

NEXUS FUTURES Scenario: THE WEB OF LIFE

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Preface

From an unlimited variety of possible developments paths and futures that might occur, we chose a set of three different, broad-brush scenes corresponding to three fundamentally different future visions of how we engage with water and land in Luxembourg in the year 2045. Each of these scenarios presents one, plausible, internally coherent but also challenging, future world. The scenarios are not intended to portray desirable visions of the future. On the contrary, they identify and describe potential challenges and controversial issues that human kind may face, as well as possible solutions and their potential consequences – desired or unintended - in an open manner. Taking a systems view, the scenarios differ in how science, technology and knowledge develop in parallel with our understanding of and relationships with ourselves, each other and the environment. As such, the set of scenarios highlights that all science, research and technology development policies, together with the finance that enables them, have a political framing that is 'value-laden' and directed by specific understandings of 'progress', and that resulting innovations often reflect these values in a very concrete manner.

The power of scenarios as a planning tool lies in the concrete visions that they can provide of hugely diverse potential futures, portraying potential disruptive changes (not just 'bend-the-trend' type modelling with few variables), as well as uncertainties, risks and value conflicts, in a systemic and future-oriented manner. The set of scenarios serves to table uncomfortable dimensions of the future that are often 'brushed under the carpet' in our normal 'management mode' focussed on day-to-day efficiency and success seeking . The scenarios highlight the potential for certain groups and individuals to influence the direction of development pathways. They can also help us to identify future developments for whose potential impacts we can prepare even though we are not able to prevent them from happening,. In sum, the scenarios give us a way of thinking about how we could take action, whether individually or communally, to work towards a better future in a hands-on manner.

This report describes one of the three scenarios of how we engage with water and land. This scenario illustrates a world in which making substantial investments in the integrity of the biosphere and in rebuilding and protection of biodiversity has become an existential necessity and gained primacy over all other human concerns, needs and ambitions, in government, in the economy, and in private lives. The main drivers of these changes included several consecutive years of extreme summer droughts, which had severe impacts on water and food systems and on biodiversity, leading to hardship across large sections of the populations in many parts of the world. In subsequent years, the regeneration of ecosystems and building resilient water and food systems became an undisputed priority in politics and the wider society. The education system teaches citizens that serving nature by contributing to the regeneration of ecosystems, in the context of an understanding of the interdependence of diverse life forms, is a fundamental role. This replaces the notion of the consumer citizen whose role is to contribute to economic growth that was in the hidden curriculum of most schools in Luxembourg in 2015. Individualism and some of the freedoms associated with a humanistic worldview in a liberal market economy are in dispute and in practice starkly curtailed in everyday life in 2045. In order to assume a matter-of-fact tone, the scenario text is written from the perspective of a fictitious author in the year 2045, looking back over the last three decades and noting the profound changes that have occurred.

The three scenarios were developed as part of the [NEXUS FUTURES project](#), coordinated by the sustainability science research team of the University of Luxembourg. The project serves to reframe how we can engage with water and land, and to a lesser extent energy, in a more sustainable manner in Luxembourg, in collaborative processes with decision-makers, thought leaders and stakeholders. The research is concerned with developing concepts, methods, tools and spaces for future-oriented systems thinking in order to demonstrate interdependencies across sectors, and evaluate possible paths of action from diverse perspectives and interests and understandings of the world. The NEXUS FUTURES Project was established in December 2016 by a Convention signed by the Ministry for Sustainable Development and Infrastructures and the University of Luxembourg, who fund the project in equal shares.

The main elements and most details in this and the other two scenarios have been developed in a participatory process over three years. This process included three national workshops with 30-50 participants from diverse sectors of society and additional Working Group meetings to develop the scenarios between July 2017 and December 2019. The scenario development also drew on over 50 interviews with decision-makers, thought-leaders and stakeholders in the water and food governance systems in Luxembourg. Five experts studies were commissioned to home in on specific cross cutting issues and decisions on details were taken in a working group on each scenario (for details see Annex I). We are grateful to all who engaged in this process, the purpose of which was to draw together different understandings of issues and what may be at stake across diverse fields of expertise, professional practices and interests. No single expert could have produced this set of scenarios, which we hope embodies also some practical wisdom on our current predicament and on how better to engage with our common future.

