] which expands upon his earlier works such as "Killing the Host."[40] In an article for Project Syndicate[41], James Galbraith deplores the fact that "neoclassical economics (which) relies on assumptions that should have been discarded long ago, it remains the mainstream orthodoxy" and provides outlines of recent books which he considers "show why its staying power should be regarded as a scandal."

Tom Brookes and Gernot Wagner, also writing for Project Syndicate explain that what economics really needs is a climate revolution[42.] They are not wrong and arguably new approaches to economic thinking being developed by organisations such the Natural Capitals

[37] https://en.wikipedia.org/wiki/Digital_twin
[38] https://www.bloomberg.com/news/newsletters/2022-04-05/citylab-daily-what-digital-twins-can-do-for-cities
[39] https://michael-hudson.com/2017/02/j-is-for-junk-economics-a-guide-to-reality-in-an-age-of-deception/
[40] https://michael-hudson.com/2015/09/killing-the-host-the-book/
[41] https://www.project-syndicate.org/onpoint/economics-captured-by-neoclassical-magical-thinking-by-james-k-galbraith-2021-07
[42] https://www.project-syndicate.org/commentary/neoclassical-economics-fails-with-climate-change-by-tom-brookes-and-gernot-wagner-2021-06

Coalition[43] are being developed and embedded into new forms of accounting such as the SEEA system for Ecosystem Accounting[44].

Although we did not do it in the POLIRURAL project, systems such as these are compatible with SD models of rural and urban economies and should be explicitly developed in future.

1.3.5 New and emerging scientific paradigms

The integration of human behaviour into our models remains problematic. It may be worth-while exploring how recent and emerging insight from behavioural economics can inform SD modelling applied to the development of rural regions of Europe[45].

Having said that, it may be worthwhile to explore other approaches. For example approaches using agent-based modelling or ABM[46] [47] in which economic actors (citizens, businesses, public institutions...) are treated as autonomous agents, acting according to rules based on stimuli they receive from each other and from the environment in which they operate. The use of agent-based modelling is already employed in the social sciences, and it could provide an interesting alternative approach to exploring policy options in the context of regional Foresight. It might be especially useful for modelling the dynamics of counties and small communities, districts containing ten to fifty or one hundred thousand people.

In the age of big data, such approaches are of more general scientific interest. They are not far removed from alternative approaches to fundamental physics such as that proposed by Steven Wolfram in his ‘new kind of science’ based on cellular automata[48]. This too see macroscopic laws of nature as emergent phenomena based on simple microscopic rules obeyed by the simplest most fundamental objects in the universe. Other ideas currently being explored in basic science, which may have their counterpart in the social sciences include recent efforts to understand the universe as an auto-didactic neural network. Unlikely as it may seem, this idea which was first proposed by Vitaly Vanchurin[49] is now embraced by none other than Lee Smolin and colleagues[50].

There is currently a debate going on about how to conduct science in domains which are intrinsically complex, where it is notoriously difficult to formulate productive hypotheses that can be tested by experiment, and some wonder about the role of theory in order to make further progress in our understanding of nature and natural phenomena. Several have recently written about the prospect of ‘post theory science.’[51] [52] That is science that can be

---

43 https://capitalscoalition.org/
44 https://seea.un.org/ecosystem-accounting
45 https://en.wikipedia.org/wiki/Behavioral_economics
46 https://www.pnas.org/doi/epdf/10.1073/pnas.082080899
47 https://en.wikipedia.org/wiki/Agent-based_model
48 https://en.wikipedia.org/wiki/A_New_Kind_of_Science
49 https://arxiv.org/abs/2008.01540
50 https://arxiv.org/abs/2104.03902
51 https://www.theguardian.com/technology/2022/jan/09/are-we-witnessing-the-dawn-of-post-theory-science
52 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2711825/

conducted in the absence of a testable theory. Wired magazine has joined the conversation asking how to proceed with the job of modelling in the absence of adequate theory[53] claiming that the data deluge make scientific theory obsolete and serious physicists are talking about the use of AI to replace 'theory' in the construction of models (needed for simulation) and in the interpretation of data from experiments. Arguably, there is scope for the application of ideas such as these in the development of tools that will help communities and their leaders explore the real-life policy opts that will provide optimal outcomes of benefit to communities, their neighbours, and the planet, for the near future and for generations to come.

2 SDM Applied to Regional Foresight for Rural areas

Foresight is a tool of strategic management tool with application to many areas. It is used in companies as part of the process for market and product development. It is used as an input to the planning of research and innovation by private and public organizations. It is used by sectoral associations to anticipate the challenges a sector must face and the actions they might take to address those challenges. It is used by regions and sub-regions as inputs to policy development processes. Depending on where Foresight is applied, with what intent, and also as a function of the skill and experience of the core team, the Foresight the detailed method of application and accompanying social processes vary greatly. In this project the focus is on the use of Foresight for the development of policy for rural regions. The assumption is that the process is led by groups who are not in government. They reside at grass roots level and hope to influence the policies and programs being designed and implemented by those higher up the hierarchy. The leaders of such Foresight initiatives occupy a position of relative weakness in a multi-level hierarchy. If successful in their efforts, they will provide an essential link in a system of multi-level governance. To be successful, they must practice what is referred to as 'middle up down' management by Nonaka and Takeuchi in their seminal work on knowledge management[54] [55]. Ultimately, Foresight is about provoking the kind of change needed to achieve a desire future outcome. For this reason, CKA has situated Foresight as a change management tool. One of many change management tools. But arguably one which is best suited to the implementation of desired change at the level of local government, which often finds itself abandoned or ignored by central government in times of crisis.

The POLRURAL Foresight framework, described in the next section, was provided with a view to addressing two major concerns:

- The need to optimize the chance of success of the twelve regional foresight initiatives which provide the basis for all other work of the project. In this context, success implies

[53] https://www.wired.com/2008/06/pb-theory/
[54] https://hbr.org/2007/07/the-knowledge-creating-company
[55] https://books.google.be/books/about/The_Knowledge_creating_Company.html

going beyond the production of reports and ensuring the implementation of recommendations contained in the Foresight 'package.'

- To insulate these twelve regional initiatives, from risks associated with their use as 'living laboratories' for experimentation with the use of Text Mining and System Dynamics Modelling as part of the Foresight process.

In presenting this framework, we link it to other issues explored by the POLIRURAL project, namely the concept of rural attractiveness, and outline the steps taken to go beyond the application of SD in Foresight, to the use of SDM outputs as an input to the development of indexes of rural attractiveness, which may one day be used as an SDM based tool for the further exploration of rural futures and regional policy options.

2.1 The POLIRURAL Foresight framework

The general framework provided for the execution of the twelve rural regional Foresight initiatives, includes the provision of a Foresight 'package.' That is a set of documents including

- A VISION document that describes a vision for what the region should become by some future date, for example by 2030 or 2040, accompanied by a description of the challenges to be addressed to achieve that vision
- An ACTION PLAN which lays out the measures to be implemented to address those challenges and thereby achieve the vision.
- A ROADMAP for the implementation of those measures, which includes not only the sequencing of measures, but also the intended sources of funding. It should also indicate which actors have assumed or will assume responsibility for all needed programming, resource mobilization and legislation, to make sure that the action plan is implemented.

The action plan should include measures to monitor the implementation of the action plan and evaluate the measures at appropriate stages of implementation. The foresight process should include actions phases that will lead to

- The ENDORSEMENT of the vision and action plan by beneficiaries, without which the action plan and recommendations, have little or no legitimacy or political weight.
- The ADOPTION of the package by the actors. By those in public administration who must follow up on and ensure the implementation of the measures. They reside in various agencies and authorities and levels of governance.)
- The appointment of MONITORING COMMITTEE, to ensure that the 'package' is not forgotten and to remind those in power of their commitment to ensure implementation.

It was left up to each region to design and implement the Foresight process, according to their own resources, respecting their own unique constraints, and making use of the regional programming calendar. Nevertheless, it has been recommended that the regional process include basic tasks, including but not limited to the following

- Issues Analysis to create inventories of 'things that may need attention'
- Drivers' Analysis to understand how change will happen at regional level
- Deep Dives on complex issues or issues that required 'localization'
- Exploration of policy options, to help determine the 'mix of measures' that will make up the action plan, to understand the scope for action, and ultimately decide on an optimal set of measures to address identified challenges.

The full list of tasks is explained in much more detail in D1.8, the 'Future Outlooks Methodology.'

To support the work of the regional teams and lighten the burden of work required to develop high quality inputs needed to adequately facilitate the above-mentioned tasks, a number of guides, inventories and other resources were (and continue to be) produced. These include:

- A compendium of POLIRURAL foresight actions (for knowledge sharing)
- A STEEPV Inventory of Drivers of Change
- A Guide to Deep Dives
- A Guide to Deep Dives on the regional response to COVID
- A Guide to Deep Dives on CAP reform (with a focus on farm incomes and prosperity)
- A Guide to Deep Dives on the Green Deal

Work is ongoing on the following resources

- A Guide to Deep Dives on the EU biodiversity strategy
- An Inventory of Policy Options Part I - Finance (with over 40 mechanisms)
- An Inventory of Policy Options Part II - regional response to COVID

This provides a good overview of the general framework for Foresight provided by the project, and the general context in which our experiments in the use of SD modelling must take place. Given such a framework, the main question concerning the use of SDM in Foresight, is where and how it might support or even improve the Foresight process, and if so, in what way.

2.2 Initial attempts at the use of SDM for Drivers' Analysis

In the earliest stages of the project, we looked at the possibility of using SDM to support the task of Drivers' Analysis. The general goal of this task is to help participants in the Foresight exercise[56] to understand how change happens. This is intended to lead to an understanding

[56] Local stakeholders, actors, and beneficiaries, along with facilitators of the process

of what aspects of regional dynamics can be controlled via appropriate policy measures. In particular it is intended to help participants understand major trends they can see as opportunities, build upon, and optimize. As well as which trends, they may simply need to learn to live with or mitigate via appropriate policy measures.

A good example of a driver which all regions should consider, is climate change. This tends to be spoken of at a very high abstract level. Reports often refer to changes taking place in the Arctic or in the Great Barrier Reef of Australia, as well as events that might take place many years hence, for example in 2050 or 2100.

To develop local policy measures related to climate change however, such abstract concepts need to be 'localized' and made relevant to each region and to the time in which we live. Not everyone realizes that climate change is already happening all around us, and that it effects different regions in different ways. Localization requires understanding climate change in terms of local phenomena driven by climate change such as heavy rains, floods, landslides, late-frost, wildfires, drought, crop loss, loss of property and even loss of life. To understand the impact of climate change on the region, the relevant manifestations of climate change in that region need to be identified and understood, along with their impact on agriculture, industry, prosperity, and quality of life.

Ultimately, the cause of climate change is almost universally believed to be excessive emissions of CO2 and other GHGs. Important measures to address the impact of climate change all come down to measures to reduce the CO2 footprint. But this will not bring the climate and weather phenomena back to normality overnight. So additional measures are required to mitigate the immediate or short terms negative effects of climate change, while the basic work of long-term mitigation is carried out based on measures to reduce atmospheric CO2.

This example illustrates a number of issues to which SDM is well suited. These include the complex interactions between drivers of change and aspects of the regional economy. They also include the way policy impacts play out over time, with some measures having an immediate impact and others acting with a delay impact. It also illustrates the different between what can do locally, and the need to act in concert with national and international partners. The need to act in terms of measures where control lies only partially at regional and is shared across agencies and at many levels of the governance hierarchy.

Our initial vision for implementing SDM in Foresight was therefore based on the idea that

- A drivers' analysis workshop would allow participants to co-develop a map of relevant drivers, Illustrating how they interact with each other and with the region,
- That this would then be translated into a model using system such as STELLA,
- Provide an interactive tool allowing users to explore complex phenomena such as, but not limited to, climate change,
- To develop an intuitive and qualitative understanding for how policies interact with each other and the region they are intended to benefit.

This turned out to be far too ambitious for an ab-initio approach. Especially given the constraints of the STELLA tool[57] and our growing realisation of the complexity of models that are rich enough to capture the complexity of rural regions.

We decided that the best way to progress would be to experiment alone with a series of mini models to understand what might be feasible. The results of our early experiments in the area of regional tourism are described further on. This led to a focus on the use of SDM as a tool for exploring the impact of policy options, where the burden of effort on the teams, was not to build the model, but to adapt a big model[58], based on the provision of local data, and co-design experiments intended to test out a range of policy options.

2.3 Final focus on the use of SDM in exploring policy options

D1.8, the Future Outlooks Methodology, describes an approach to the exploration of policy options provide as guidance to the regional leadership teams of the project. It underlines the need to provide complete solutions to address the challenges which must be overcome to realize the vision for the region. By 'complete solution' it as meant that what is required is not a single measure, which may prove inadequate on its own, but the entire range of measures (the policy mix) which much somehow cooperate and conspire with each other to yield the intended outcome.

This approach requires some understanding of how the world works. To address a single challenge, an action plan may include many steps, ranging from feasibility studies, to pilot projects for proof of concept, evaluations, and scale-up programs. Without this level of detail, it is hard to anticipate what really needs to be done to make things happen, the level of cooperation it requires, or the timescales required to from concept to intended impact. This and related issues were evoked in D1.8, further developed with each regional foresight team in the coaching activity based on reviews of the draft regional action plans, as well as in the training provided on the Mission Oriented Approach.

D1.8 introduced the concept of intervention logic, needed to understand how different measures reinforce and complement each other, and not far removed from one might expect from an SDM.

It referred to related ideas such as the 'theory of change', the Log Frame, and associated concepts such as 'input,' 'output,' 'outcome,' and 'impact' as illustrated in the following diagram. It was recommended that the regional Foresight teams discuss the intervention logic

[57] Mainly in terms of the difficulty we encountered when trying to construct simple user interfaces for complex systems

[58] In our case a model with 8 modules and over 300 parameters

with stakeholders to help them understand the policy choices they make, and to include this reasoning in the ‘action plan’ part of the Foresight package.

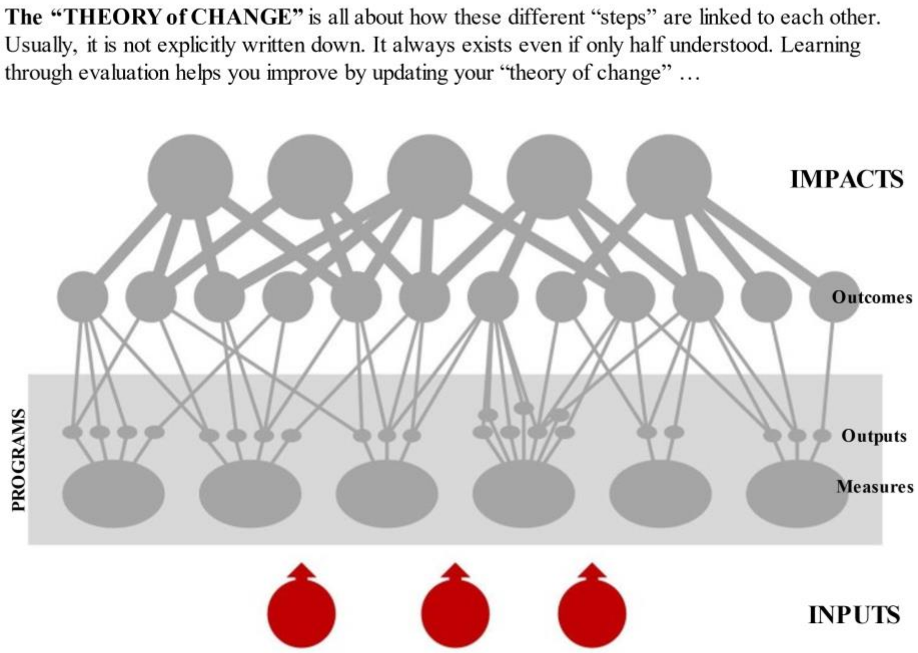


Figure 1: Understanding the intervention logic

This diagram is intended to reflect the reality that policy challenges often hide a lot of complexity and that combinations of measures are required in order for these challenges to be addressed. Different measures act on the region in different ways, over different periods of time. The phasing of measures, the order in which they are executed, is important. Different measures in the mix may complement each other in different ways and the impacts may happen with a delay in that a typical measure can be expected to provide an impact that will unfold over years, for example over periods of 3 to 10 years. These are all issues that will not be obvious to typical stakeholders taking part in the Foresight process. They may not even be obvious to the policy experts taking part. It is therefore reasonable to ask if tools exist for use in the context of a Foresight process, that will help stakeholders better understand the implications of the policy choices made, their interactions, and how their impact might emerge over time. Understanding such issues, is arguably a useful preparation for the application of SDM to a process which is intended to produce an action plan and a roadmap.

It is a well-established principle that what gest measured gets managed and in using the Log Frame, it is common to provide indicators at every level of ‘achievement,’ at the level of outputs, outcomes, and impacts.

D1.8, therefore, also discusses the issue of KPIs or Key Performance Indicators. Experience show that leaders of regional foresight initiatives, and those who take part in those initiatives have great difficulty dealing such issues. Nevertheless, a lot can be learned from a discussion on the use of indictors. It tends to provide a perspective that entirely qualitative discussions cannot. In particular it helps to get an idea of the scale of initiatives, the time and effort and resources that reaching certain goals might require.

We thought that providing a full set of indicators for all measures that make up the action-plan in the regional Foresight package, would place an unreasonable burden on the regional Foresight teams and their facilitators, so we suggested that the teams focus on a limited number of the most important ones, for example on relatively simple and easy to understand measures of “impact.”

Ultimately these can be considered as indicators of performance of the local economy. Nevertheless, the design of indicators is not as easy as it may look. Guidelines for creating indicators were provide in 1981 by George T. Doran writing in Management Review[59]. He suggested a set of rules summarized by a SMART mnemonic. There are many variations on this and on what each letter means, but the following table captures the general idea, adapted to the needs of the POLIRURAL project.

S	Specific in the sense of clear and easy to understand
M	Measurable, this may sound obvious, but most will not know what data exists…
A	Achievable, also obvious, but few have a reliable ‘feeling’ for numbers…
R	Relevant, especially if proxies are used, their relevance should be explained
T	Time-bound in the sense that it should be achieved by a clear date

Table 1: The SMART indicator framework

These issues, the need for an effective policy response, based on a complete solution or adequate policy mix, an understanding of their interactions, and of the means by which their impact can be measured, are all aspects of the exploration of policy options by traditional means, that we wanted to capture in our use of SDM in Foresight.

The general idea is that the users would be presented with a model, that they would interact with that model by varying parameters that correspond to policy options, and that they would see how those choices of parameter would translate through the dynamics of the model into ‘impacts’ reflected in the evolution of the KPIs over time.

For this to work, it would be necessary for the Foresight teams, to explore policy options and their impact on KPIs, the old-fashioned way. D1.8 provided guidance along those lines. The

[59] Doran, G. T. (1981). There’s a SMART way to write management’s goals and objectives. *Management review*, *70*(11), 35-36.

regional teams were nevertheless allowed to organise the exploration of policy options as they see fit, to ensure an adequate and timely outcome of their exercise.

The intention being that they would later explore a selected number of policy options, not as novices, but as Foresight facilitators with some experience, providing a point of reference with which to compare the results of experiments carried out with the use of STELLA.

3 Building SD Models for Use in Foresight

As previously indicated, it was decided that given the state of the art, and the tools available, that it would be best to explore the application of SDM to Foresight as support for the task of exploring policy options, with a view to selecting mixes of policy measures that are intended to fully address the challenges associated with the achievement of each regional vision.

Our concern was that whatever the outcome of our experiments, based on the use of STELLA, each regional team should not be prevented from successfully completing its regional foresight initiative. D1.8 was intended to provide the regional teams with the guidance they would need to do this. It also emphasised the use of basic ideas, techniques relevant not only for Foresight but resonant with the intended application of SDM. These included the use of scenarios (to describe policy options), intervention logic and use of smart indicators (KPIs).

The first stage of the work of building SD models consisted in exploration of the use of mini models. That is, very simplified models, which would allow us to verify the basic outline of our approach and provide training material with which to introduce the SDM concepts to the regional teams.

We focused on building a mini model for rural tourism, an area in which CKA has some experience as a consultant for national governments and big investors. This led to the idea of a 3-layer model, also to the development of a framework for working with what we referred to as 'paper-models'. That is models which do not require working with software-based systems such as STELLA. But which can be implemented using pen and paper, or post-it's on a white board. At the time we referred to this kind of model as an 'alpha model' to indicate our intention to later transform it into a software model based on STELLA, but we have since started to refer to these as paper models.

We implemented a sub-set of the paper tourism model using STELLA. It was at this point that we became frustrated by the limitations of the user interface and understood that it would not be possible to create a large complex model in STELLA with adequate provision for the exploration of policy options by its users. At this point, we had learned enough to move ahead with the construction of the 'big' SD model and defer the development of user interfaces to a later date, when this could be done working with AVINET, with a view to allowing users access to the model via the Innovation Hub.

In the following sections we describe the main tasks and achievements of our work so far

- Development of a paper SDM for rural tourism
- Demonstration of the exploration of policy options for tourism using STELLA
- Creation of a general framework for 'paper SDM' illustrated by relevant cases
- Creation of the full SD Model for rural regions

- Regional adaptations of the full SD model based on regional datasets
- Provision of access to the regional models via the Policy Options Explorer
- Design of experiment with regional users for evaluation and feedback
- Use of SDM outputs as inputs to an index of Rural Attractiveness
- Its use as a tool for exploring policy options via the Rural Attractiveness Explorer.

3.1 Mini models and lessons learned from modelling rural tourism

The rural economy includes many different sectors, all with their own characteristics. We chose to start by looking at the case of rural tourism. This was an area in which CKA has good experience and it relatively simple compared to other domains, and therefore a good place to start. The construction of this mini model was carried out in two phases:

First an 'alpha model' terminology borrowed from an old practice in IT, where the alpha model is a paper model, that captures all of its features, before any code is written. The authoring of the alpha model is something that can be done using the relatively familiar language and concepts of tourism and economic development. It avoids worrying about the technology of modelling software and the difficulties associated with building interfaces in real-life, and all of the technical challenges and compromises that those tasks necessarily involve.

Then the corresponding 'beta model' using STELLA. The goal was to implement the alpha model in STELLA along with an interface allowing the exploration of policy scenarios by simply varying input parameters and visualizing the impact this would have on a set of KPIs.

Our intention was that this should be simple enough for us to model, while retaining enough complexity to reflect qualitative aspects of the real world. With this in mind we chose a model comprising three interconnecting layers.

- A top layer provided by measurable and meaningful KPIs.
- A middle layer consisting of factors that make up the 'machinery' of the regional tourism economy.
- A bottom layer also consisting of factors but specifically those provided by policy measures.

We started by choosing a simple set of KPIs, knowing that these could eventually be extended, depending on the nature of the policy challenge to be addressed. The chosen KPPIs were

- The number of people who visit the region as tourists,
- The number of nights they spend there,
- The amount of money they spent there,
- The number of jobs supported by their coming to the region.