Ariane König, 3 November 2019

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Key Issues

- Key impacts of summer droughts: Seasonal and regionalised organisation of economy and society?
- Advances in artificial intelligence: Unemployment and the Universal Basic Income
- Limits to the free movement of capital in the EU: Links between land ownership, interpretation of laws in relation to uses of property, and climate resilience
- Investing in regenerative sustainability for drought resilience: Measures and monitoring for learning
- Intelligent water systems: Distribution, treatment and regulation of access
- Regenerative food and fibre production: What, where, who and how?

Executive Summary of the NEXUS FUTURES Scenario ‘Web of life’

15 September, 2045, Luxembourg City, place de l’Europe. Today is the thirtieth anniversary of 168 States signing their commitment to the United Nations Sustainable Development Goals in New York. Looking back at the situation in 2015 it is remarkable how much has changed! This is thanks to concerted and sustained efforts, internationally and in Luxembourg, to reverse the adverse impacts on the natural environment of 150 years of industrialisation. However, some people consider that we have not gone far enough: hardship and the existential challenges arising out of climate change and environmental damage persist in shaping the lives of most people, rich or poor. Whilst carbon emissions have been curbed, other environmental conditions - the state of biodiversity, land degradation and ecosystem functions, as well as water quality - are far from what they used to be at the turn of the 20th century. Other actors in society complain that the price paid for regenerative rural development and a climate-neutral Europe, in terms of today’s constraints on individual freedom in Western social democratic societies, was too high.

What are the main factors in today’s Luxembourg affecting personal, organisational and governmental intentions? What issues demand action? What are the consequences of past and present choices? Looking back thirty years, the main changes that have occurred, and the main drivers of these changes, are as follows:

1. Environmental change: Seasonal water scarcity, pollution and ecosystem collapse

Changes in the climate system and the earth itself, causing extended summer droughts starting in the 2020’s, led to large-scale collapse of interdependent webs of life in wild and managed ecosystems. Ever since then, extended and recurrent summer heatwaves and droughts have severely hampered both economic development and personal well-being. More seriously, the droughts caused systemic failures of food and water provision in most regions of the world, with skyrocketing food and water prices and human hardship at many levels throughout the 2020’s. For example, following the widespread collapse of insect populations, beginning in the first two decades of the millennium, vegetable and fruit pollination by hand became the norm, and had to be reflected in higher food pricing. Shorter hydrological winters in the northern hemisphere led to increasing populations of disease vectors and thus the wider occurrence of infectious diseases. All year round, warmer surface and wastewaters help microbes with antibiotic resistance markers to thrive; they benefitted from antibiotic use, both in intensive large-scale animal husbandry farm operations and excessively in humans, including in households until the 2030’s.

The consequences of water scarcity and environmental pollution impacting the food system included the unravelling and reknitting, at times painfully, of relations and power structures within societies over the last three decades. The fact that many people witnessed or underwent existential crises in these recurrent drought years changed common understandings of our world and the place and agency of humans within it. A simple trip to the supermarket with incredible ranges of affordable choices is a thing of the past. The drive for independence of food supply was not successful, but food imports have been reduced to a minimum (largely grains and oils), peaking with fresh fruit and vegetable imports in the winter months for those who can afford it. Today’s perceptions of nature, health and nutrition, citizenship, work, and the meaning of ‘a good life’ are utterly different from those of the 2020’s, such that individuals and societies can better cope in turbulent times, and no longer entrust themselves to false certainties. In consequence, people relate differently to other forms of life, to fellow citizens and to themselves. Today in 2045, the impacts of seasonal water scarcity amongst growing populations, and the unintended consequences of human actions, such as environmental pollution causing collapsing ecosystems (whether managed on farms or not), are major drivers of attitudes and choices at work and at home. However, there is a very different pattern of individual and

collective responses compared with those of the 2020's, both in Luxembourg and abroad. The idea of progress underlying 'quality criteria' and our 'design logics' is not what it used to be.