The middle later intended to capture the 'economic machinery' of the region also contained four key factors, judged to be of importance for the tourism sector:

- Infrastructure
- Accommodation
- Monuments and amenities
- Activities, events, and experiences.

The final layer referred to three different kinds of policy measure. In this case

- Programs to enhance access to, visibility and awareness of the region for tourism purposes,
- Programs to develop needed skills and human capabilities.
- Programs to encourage tourism related entrepreneurial activity.

These three layers were joined to reflect the causal logic of how programs influence the machinery of the economy, with the impact of those programs then being reflected in changes to the KPIs. All of this was represented in the following diagram.

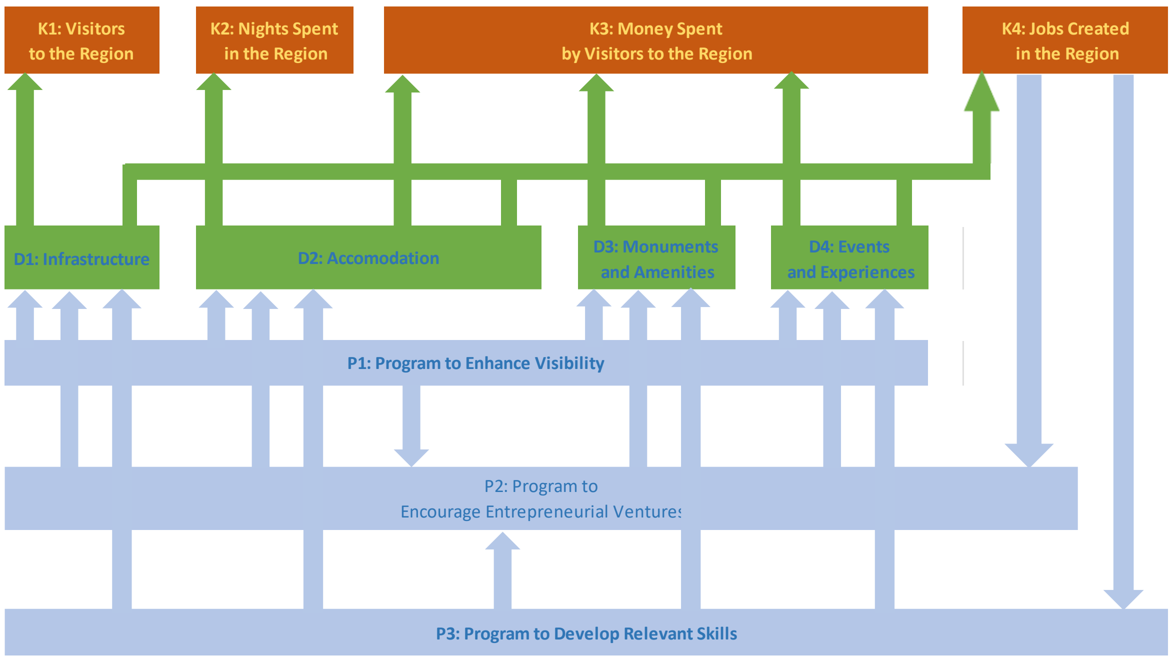


Figure 2: The paper model for rural tourism

This diagram hides a lot of complexity. For example visitors might come for short stays, weekends, or long stays. They might come in winter or summer. They might come by road, train, plane, or by boat. Infrastructure could refer to transport and mobility, regional airports, train lines, or car parks for tour buses. It could mean public toilets and showers, trails and pathways, picnic places, seating for older people, wheelchair access, nature reserves, places of natural beauty, signage, publicly available maps and apps and websites, local tourism- or booking-offices. The same can be said of any of the 11 elements referred to in the diagram.

The making of such models is not an exact art. And building such a model using a brain storming approach involving for example 100 stakeholders, who have nothing to do with tourism, could turn out to be a very long-winded affair. Sometimes it will be useful to proceed in his way. Other times, it may be best to start with a ready-made model and start a discussion using that as a starting point.

Clearly such 'paper models' model can be extended and improved in many ways. It will never be perfect, but it can be improved. The process of improvement could itself evolve into a useful form of stakeholder engagement.

One of the 'games' you can play with the three-layer model is to ask what the arrows mean. It is surprising how people are happy to draw arrows between boxes without knowing what the boxes represent, or what an arrow pointing from one box to another actually is intended to represent. It is not an exact science. It is a learning process. And a useful result may take many forms. One way to encourage deeper debate and encourage learning about (in his case) the tourism economy as a system is to ask if there are missing arrows and gather views on what each arrow might contain. One way to structure such a process is to use a matrix like the one below.

The matrix provides a way for recording narratives that explain how the drivers will have an impact on the KPIs
A-priori the KPIs are Independent Variables
In a more detailed model they may be elaborated upon

	KPI 1: No. of Visitors to the region	KPI 2: No of Nights spent in the region	KPI 3: Spending by visitors to the region	KPI 4: Jobs created in the degion
Lower limit	-	-	-	-
Upper limit	100.000	200.000	50.000.000,00 €	1.000
D1: Infrastructure (travel, comfort, experience ...)	Airports and ports, train and bus stations make the region more accessible and easier to reach. The availability of public toilets and showers make benig there more comfortable. Facilities for outdoor activities such as trails and pathways, picnic places, seating for older people, access for wheelchairs also make it more attractive... also car-parks, parks, nature reserves, places of natural beauty, signage, maps, a tourism or bookings office...			Good infrastructure creates jobs in building and maintenance, as well as in runnning facilities and amenities...
D2: Hotels and accomodation (no of beds avaliable)	The presence of suitable accomodation makes the region more attractive for different categories of visitor	The number of beds and rooms creates the potential to welcome visitors who stay for more than one day...	The quality of accomodation affects the spending on this item, also the use of facilities such as conference rooms, in-house restaurants and bars... also youth hostels and camp-sites...	Accomodation creates potential for jobs in hospitality, managers and line-staff, front desk, kitchen, floor, cleaning etc.
D3: Sites, monuments and museums (no of amenities)	These make the region more attractive as a destination by giving visitors things to do	They provide incentive to stay over and experience more	They provide visitors with opportunities to spend their money in the region	They create employment for managers and line-staff, curators, performers and other service providers
D4: Events	Festivals are a great way to attract people to a region ... the numbers can range from 100s to millions over 1 million ... this needs to be built up over time ... but music festivals are not the only kinds of event ...	In some cases the family follows... medical tourism for example...	Their main impact may be on spending and catering but also on fees... the policy trick is to extend the festival season into other seasons and make full use of infrastructure and transform seasonal work into full time jobs ...	Festivals (for example) also create employment for musicians, support staff such as riggers, sound and lighting crews... Medical and sports tourism creates jobs for doctors, nurses, dieticians, trainers and physio-therapists and other specialists...).
D5: Entrepreneurial Ventures	Entrepreneurs invest in events and things to do... paint-ball, sports, muisc and drama festivals, training camps ... clinics for medical tourism... all providing reasons to come and visit...	Entrepreneurs are required to invest in different kinds of accomodation ranging from high-end hotels to camp-sites... all enabling longer stays	Entrepreneurs are needed to invest in cafes, bars, restaurants, cinemas and concerts halls, dance and festival venues... all increasing the need to stay over-night...	Jobs are created in design and construction, of buildings, interiors, experiences ... as well as for running and maintenance ...
D6: Skills	The availability of a suitable labour pool is a limiting factor on the type of accommodation available	The availability of a suitable labour pool is a limiting factor on the length of stay, due to its impact on the quality of accomodation and amenities...	The availability of a suitable labour pool is a limiting factor on speending due to its impact on the quality of opportunities for leisure and entertainment...	the availability of a suitable labour pool is a limiting factor on the job places that can be filled...
D7: Visibility and Awareness	People will only come if they know about what is going on...	They will only stay or come back if it is fun and has suitable accomodation...	Visitors will budget for the visit on the basis of anticipation of what there is to do	This creates feedback loops in terms of attractiveness for entrepreneurs ... who invest and create jobs...

Figure 3: Understanding the 'boxes' and 'arrows' of the paper model

This matrix where every box is linked to every other box, provides a way to organize and systematically explore the relationships between the boxes in the model. Each box in this matrix lies on a 'column' which corresponds to one of the boxes, and on a 'row' which also corresponds to a box. The diagonals can be filled in with an explanation of what the box is intended to represent, and the off diagonals can be filled in with an explanation of what the arrow represents. Boxes that correspond to arrows joining policy options to the middle layer or to the KPIs, effectively explain the intervention logic. Boxes that correspond to arrows pointing the other way, may correspond to feedback loops. In any case, the use of this matrix provides a support for discussions around the model and the dynamics it represents, allows everyone to contribute to updating or improving the model by assigning more boxes, and more arrows. It provides a record of what was decided and can be used as a starting point for follow-on meetings, or to inform those who were not present of the lessons learned and insights gained.

One of the reasons we developed the 3-layer diagram was not only that it does not require complex software to generate and is almost immediately understandable by someone from the general public. It's main virtue of the 3-layer model is that it is much easier to read than the corresponding one in STELLA, which looks something like the diagram below.

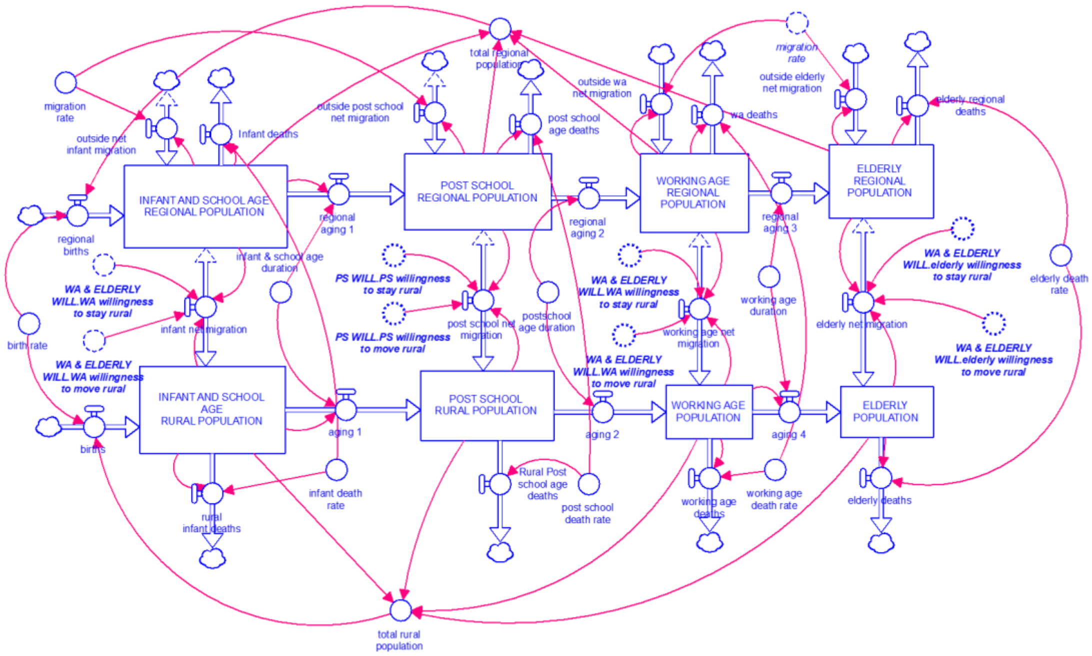


Figure 4: The 'boxes' and 'arrows' of the STELLA representation

This is much less intuitive than the 3-layer model presented earlier. So, we were interested in finding ways of shielding the user from this kind of complexity, exposing users only to those parts of the model that are of interest at any given time.

STELLA allows one to create user interfaces. It allows one to hide the model by keeping it in the background, providing simple ways the user can tweak model parameters, and visualize the evolution of parameters over time.

We experimented with this to demonstrate how SDM using STELLA could support the exploration of policy options. Due to the constraints of the system we could only do this with a small part of the model, so we choose to do it with the part concerning infrastructure, taking the case of development of an airport, to model the impact of various airport measures on

KPIs such as the number of visitors to the region. We could have extended this to other KPIs such as its impact on accommodation, and nights spent in the region, or money spent in the region. But we decided to focus on the simplest case, as we struggled to contrive a simple and easy to understand user interface.

To implement this we had to make many simplifying assumptions such as equating infrastructure with airport 'capacity' as an outcome of various policy measures, as a result of projects to expand the airport to make it more efficient, to extend the runway to receive bigger planes or add runways to receive more planes of the same size. Aspects we tried to capture nit eh mode include the fact that runway projects take many years to implement so the impact will not be seen for a while. When an airport opens it will take a while for the public to get to know about and for traffic to expand. Its success will also depend on other measures to develop things for visitors to do and reasons for the to visit. The point is that building a model even with a small number of parameters is not easy and requires realistic insight into 'how the world works.' We calibrated the model using data obtained from reports on real airport expansions. We had to build into the model realistic constraints such as the fact that airports have a maximum capacity and are capped at that level of traffic it can sustain. Furthermore, they rarely operate at full capacity, and start to plateau at around 80% as the quality of service starts to fall off.

The mini model intended to capture these features of a regional tourism dynamics are based on a beta model which equates infrastructure with a regional airport, modelled simply by the number of passengers it can receive in a year. Historical data from a real airport was obtained to establish a baseline and the scenario 0 below is a simple extrapolation of this data, with a cut-off at just below full capacity. The model was completed by various assumptions about the number of visitors coming for tourism purposes. The different policy measures were simply modelled by their impact on the ceiling for capacity. The following screen shot gives you an idea of what the user interface looks like.

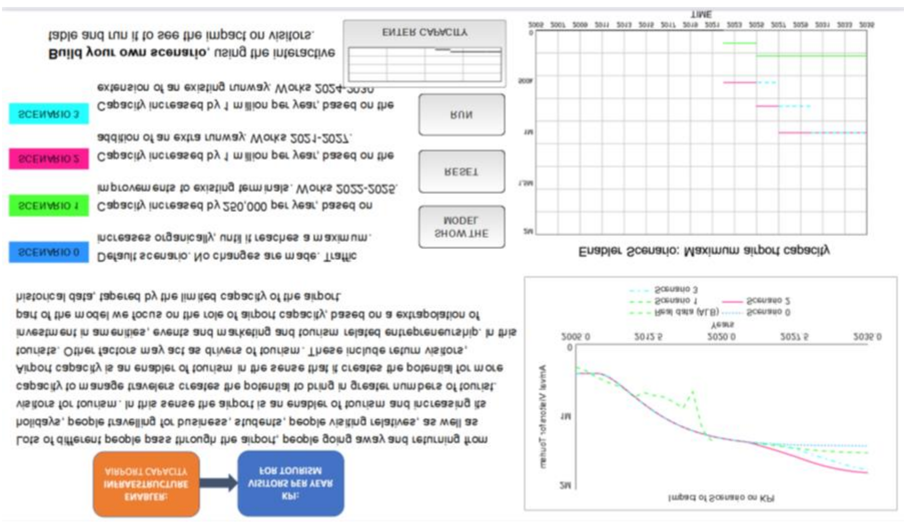


Figure 5: Exploring the mini model for rural tourism

This allows the user to explore a baseline scenario where nothing changes and compare it with different policy scenarios on the basis of impact on the main KPIs which is the number of visitors to the region.

- Scenario 0: This is the default scenario where no changes are made to improve the airport. Click on run to see how the traffic increases organically, until it reaches a maximum due to the limited capacity of the airport.
- Scenario 1: Airport capacity is increased by 250,000 per year, based on improvements to existing terminals, with work starting in 2021 and finishing in 2023. Click on "run" to see how this scenario will impact the number of visitors for tourism.
- Scenario 2: Airport capacity is increased by 1 million per year, based on the addition of an extra runway, with work starting in 2021 and finishing in 2027.
- Scenario 3: Airport capacity is increased by 1 million per year, based on the extension of an existing runway, with work starting in 2024 and finishing in 2030.
- Scenario X: Build your own scenario, using the interactive table and run it to see the impact on visitors.

The main lessons from this were as follows

- STELLA does not provide an adequate environment for developing interfaces to big models involving many parameters.
- Even for small models such as the mini model for tourism, it is not easy to model realistic policy interventions, without the help of domain experts. A better approach may be to develop a wide range of mini models addressed to timely and common policy issues, but with the help of experts who understand both the details of the policy intervention, and how the regional economy is likely to respond.
- The effort required to develop even simple SD models using STELLA is quite considerable. The paper-model approach is nevertheless very promising, as it avoids all of this overhead.

The experiment in developing the paper model for tourism suggests a general approach based on the use of paper models, which may prove to be the simplest and most practical way forward until important issues with the STELLA approach are adequately addressed.

3.2 The general 3-Layer model or 3LM

An important finding of these early experiments on developing SD models for the exploration of policy options is that here is much to be learned by working with paper SD models, using nothing but post-its and wite-boards. The basic approach is to model the system as a 3-layer entity as follows.

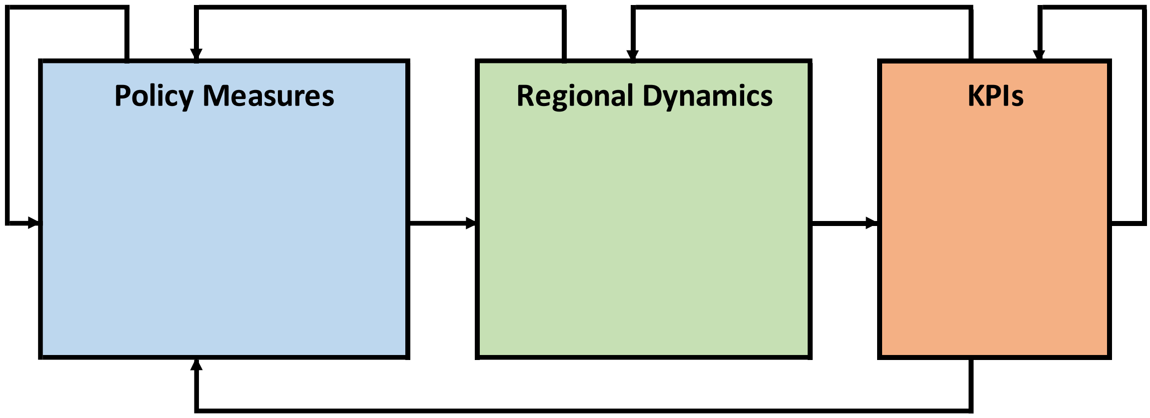


Figure 6: The general paper 3LM

This is nothing but a simple representation of the mini model for rural tourism described above. It could be printed out large, projected on a wall or shown on a screen. All that has to be done is to insert 'post-its' in each of the 3 boxes to end up with something very close to the 3-layer model of rural tourism shown before, as follows.

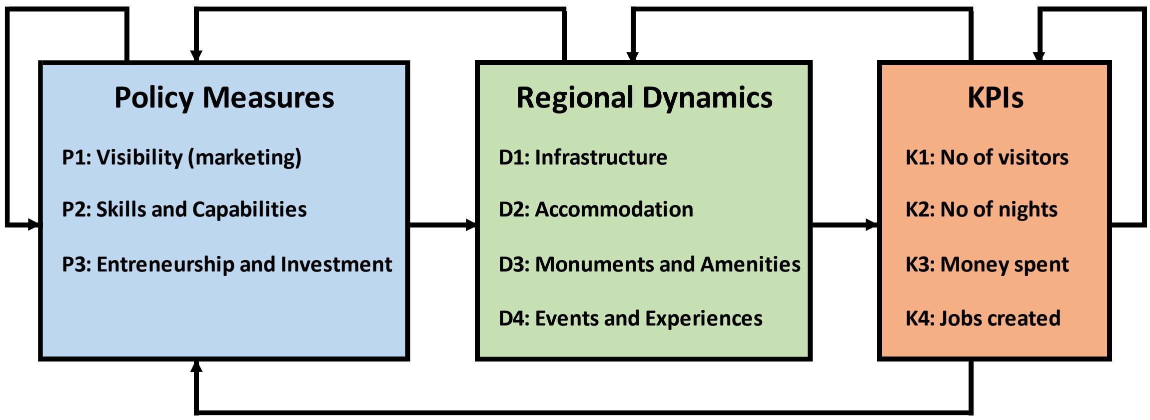


Figure 7: The paper 3LM for rural tourism

The selection of policy measures can be supported by the provision of an inventory of policy options, as is already being done in the project, but for different reasons. It could also be supported by the provision of a guide to deep dives. Several of which have been provided in the project, but once gain for slightly different reason. It is also part of the job of the foresight leadership team to make sure they invite stakeholders from the sector who will have expert knowledge from professional life, as well as researchers who may be experts in the field.

We did not create a guide to deep dives on tourism in this project, but it is easy to imagine what it might look like. To start with it might start by examining different kinds of tourism, all of which have their own needs in terms of infrastructure and support services, but not all of which correspond to opportunities for the region. A priori these might include

- Festival tourism suited for short stays and long weekends,
- Youth tourism based on thing to do in the spring break or summer holidays,
- Health tourism for active people, who like exercise and want to eat well
- Cultural tourism for discovering history, visiting monuments and sites of cultural interest
- Medical tourism catering for specific needs and people travelling with family members
- Sports tourism aimed at professionals and high-level amateurs who need to train out of season
- Business tourism, which caters to fairs, conferences, and meeting away from the office
- Local tourism catering to people from nearby towns and cities who simply want to get away from the daily grind.

The advantage of this 3-layer representation is that it also invites a discussion on 'feedback loops.' Some users may remark that the diagram provides no feedback loop for the regional dynamics box, ignoring the fact that there may be internal interactions and complex dynamics taking place, which should be reflected in an ideal model. The facilitator may decide to add it in or if deemed unnecessary in this instance, leave it out. Such changes are easy to make using such paper models, as no software editing of any kind is required. It can simply be done using markers and post-it notes.

Another lesson from out early efforts with the mini model for rural tourism, is that it also suggested useful ways to motivate, structure and capture the findings of a discussion on the 'dynamics' of the model, the way in which the different entities are related to each other and influence one another.

Based on what we did for the case of rural tourism, the next step after creating the model shown above is to create the following matrix.

The PDK Matrix	Policy Measures P1: Visibility and marketing P2: Skills and capabilities P3: Investment and Entrepreneurship	Regional Dynamics D1: Infrastructure D2: Accomodation D3: Monuments and amenities D4: Events and Experiences	KPIs K1: No of Visitors K2: NO of nights stayed K3: Money Spent K4: Jobs Created
Policy Measures P1: Visibility and marketing P2: Skills and capabilities P3: Investment and Entrepreneurship			
Regional Dynamics D1: Infrastructure D2: Accomodation D3: Monuments and amenities D4: Events and Experiences			
KPIs K1: No of Visitors K2: NO of nights stayed K3: Money Spent K4: Jobs Created			

Figure 8: The PDK matrix

As before, this can be printed out large, projected on a wall or shown on a screen. A facilitator can animate a meeting where people put post-it's into the empty squares, and led a discussion intended to crystalize the most important insights into the dynamics behind the paper mode.