2. Government and governance under the leadership of Generation Z

Policies and practice that consider environmental protection more important than the free use of one's own private property have become widely accepted over the past three decades, although they can still sometimes cause disagreement and tensions. Regenerating the integrity and diversity of webs of life on and under the earth and in water to build resilience in the face of rapid global change is recognised as an existential need. Severe summer droughts resulting in scarcity, and thus soaring prices, of water and food have hit home. Over 70% of land in Luxembourg is defined as Natura 2000 Area. A large share of this is publicly owned, by the state or by municipalities.

Attention and resources are directed in priority to regenerative activities, in government, the economy, and personal lives, across the EU and in Luxembourg. In far-reaching policy and legislative reforms, including of the EU Common Agricultural Policy (CAP), regulation of the environment, spatial and urban planning, agriculture and nutrition have been closely integrated. Given the much greater extent of environmental protection zones, all new plans for human activities, projects and proposals are subject to *ex ante* sustainability checks. In Luxembourg, in order to maximise wilderness areas for more rigorous environmental protection and relatively undisturbed ecosystems to further the rebuilding of biodiversity and resilience to global change, the development of human activities and associated material, energy and information flows is as far as possible directed to a densely-settled central green urban basin. This basin largely corresponds to the catchment area of the Alzette and extends from France to close to where the Sûre flows into Germany. The three former main centres of population (around Esch-sur-Alzette, Luxembourg city and Ettelbrück/Diekirch) have grown together into one large ribbon-development city. This concentration of the Luxembourg population and government into the green urban basin makes Luxembourg even more like a city-state than it already was previously. Luxembourg is a well-reputed and leading actor in global networks of cities for regenerative sustainability. The green urban basin is embedded in a local food garden zone (including pasture and agroforestry areas), which in turn is flanked on the west and east by a wilderness zone; both of these zones are much less densely populated. The urban basin, whilst dense, is, thanks to much green infrastructure, enmeshed with wildlife corridors and protected watercourses.

A new set of progress indicators to assess the web of life's integrity and diversity is now accepted as the best proxy to measure the regeneration of healthy life in diverse forms on earth. It has replaced GDP as the main measure of societal progress. Advances in use of the internet and mobile devices for combining collective human intelligence with artificial intelligence and machine learning, and their use by citizens and governments alike, provide a sturdy infrastructure for knowledge flows for decision-making in the public and private sectors alike. Former technocracies, in which excessive reliance on expert advice resulted in disengaged and misinformed populations, have thereby been turned into knowledge democracies. In keeping with the overarching societal goals embedded in the set of progress indicators, and other social structures and practices, 'Generation Z', or Gen Z, born between 2000 and 2020, see themselves as a workforce at the service of other forms of life than humans.

3. New grid infrastructures have revolutionised the provision, treatment and pricing of water

Development of water infrastructure in the green urban basin now distinguishes between biological and technological circuits and uses. In central areas, each of the two overarching circuits provides water at three different quality levels in two more 'sub-circuits', there are therefore six different circuits from which water can be drawn that are differentially priced. In addition, a water

system driven in part by sensors at the level of households and firms, combined with learning algorithms, allows two further dimensions of differential pricing according to the season (summer or winter) and the level of water use above a certain minimum threshold. The technological circuit that excludes water usage relating to food and hygiene includes water from riverbank filtration of the Moselle. Smart integrated grid planning, and the need continually to upgrade the information, energy and water grids, have led to investments in main pipes and their branches starting from a central pilot area in the basin. After successful proof that it enabled real water savings and a broader array of economic activities in the summer drought months, the integrated grid with the differentiated water circuits has grown along the entire urban basin over the last thirty years. This grid system, providing more affordable water, energy, transport and information services that are also highly adaptive to different purposes, has attracted many Luxembourgers to move from more rural areas to the green urban basin.