The following matrix provides a variation on this, which has the virtue of relative simplicity. As is worth pointing out always in these things, it is not an exact science.

The D-K Matrix	Regional Dynamics P1: Visibility and marketing P2: Skills and capabilities P3: Investment and Entrepreneurship D1: Infrastructure D2: Accomodation D3: Monuments and amenities D4: Events and Experiences	KPIs K1: No of Visitors K2: NO of nights stayed K3: Money Spent K4: Jobs Created
Regional Dynamics P1: Visibility and marketing P2: Skills and capabilities P3: Investment and Entrepreneurship D1: Infrastructure D2: Accomodation D3: Monuments and amenities D4: Events and Experiences		
KPIs K1: No of Visitors K2: NO of nights stayed K3: Money Spent K4: Jobs Created		

Figure 9: The D-K matrix

The ultimate goal of this approach is to help participants acquire insights that will help them to better understand the scope of available policy options and their possible impacts, discussing the relative merits of those options based on a better understanding in how they relate to the regional economy and how their impact unfolds over time.

3.3 Paper 3LMs applied to different policy domains

The various guides and inventories developed to support stakeholder participation, can help to facilitate discussions around paper models using the 3LM format. We did not develop guides and inventories for all sectors and all possible policy challenges. Regional teams might decide to do his themselves and share. It is also work that in other projects and at another time.

3.3.1 A paper 3LM for the diversification of the rural economy

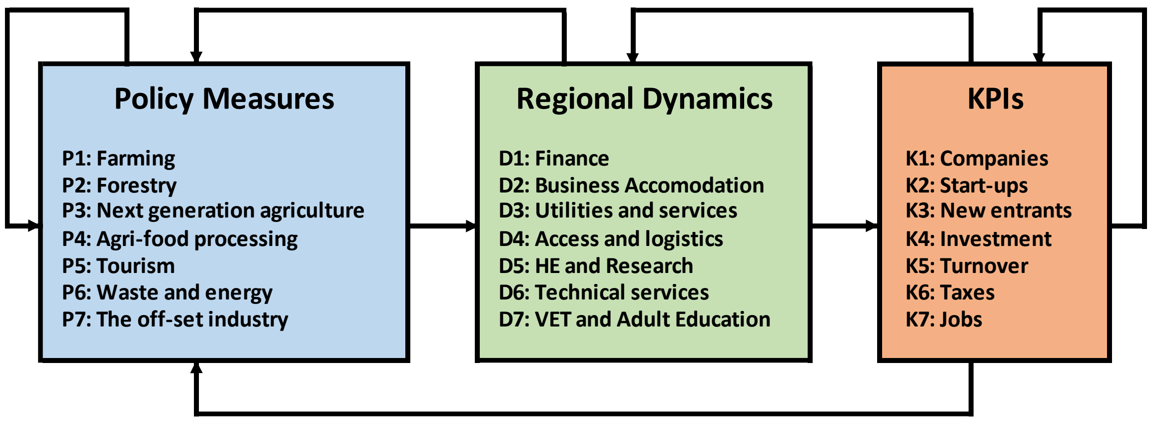


Figure 10: A paper 3LM for diversification of the rural economy

Each P1 to P7 listed under the policy measures, is shorthand for a sector and for the mixture of policy measures intended to promote the development of business in that sector. Such a list is highly 'perfectible.' It can be improved through group work by adding new sectors or deleting ones that do not seem relevant.

It is also possible to imagine a hierarchy of models that look more deeply into what is happening in any of the sectors. His model looks at all sectors of the economy. But others might be bended to look in detail at what is happening inside a specific sector. We have already looked at a model for P5, tourism. It might be desirable to consider a 3LM for the energy sector.

3.3.2 A paper 3LM for the rural energy sector

There has been a lot of progress in the last decade in particular on the development of the energy sector in rural regions. This has the potential to increase resilience to supply chain disruption, as we are experiencing right now with the war in Ukraine. It can create new revenues for farmers and new jobs for people living in rural regions. It can also help to reduce the carbon footprint of farms and rural communities.

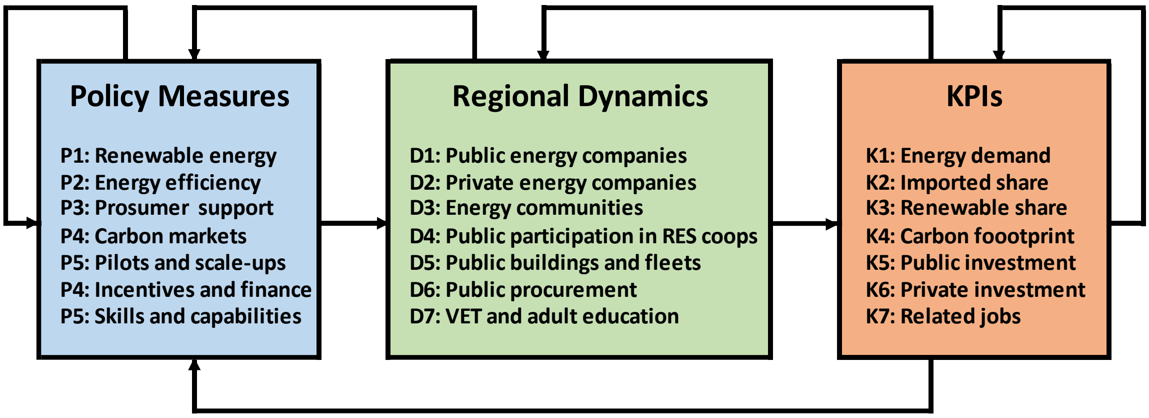


Figure 11: A paper 3LM for the rural energy sector

P1 could include production of electricity, natural gas, and liquid fuels, from fossil fuels, wind, solar or waste. It should include transmission and distribution. Any of these can be considered a sector in itself. One can imagine working with 3LMs energy efficiency which includes measures related to district heating and cooling, material resources efficiency (for indirect or embedded energy savings) as well as carbon project and markets for offsets.

These mini models link up with each other. Energy consumption and carbon footprint are nowadays considered KPIs for industry sectors, not just turnover and numbers employed. All sectors have an energy component and so we can see the inevitability of connections between these mini models. as much can be said of transport, as is said of energy. In this case KPIs might include the electrification of fleets and the on-site installation of charging points.

3.3.3 A paper 3LM for transport and mobility

As part of the energy transition, cities have taken measures to reduce the use of ICEs and encourage the use of e-vehicles. The use of bikes, e-bikes, and cargo bikes is also being encouraged and many cities now have cycling and walking strategies in place. The benefits are not only in terms of lower carbon footprint, but less noise and pollutions from exhaust as well as better health from more exercise. This means longer more active lives for citizens and lower healthcare costs.

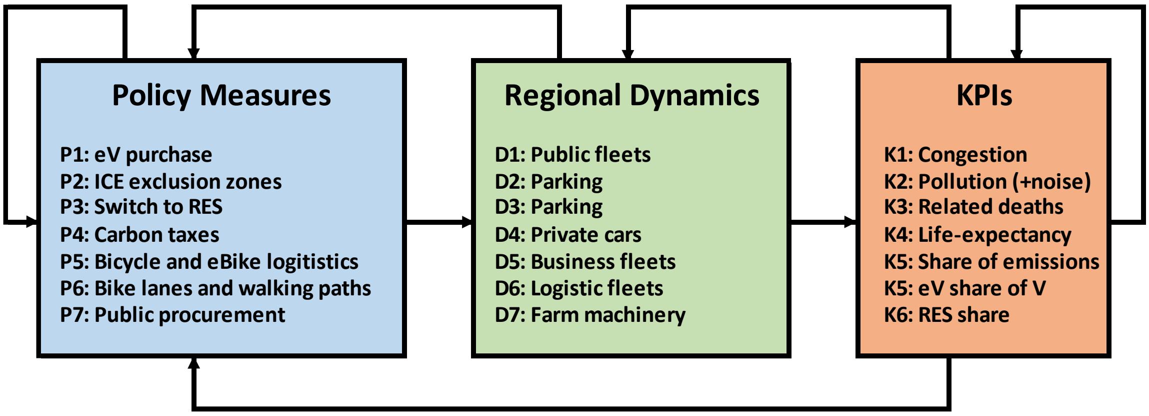


Figure 12: A paper 3LM for transport and mobility

3.3.4 A paper 3LM for the decarbonization of agriculture

Agriculture must now do what is being asked of all industry sectors. It must reduce its carbon footprint. There are many solutions but arguably due the old-fashioned farmers lobby, governments have been slow to act.

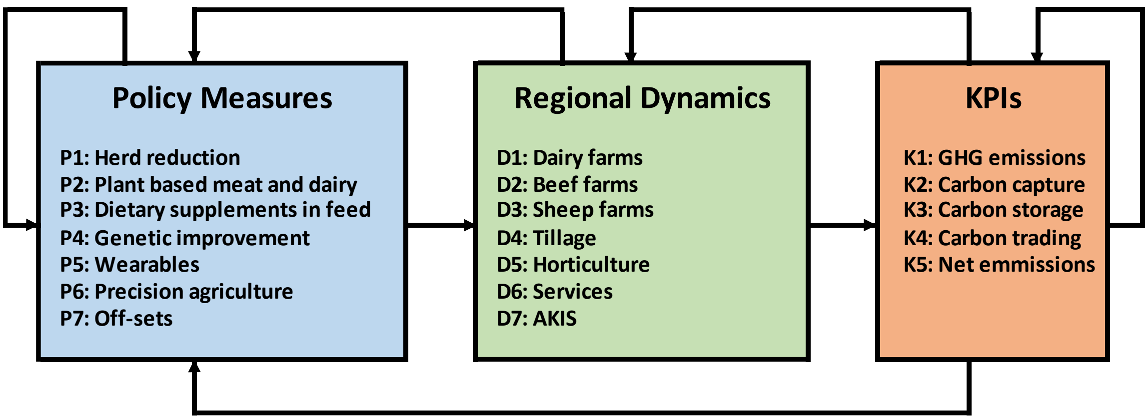


Figure 13: A paper 3LM for the decarbonisation of agriculture

3.3.5 A paper 3LM for biodiversity and natural capital

This is one of the most interesting areas for policy innovation in recent years. It is of especial importance for those living in rural areas. The POLIRURAL project will produce a guide to deep dives in this domain, explaining among other things, the range of policy option available, from which farmers, landowners and other industries can benefit. It is closely linked to the decarbonisation of agriculture, the diversification of rural economies and the development of rural energy systems.

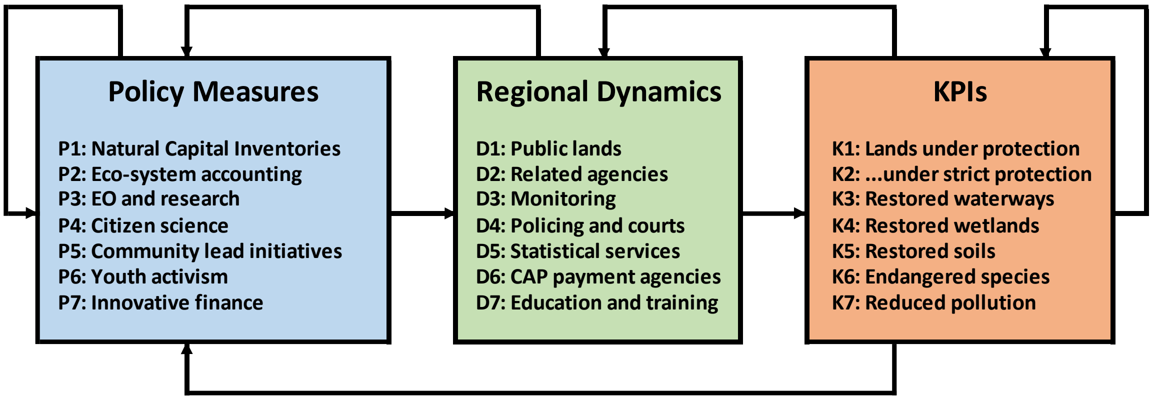


Figure 14: A paper 3LM for biodiversity and natural capital

3.3.6 A paper 3LM for new entrants

One of the early findings of the project was that an exclusive focus on new entrant farmers would not be productive. The sustainability of rural economies and new farming activities, rely on the dynamism and vigour of other aspects of the rural economy. So, any plan to attract new farmers to a region, is unlikely to provide a formula for growth unless that plan is 'completed' with plans to develop complementary aspects of the economy. A further issue has come into play and that is the impact of the pandemic on rural economies. Among other things this has meant an increase in the movement of people from urban to rural areas, as well as an increase in the practice of working from home.

For these reasons it makes sense to embed an exploration of 'new entrants to farming' into a broader picture of new entrants to any and all economic activity in rural areas, of which farming is only a part. As well as those who live in rural areas and used to work in town, but now work from home. This requires a broader, more holistic view of the rural economy, which is in fact consistent with modern calls for a more "systemic" approach based on more comprehensive engagement with stakeholders.

In way our interest in 'new entrants' has grown to include:

- New entrants to farming,
- New entrants to any other economic activity in rural areas,
- New behavioural trends such as working from home (WFH)
- New entrant entrepreneurs seeking lower rents,
- New institutional actors having a transformational effect on rural economies.

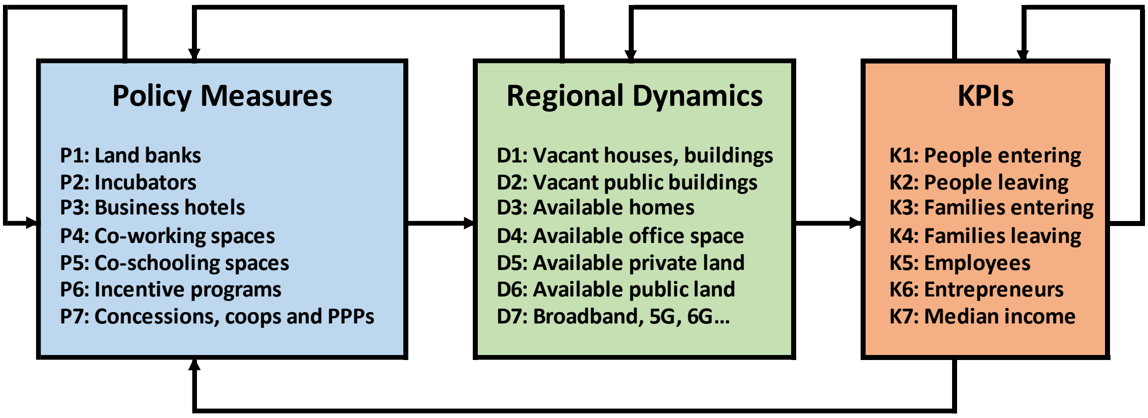


Figure 15: A paper 3LM for new entrants

3.3.7 A paper 3LM for improving regional governance

The Long-Term Vision for Rural Areas, the LTVRA, describes a vision for rural regions of Europe in 2040, by which time rural regions are strong, connected, resilient and prosperous. The first of these is all about local governance. The vision foresees rural regions that are pro-active in shaping the policies that will affect them, even when those policies are established higher up the hierarchy.

For local communities that might mean having an impact on policies decided at sub-regional, regional, central government and EU level. The partners of the POLIRURAL project have recent direct experience of how effectively (or not) they have been able to influence key policies such as the most recent CAP Reform and the Green Deal, for the benefit of their region.

They may like to build upon this experience to articulate the kind of improvements they want to see by 2030. Not only in terms of how you influence policies, through vertically and horizontally integrated governance mechanisms, but also in terms of execution, and in organizing the finance needed for policy implementation at local level. In both the new CAP and the RRP, the member states are required to complete financing from other (non-EC) sources.

The LTVRA, states that in future rural regions must benefit from all EU level policy areas, and it is up to those in public administration at regional and sub-regional level to orchestrate the effects of all policies at regional level, based on a new EU model of democracy60.

From now on, those involved in public administration need to participate in the design of policies that affect them and coordinate the inputs of all policies of relevance for the

[60] https://ec.europa.eu/info/strategy/priorities-2019-2024/new-push-european-democracy_en

development of their region, that is the inputs of policies managed at sub-regional, regional, members state and EU level, not only those for agriculture and forestry, but for industry and environment, energy, transport, research, innovation, education and training, healthcare, security, and emigration.

Right now, the biggest priorities are arguably, the coordination of inputs from the new CAP reform, the Recovery and Resilience plans, the Green Deal, and the new Biodiversity Strategy.

To help the regions taking part in the project navigate this new territory, POLIRURAL has developed an inventory of policy options which focuses on finance and describes over 40 mechanisms for the financing of regional and sub-regional policy measures.

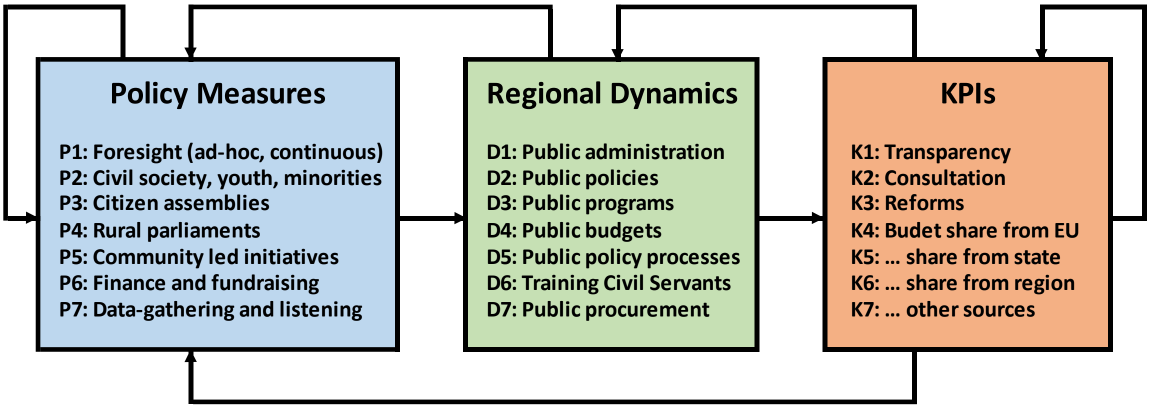


Figure 16: A paper 3LM for regional governance

3.4 The Core SD Model

The project required the development of a 'full' SD model. What this meant was ambiguous, but it was clear that due to its complexity and the issues encountered in developing the paper model for rural tourism, that we would not have time to attempt to co-design the full model in cooperation with the regional leadership teams. The best we could hope to do, would be to create a baseline model and late adapt it in some way, in collaboration with each of the regional teams, aligning as best we might, to the specificity of each region and its ongoing Foresight exercise.

This work was undertaken by 22SISTEMA and resulted in the creation of a baseline SD model in STYELLA, comprised of 8 modules, containing over 300 parameters. This is far too complex to illustrate in the main body of the report. Nevertheless, their structure can be illustrated using a screen shots of STELLA for each of the modules listed as follows:

- Population,
- Education,

- Quality of life,
- Agriculture,
- Natural capital,
- Employment,
- Rural Attractiveness,
- Rural retention capacity.

Given the size of the model, there was no time to describe each box in detail and explain the meaning of the links between them. The approach has therefore been to provide a model that will allow us to proceed and undertake efforts to improve the model at a later stage. This represents a lot of work and what has been achieved so far can of course be improved and may need to be adapted to better reflect the nature of the region and the goals of its specific Foresight exercise.

The core model, its regionally adapted variants, and the work needed to create them, are described in detail in deliverable D5.4, available on the POLIRURAL website.

3.4.1 Extracting 3LMs from the Core Model

Conscious of the potentially overwhelming complexity that a full model with 8 modules and 300 parameters might present for a non-expert user, we had to confront the challenge of how to simplify the experience for the region team. We wanted to preserve the idea of the 3-layer approach, described previously. This distinguishes between

- Input or control parameters which allow the user to select different policy options,
- Output parameters or KPIs, which reflect the performance of the region in response to the choice of policy options, which can be visualized as they evolve overtime,
- The machinery of the regional economy, which operates in accordance with the rules embedded in the mode, and whose behaviour is modified by the different choices of policy options. By regional economy we are referring to the economy in the largest sense of the term, to include everything to do with industry, society, the environment, and public services.

For practical purposes we had to assume that the input and output parameters are already contained within the full model, and our approach was following training and in consultation with 22SISTEMA, to ask each of the regional teams to select from among the 300+ parameters of the full model, a subset of about 10 that they intend to use as control parameters with which to explore different policy options, as well as a subset of up to 10 other parameters allowing them to visualize the impact of policies on the regional economy. The following schema illustrates how the full model was used as a basis for defining the interactive system each regional teams would use as a laboratory for exploring policy options for their region, in a limited number of domains of interest.

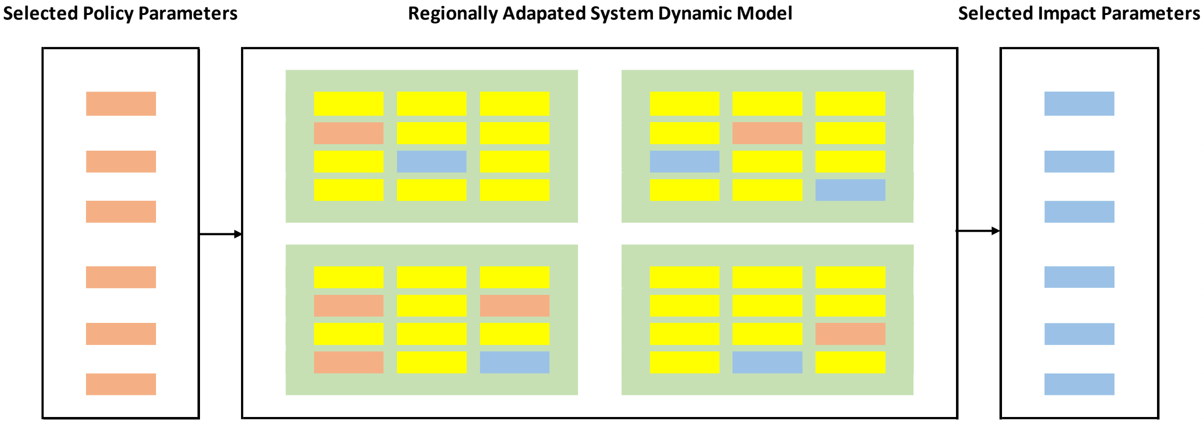


Figure 17: Extracting a 3LM from the core model

To achieve this goal, and ultimately provide users with a regionally adapted model, they could use with local stakeholder, the model builders proceeded in phase as follows:

Phase 1: 22SISTEMA worked with users to obtain regional data sets with which to populate the model. In many cases the data was not available. In other cases, when the data was available, it did not have the required resolution, or did not adequately cover the years needed to populate the model. In such cases, standard techniques such as interpolation or use of proxy data, were applied to improve the data sets, and allow the model to run.