4. The division of ‘productive’ work between intelligent machines and humans, which serves as the basis for public revenues, has brought drastic changes

Learning machines and robots have superior language processing skills, image recognition skills and capacities to cope with some types of uncertainty compared to the human brain.

Having grown up and studied with language processing devices and learning machines at their service, GenZs’ own skill development was directed into different areas. Since the 2030’s Artificial Intelligence (AI) and machine learning have fundamentally changed the functioning of the economy in general and the nature of the job market in particular. These machines are the cornerstone and provide for a new welfare system.

Since the 2030’s AI has allowed for the adoption of the Universal Basic Income (UBI) in a number of EU Member States including in Luxembourg. The UBI is a voluntary sign-up system to receive monthly payments of a basic income that is 30% above the minimum wage. It was introduced in the 2030’s in return for engaging in environmentally regenerative activities for at least 20 hours a week; it does not exclude engaging in additional work contracts in the private or public sector. The UBI also replaced the previous pension scheme. Individuals choose from a range of tasks , depending on physical fitness levels and expected health benefits and impacts of moderate work outside in the fresh air. Unlike romantic humanistic notions of the turn of the century that the UBI should allow for more freedom in citizens’ lives - and thus should be free of ‘nanny strings’ from the state and unconditional - the purpose of the UBI in Luxembourg was to help shift citizens’ allocation of time towards regenerative activities on publicly owned land, along with the relevant training. Regenerative services expected from UBI recipients include subsistence farming activities in agroforestry and permaculture gardens. These enable live-soil production with composting, biomass accumulation and biodiversity above and below ground, for carbon sequestration and water retention and cleansing. Processing and preservation of harvested foods for the winter also features on the task lists. The UBI is financed partly through advances in artificial intelligence technologies, and from a fundamental tax-reform that now includes taxation of goods and services predominantly provided by machines, as well as through environmental and wealth taxes.

Jobs in Luxembourg are predominantly in the circular economy, data services and ICT, green finance, eco-technologies and co-design and implementation of nature-based solutions, participatory planning, the construction sector, agriculture, maintenance and perpetual upgrading of the associated triple grid system, and in the preventive healthcare sector. The public sector employs most architects and planners.

5. Citizens lives in Luxembourg

Learning to cope with turbulent changes in the environmental and society whilst contributing as effectively as possible to regenerating a diverse and resilient web of life is probably the main aim in

life most often cited by individual people, families or nations. The school and life-long learning curriculum teaches a participatory sensing system, which allows every citizen to contribute to the collection of data on the state of biodiversity, water quality and land degradation whilst engaging in public permaculture and other regenerative projects. This monitoring system can be visualised as like overlaying the web of life with a web of minds; it is designed to encourage mindfulness of human interdependence and interconnections with other life forms. Participatory analysis, evaluation and co-design of statistics and indicators that make sense to all, is organised by permanent officially-appointed citizens' councils and ad hoc citizens' assemblies (members of both are drawn at random from a ballot from those who opted into receiving the UBI). This allows citizens to continuously make sense of their individual and collective impacts (regenerative and or 'abusive') on the environment at work and at home, better to understand the causal relationship between the state of the environment and their quality of life, and through this interactive knowledge co-creation process to learn how to live a 'better life'.

The healthcare system has switched from a focus on treatment to that of prevention, including from good nutrition with complex and diverse plant foods and nurture of a diverse gut and skin microflora beneficial to our immune system. Facilities for surgical operations are scarce and antibiotics and antiviral drugs are no longer reliable due to widespread resistances that spawn in warm water in the more old-fashioned water treatment plants. The health infrastructure focuses on offering preventive holistic health services including osteopathy, yoga and meditation classes, Ayurvedic treatment, and herbal medicines. These methods now have a more important role than the previously widespread Western ones that relied on interventions to cure unpleasant symptoms. The health system has been taken over by highly motivated young men educated in traditional Chinese medicine and Ayurvedic approaches from Asia.