Phase 2: 22SISTEMA then worked with users to

- Select a limited number of policy issues they would like to explore
- Select a limited number of model parameters to be used as control parameters, allowing the user to explore different policy options by simple making different choices of parameter.
- Select a limited number of model parameters to be used as impact parameters, allowing the user to visualize the impact of different policy options on the region over time.
- Carry out a 'design of experiment' task, as preparation for their first use of the system. This task resulted in the provision of a document which recorded their initial expectations, and clarify among other things, how they intended to use the system, and what they hoped to learn from using it.

Without being too directive it was suggested that 5 to 10 control parameters and 5 to 10 output parameters should suffice.

Phase 3: 22SISTEMA and AVINET then worked together to create a series of online user interfaces to implement each regionally adapted SD model, allowing the user to explore their selected policy domains. When these were regionally adapted models were ready, training was provided to each user team on the use of the system they had helped design. The users were remined of the importance of recording their efforts, and of the need to provide feedback. Not only on the basis of the experiments they had designed, but on any other issues they might have discovered in the course of their explorations.

Phase 4: This was the final phase of work, in which the users were confident about using the models they had helped create and execute the experiments they had designed. Feedback is currently being collected on this. Preliminary results are included in this report. Final results and the results of another ongoing wave of experiments will be reported on in a planned paper on the use of SDM to be published in the future in a peer reviewed magazine. The on-going wave of experiments referred to above, connects this work on SDM with other work conducted in the project on 'rural attractiveness.' This work is reported on elsewhere in this document.

It is worth noting the effort required to complete each phase of this work. 22SISTEMA for example, indicates that it met individually with each of the 12 regional teams or their representatives, at least 5 times before reaching the end of Phase 2. With some partners, many more meetings were required. Phase 3 and 4 of the work were also quite burdensome.

The first lesson from all of this is that there is a need to reduce the burden of effort required to localize the model and initiate its users. But there are other lessons to be learned from the experience.

All of this is a reflection of the fact that the users, consist of people from a wide variety of different backgrounds. Most of these are not modellers. They have no experience with or knowledge of modelling. Furthermore most are not economists. They have limited understanding of how economic and social development happens. This is not a reproach, just a reflection on the reality that most people when they come in contact with models such as the 8M-SDM are being confronted with a wide range of complex issues for the first time.

This means that care must be taken to adequately initiate users to the model, the policy options explorer, and the possibilities it presents. On the other hand, it reveals an important and more or less unanticipated role for the tool, that of the educator. This is perfectly compatible with a well-established view of Foresight as a collective learning process.

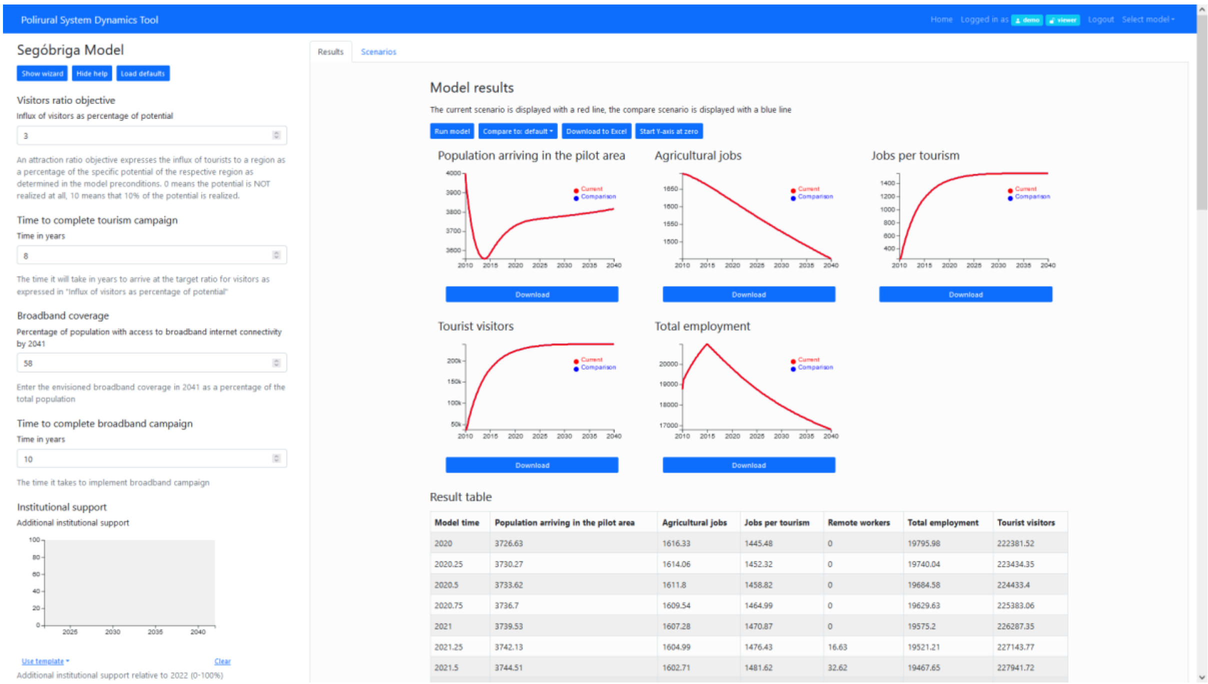
3.4.2 The Policy Options Explorer and regional adaptations of the Core Model

Based on the work described above, 22SISTEMA worked with the Foresight Leadership teams to create regionalized models. This resulted in the production of 17 regionally adapted models, 11 of which have been implemented on the POLIRURAL Innovation Hub, via what we refer to collectively as the Policy Options Explorer.

The process for the development of the regionally adapted models is explained in detail in D5.4, where a table containing the choice of control variables and selected KPIs for each of the regions is provided in annex.

The result of this work for the 11 regions is available via the following link https://polirural-sdm.avinet.no/ at the AVINET site, accessible via the username and password 'demo.' We have not gone 'public' with this but intended to do so once the regional leadership teams have finished their experiments as first uses of the system.

To give you an idea of the user experience, what follows is a screenshot of what the user sees when they enter the system for the region of Segóbriga.



Model time	Population arriving in the pilot area	Agricultural jobs	Jobs per tourism	Remote workers	Total employment	Tourist visitors
2020	3726.63	1616.33	1445.48	0	19795.98	222381.52
2020.25	3730.27	1614.06	1452.32	0	19740.04	223434.35
2020.5	3733.62	1611.8	1458.82	0	19684.58	224433.4
2020.75	3736.7	1609.54	1464.99	0	19629.63	225383.06
2021	3739.53	1607.28	1470.87	0	19575.2	226287.35
2021.25	3742.13	1604.99	1476.43	16.63	19521.21	227143.77
2021.5	3744.51	1602.71	1481.62	32.62	19467.65	227941.72

Figure 18: The Policy Options Explorer based on the core model

Looking at this in more detail we see that the user can enter the scenarios screen to define and save a scenario based on selection of parameters intended to reflect different policy choices. The following indicates what the user will see.

Current scenario

Save current scenario

Parameter	Value
attraction_ratio_objective	"3"
cultural_appeal	"shared_knowledge"
final_technical_obsolescence_time	"10"
population_covered_objective	"58"
time_to_complete_broadband_campaign	"10"
time_to_complete_campaign	"8"

Figure 19: Defining different policy options

This next image gives an idea of what the output looks like. In this case, the model is run to generate time-series representing the evolution of the selected KPIs over time.

Figure 20: Comparing the impact of different policy options over time

In this case the baseline scenario is compared with the chosen policy scenario model by the users' choice of input parameters. In principle it is possible to compare the impacts of a number of different policy scenarios and use the output as a basis for discussion which will help the users optimize their policy mix.

The regions are currently conducting experiments on the use of the Policy Options Explorer and their feedback is recorded in an internal deliverable entitled "POLIRURAL Compendium of Regional Foresight Initiatives."

The 11 implementations are for the regions of Apulia, Central Bohemia, Central Greece, Galilee, Gevgelija-Strumica, Häme, Monaghan, Segóbriga, Slovakia Region and Vidzeme.

The model for Mazowieckie could not be finished due to lack of data. More specifically,

- Population data were gathered at regional level, but the data for rural and urban populations were merged.
- Employment data were only available at national level. It was considered to use the relative ratios of population employed in the different sectors. But this was too much of an assumption, for local dynamics would have been dismissed in the process.
- Data for the education module were only available as ratios for the whole nation, so it was not possible to extract local data.
- Agriculture data was very complete but again only available at national level.
- No values were available for Natural Capital and Quality of life modules.

It is worth mentioning that these results were obtained at great effort. Most data sets needed some kind of pre-processing or adaptation, before they could be introduced into the model.

3.4.3 Regional SDM experiments using the Policy Options Explorer

The regional adaptation of the core model and their use by the local Foresight leadership teams is in effect a form of citizen science. To capture as much useful feedback as possible, feedback that goes beyond polite banalities such as 'yes, that was interesting' it is necessary to organize the work of the first-time users as formal experiments.

To this end each regional team was asked to undertake a design of experiment task in which they are expected to

- Work to understand and improve the model,
- Define what they expect of the model in terms of
  - The dynamics or phenomena it is expected to clarify,
  - The group work with stakeholders it is expected to support.

More precisely, each team has been asked provide statements in advance of their work using he model which indicate, based on the training they have received and their contribution to model design, working with 22SISTEMA and AVINET.

- What they expect to hope to achieve from using the model

- The kind of policy scenarios they want to explore and with whom
- How they intend to introduce and test the use of the model with various groups of stakeholders.

They are asked to do this in advance of using he system, and then they are asked to report back on the following, based on their experience:

- Were their expectations met?
- Did they carry out their experiments as planned?
- If not, then why, and what did they do instead?
- What feedback do they have on the model itself?
- What feedback do they have on the interface and its usability?
- What feedback to they have on this approach to exploring policy options?
- Any other remarks they may have to help develop a next generation version of the system?

Most, if not all of the regional teams have completed a first cycle of experiments and have provided feedback. This has not yet been processed. That work will start soon. We hope to have this completed before the summer, with a views to presenting our findings on the results of these experiments in a paper submitted to a peer reviewed journal.

3.4.4 Regional SDM experiments using the Rural Attractiveness Explorer

Rural attractiveness, along with new entrants is one of the key issues explored in the POLIRURAL project. A document entitled 'Compendium of Regional Evaluation Reports,' provided in February 2021, provided an analysis of the role of concepts such as 'rural attractiveness' as well as the nature and role of 'new entrants,' with a view to orienting future efforts of the regional plots. This confidential internal deliverable was an unplanned output of WP4 based on the results of an evaluation exercise conducted by the regional Foresight teams on policies of relevance to the regions, including policies carried out elsewhere or prior to the regional Foresight exercises of the project.

Since the earlier work of the project on the topic of rural attractiveness, the project has gone through several pivots and modified its thinking on his issue. Most of these changes are outlined in the compendium of national evaluation reports. The most important changes being…

- A pivot away from pursuit of a universal definition of attractiveness, towards a more flexible approach that sees merit in allowing for the emergence of diverse region-specific concepts of attractiveness, adapted to a regions state of development, its identity or sense of self, its values, and aspirations for the future.
- A pivot towards the embedding of concepts of attractiveness as elements of the vision of the region, to be made more explicit in D1.8 the outlooks methodology.

- A pivot towards more explicit use of concepts of attractiveness as drivers of the intervention logics that are implied by the action-plan as part of the "Foresight package."

Thanks to these discussions with the pilots and their experience working with concepts of rural attractiveness, our understanding has evolved over the course of the project.

One of the most interesting insights came from the Monaghan team, which observed that "rural attractiveness" was seen in the past (in Ireland) as an outcome of growth and development, but never as a driver of growth and development. Monaghan is now trying to develop the idea of rural attractiveness as a driver of development and has adopted an approach to rural attractiveness based on clear actionable criteria, that can be translated into policy measures.

This forces us to consider aspects of rural attractiveness (RA) that may be amenable to treatment by SD Modelling.

Recently, building on the work of Plan4All on the development of an Index of Rural attractiveness, it has been decided to try to link this with the core SD Model and its regional variants. We have already succeeded in doing this based on cooperation between Plan4ALL, AVINET, 22SISTEMA and CKA.

The Rural Attractiveness Index (RAI), originally developed by Pplan4All is a composite index with six sub-indices, and thirty-six sub-sub-indices representing different aspects of rural attractiveness. It was designed based on the principle that regions can only be attractive in comparison with other regions[61]. Another design consideration was that the intended meaning of rural attractiveness may depend on where, when, and by whom attractiveness is determined [62] [63] [64] [65].

All of this is consistent with key findings of the POLIRURAL project concerning rural attractiveness. The project observed that concepts of rural attractiveness often feature in regional development strategies, that they differ significantly from region to region, conditioned by developmental priorities such as the desire to attract investors, entrepreneurs,

[61] Russo, A., Smith, I., Atkinson, R., Servillo, L. A., Madsen, B., & Van den Borg, J. (2012). ATTREG. The Attractiveness of European regions and cities for residents and visitors-Scientific Report. Accessible at https://lirias.kuleuven.be/retrieve/210755

[62] Ibid

[63] Argent, N., Smailes, P., & Griffin, T. (2007). The amenity complex: towards a framework for analysing and predicting the emergence of a multifunctional countryside in Australia. Geographical research, 45(3), 217-232. https://www.academia.edu/download/41704840/The_Amenity_Complex_Towards_a_Framework_20160128-10002-1pbr99g.pdf

[64] Détang-Dessendre, C., Goffette-Nagot, F., & Piguet, V. (2008). Life cycle and migration to urban and rural areas: Estimation of a mixed logit model on French data. Journal of regional science, 48(4), 789-824.

[65] Lysgård, H. K., & Cruickshank, J. (2013). Creating attractive places for whom? A discourse-theoretical approach to knowledge and planning. *Environment and Planning A*, *45*(12), 2868-2883.

or tourists. In this sense the development of a concept of attractiveness naturally aligns with the creation of a 'vision' for the region, as anticipated in the Foresight process.

Plan4all demonstrated the use of their index by providing a map-based visualisation of rural attractiveness covering all regions of Europe. The following diagram describes an adaptation of their original index constructed to allow the Index to be driven and updated dynamically by the SD models.

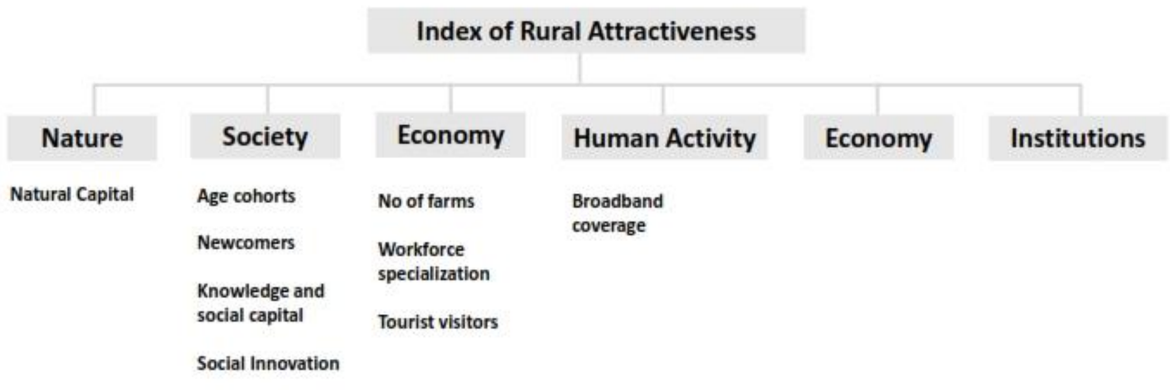


Figure 21: The Index of Rural Attractiveness

This variant on the original index uses four instead of six sub-indices. It uses nine sub-sub-indices instead of thirty-six. Most of these sub-sub-indices are new and correspond to outputs of the regional SD models developed by 22SISTEMA.

The team comprised of Plan4All, AVINET, 22SISTEMA and CKA is currently putting the finishing touches to an online system allowing users to explore the impact of different policy options on this new RAI.

We refer to this system as the Rural Attractiveness Explorer. It takes the outputs of the regionally adapted SDM models and converts them into the SD-adapted RAI, which it presents using four different visualisation strategies. Users can then compare

- the evolution of RAI over time across regions,
- the evolution of RAI sub-indices over time across regions,
- the impact on RAI of different policy choices for a single region,
- the impact on RAI sub-indices of different policy choices for a single region.

We hope to have it up and running in June 2022, available for the regional Foresight teams, and for anyone else who wants to experiment with it. We are looking forward to seeing how the Foresight teams evaluate these new tools. As before, we will ask the regional teams to carry out a 'design of experiment' task to optimize the feedback from their work. An important point of interest will be he feedback on the four different visualisation strategies which for the time being we refer to as the 'map,' 'dots,' 'discs,' and 'data race' strategies.

4 Part 4: Preliminary Findings

4.1 Findings from use of the Policy Options and Rural Attractiveness Explorer

We have not yet had time to process the results of the detailed experiments carried out by the partners in their first use of the Policy Options Explorer. We have not yet carried out the experiments in the use of the Rural Attractiveness Explorer. We expect that these will provide a great many interesting and useful recommendations for the future. Our intention is to publish these findings in a peer reviewed journal towards the end of the project, most likely in the period after the summer break. Nevertheless ir is possible to describe preliminary findings based on our experience to date of designing and piloting SD applications in foresight.

4.2 Need for a comprehensive program of activities

The most important preliminary finding is an appreciation of the scale and complexity of the SD models needed to explore realistic policy options, in the context of an exercise intended to yield concrete results in terms of the 'actors' of public administration being activated, resources being mobilized, and policy measures being implemented. It suggested that ultimate success in developing SD models for use in the context of a Foresight exercise, and as support for collaboration with stakeholders, will require a concerted program of research, much more ambitious than that undertaken in POLIRURAL, spread out over many projects and many teams. A good way to get started on this might be to create a network involving all of the projects that have attempted to far to develop the field of SD and related modelling approaches applied to economic and socials systems. It is possible that the FP funded projects mentioned in part 1 of this report could provide a good starting point for the development of such a network.

4.3 Working with paper models and mini models

There is much to be learned from building small 'paper models' and 'mini models' whether on paper or in STELLA. Ideally these should be developed with the help of teams combining expertise in

- The social economy of regions,
- Policy design and implementation

- The modelling of complex socio-economic systems,
- The design of use interfaces and stakeholder engagement processes.

These would benefit from the creation of inventories of policy options, as well as discussions on the use of KPIs and the challenge of obtaining adequate data to populate such models.

Arguably, such work should precede attempts to design models for implementation in platforms such as STELLA.

4.4 Work needed on model calibration

The SD modelling approach is attractive because it provides the possibility for learning about complex systems. These tend to defy intuition. It is very hard even professional users to have a good understanding of how highly interactive systems evolve over time. It should be useful for both beneficiaries and actors to gain a deeper understanding of the how impacts emerge and play out over time, the need for complete rather than partial solutions, and the trade-offs implied by choosing one option instead of another. It would be very helpful to have a catalogue of examples of complex dynamics. Examples that go beyond text-book examples which often far removed from real world phenomena. In this context we need examples of complex dynamics from the real word of socio-economic development. This would help in dealing with issues such as model calibration, and model testing to ensure that models reproduce known phenomena of growth and development before they can be considered fit for use as policy design tools.

4.5 Work needed on KPIs

The design of models could benefit from an approach that starts with meaningful KPIs. These should then be built into the models from the start. Given the current interest on the role of carbon, and other greenhouse gases, as well as concern for social justice in the green transition, time is ripe for a discussion on the role of non-traditional indicators, and how related data may be gathered. Perhaps using new techniques of crowd sourcing and citizen science. This discussion on the use of non-traditional indicators could draw inspiration from the wide range of innovative new reporting initiatives based on CSR[66], ESG[67], SDG[68], SBT[69],

[66] Corporate Social Responsibility reporting
[67] Environmental, Social and Governance reporting
[68] Sustainable Development Goals reporting
[69] Science Based Targets

CA[70], the work of the Capitals Coalition[71] a merger of human and natural capital reporting initiatives, and emerging frameworks for Ecosystem Accounting[72].

4.6 Work needed on data gathering

Obtaining adequate data with which to populate the SD models has been an overriding concern in this project. The lack of suitable data led to the abandonment of efforts with respect to one of the regions of the project. Most of if not all projects where data was available, required some pre-processing of data before the models could be populated. Good modelling requires a transparent and preferably standardised approach to handling data sets. Without this, statistical offices or other data gatherers cannot improve their game to better meet the needs of modellers. This issue overlaps with the mission of the rural observatory foreseen as part of the Rural Pact, intended to help implement the LTVRA or Long-Term Vision for Rural Areas. It also overlaps with the issue of KPIs referred to above. The introduction of new KPIs or any 'innovation' in their definition, will require efforts in the gathering of related data, to make them available to modellers and decision makers.

As part of the LTVRA, the Commission has stated that "a rural observatory will be established to improve data collection and analysis on the situation of rural areas[73]." This initiative will require the establishment of standards on data and data collection for rural areas. Perhaps the experience of the POLIRURAL project can provide some actionable ideas once they are fully formulated.

This is an area where the POLIRURAL project can provide inputs, based on the 12 regional Foresight exercises as well as on the experience we have had with SDM.

4.7 Work needed on user interfaces and modelling environments

One of the key challenges of the project arises from the fact that the SDM tools developed are intended for use by the general public. That is for use by a wide range of people most of whom are non-expert in areas such as modelling, economics, or regional development. The best of these will bring curiosity, an open mind, and a willingness to learn. Yes, even these will require

[70] Carbon Accounting
[71] https://capitalscoalition.org/
[72] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ecosystem_accounts_-_measuring_the_contribution_of_nature_to_the_economy_and_human_wellbeing
[73] https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)698027

help in the use of these systems. The software systems and user interfaces associate with any SDM will need to take this into account. We have started to investigate this with our exploration of different visualization strategies in the Rural Attractiveness Explorer as described previously.

Nevertheless, software and use interfaces will not be enough. Suitable content is also needed. We have started to address this in the development of inventories, such as the inventories of policy options, and the guides to deep doves on specific challenges. We think that this is one aspect of the modelling environment which will be essential for its success, and which may need to be systematically developed, with a view to their use as support for the use of SD models in Foresight for regional development.

We tried to further explore this issue in the project, by focusing a part of the projects, effort in Text Mining, on the challenge of producing Curated Readings Lists or CRLs, on the premise that the inventories referred to above, are essentially collections of CRLs.

4.8 Potential lessons from elsewhere

Finally, we refer back to the last section of part 1 of this report which refers to trends which are related to or adjacent to, the adoption of SDM for use in Foresight. This section is not exhaustive[74], but it refers to

- Community Based System Dynamics,
- Low code and no-code development paradigms and platforms,
- Lessons from the world of online games,
- Digital twins,
- Agent based Modelling, and
- The use of AI in theory-free approaches to the modelling of natural phenomena.

It may be productive to explore these areas, in conjunction with SDM applied to regional development. Perhaps this can be part of the comprehensive research agenda referred to above.

[74] We did not mention modelling using Bayesian Networks