Can the adoption of simple lifestyles largely focused on securing a basic existence as part of a non-hierarchical web of interdependent diverse life forms be considered an advancement of human culture and dignity? Does a more widespread awareness of how the material world shapes the mind, and how other fellow humans and the welfare of other species condition our intentionality and 'free will', still shock some of the humanists of older generations? Some sociologists call this a post-humanist era. Is this 'progress'?

In order to explore these questions further, the scenario 'Web of life' seeks to offer a perception of the state of the interconnected spheres of the environment, society and government, science and technology, as well as the personal spheres of citizens and their lifestyles, with a focus on life in Luxembourg.

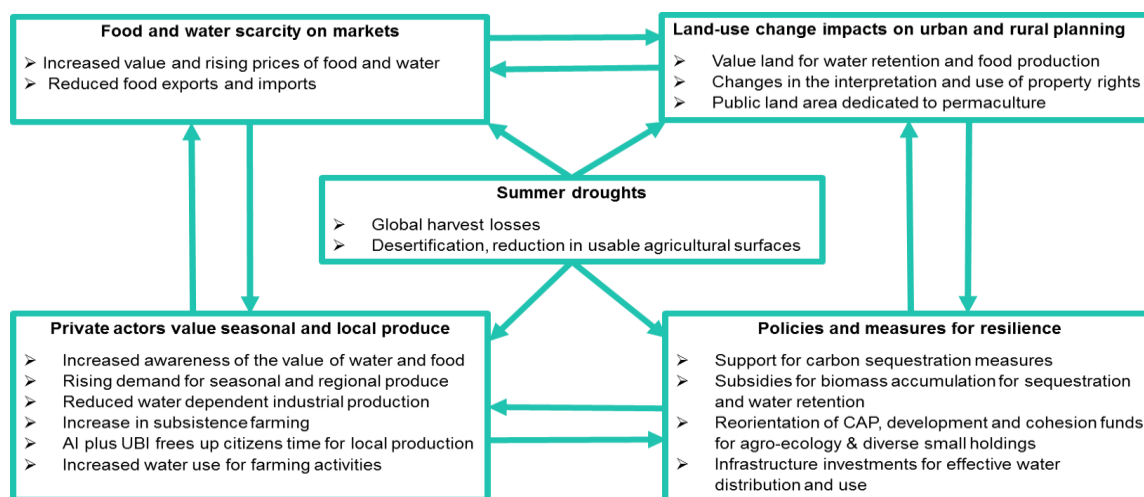


Figure 1. Emergence of a new focus on basic existential needs for life on earth

This figure illustrates the main systemic interactions between changes in the environmental, social and personal spheres as a consequence of recurrent summer droughts.

1. Europe's place in the world on 15 September 2045 and how it got there

The first two decades of the twenty-first century were defined by disconnected developments in the West and the global South. Rapid global environmental change, including hurricanes, typhoons, droughts, and sea level rise, increased hardship in the global South. Meanwhile, across the Western world the intellectual elite were mainly concerned that the combination of populism, fake news on the internet, and the lack of quality control processes for web-based knowledge would undermine democracy in information societies.

In the 2020's, after a series of experiences of hotter summers with drought periods and extreme weather events, it was finally widely understood that halting further destruction of the planet's life support system called for radical, not merely incremental, change. Concerted action and greatly reinforced solidarity between the Northern and Southern hemispheres was required, in order to secure the future basis for the interdependent web of life on earth as we know it. Breaking out of the patterns of behaviour prevailing in the rigid neoliberal economic system of the 2020's required fundamental changes in how societies thought about, valued and organised economic production, consumption and life-styles. At the same time, radical innovation in design criteria for the digital realm helped to realise the full potential of a networked knowledge society. This paved the way for new democratic forms of governance in technical domains based on knowledge co-creation and participatory sensing, with mobile devices as the evidence-base for decisions, replacing the previous expert-led technocracies in most EU countries. However, it would be a delusion to imagine that most of these developments were planned or managed. Society as it is today emerged at least as much from unintended side effects of human action and unanticipated change as it did through any intentional influence from policy makers and planners.

The 2030's saw the election of a new generation of environmentally active leaders from Generation Z, many of whom successfully contributed to navigating the massive cultural changes in a turbulent world, to the benefit of the EU and Luxembourg. Several of these leaders, with women in the majority, were genuinely motivated by the need for regeneration of life on earth, as well as for the protection of less-advantaged members of society from prevailing patterns of 'success to the successful' that had contributed to rampantly rising social inequity during the first two decades of the

century. A variety of social governance arose that made extensive use of participatory sensing-based monitoring systems of biodiversity and water and soil quality. In parallel, people found themselves occupied with time-consuming responsibilities to contribute to collective regenerative action. Together, these trends translated into the development of new lifestyles far removed from the kind of humanistic visions of freedom for 'self-realisation' that were perceived as representing progress in the 20th century.

This section looks at Europe's place in the world in 2045 and its development path over these last four decades. Changes in the global physical environment; governments, governance and GenZ; and the economy and technology, are considered in turn. This serves as a backdrop for taking a closer look at life in Luxembourg in section 2.

1.1. Global environmental change: Seasonal water scarcity sapping life out of food webs

Starting in 2017 summer droughts drastically increase in severity and impacts across the globe: Governments, science, the economy and populations were largely unprepared. How could a 'science- and prediction based' civilisation like ours in the 2020's be so completely taken by surprise by droughts? Part of the answer is probably that governmental and expert attention was focused on global change and annual averages, whereas droughts and hydrological phenomena are strictly regional and seasonal events and therefore potentially easily masked under prevailing measurement regimes. Some drought experts were clamouring for resources and attention,¹ but were only heard after the first catastrophic impacts became visible, not only in the global South but also across the Western world, including Europe. Prolonged summer droughts resulting in water shortages in 2018, 2019, 2020 and 2021 made clear for the first time the biophysical limits to economic and personal activities, across Europe and in Luxembourg. Successive droughts over four years then had impacts on national and regional economic development plans and the form of consumption-based life styles, including in the US and across the EU.

The water scarcity and pollution transforming food systems and cultures in the 2020's: In the 2020's, in most regions of the world, yields of food crops grown in large-scale monocultures, in particular all those with shallow root systems such as maize, failed repeatedly. These impacts resulted from the growing population, economic activities and changes in precipitation patterns, which caused periods of drought. Managed terrestrial ecosystems such as agricultural fields designed for efficiency and maximum yield, proved ill-adapted to the 21st century context, which included extreme variability in weather patterns and multiple environmental stressors and pollutants. A vicious cycle resulted, of yield losses, expansion of cropland, reduction of biodiversity and associated ecosystem services including water and air quality, and further reduced resilience in croplands.² Massive harvest losses, bringing famines and sky-rocketing food prices, finally rammmed home the message that this most intricately constituted layer of earth where soil meets the vegetation layer is the most critical interface between water on earth, ecosystems and human needs (WWAP UN Water, 2018). Life in this upper soil layer requires the utmost care for its regeneration. The EU and most other world regions developed strategies to switch their entire food systems, including regulations and subsidy regimes, to agro-ecological and agro-forestry practices as swiftly as possible.

In the global West it was soon understood that water shortages in the summer months were not the only factor hampering efforts to rebuild local food systems with the capacity to provide for healthy diets all year round to rural and urban populations. Vegetable and fruit cultivation also depend on insect pollinators, which suffered such rapid decline between 2000 and 2030 that demand for their services far outstripped supply.

Recognition of the urgency of the regeneration of ecosystems in the 2030's: Biodiversity regeneration was thus recognised as a prerequisite for food security.³ Since the turn of the 21st century, the capacity of most terrestrial ecosystems to withstand pressures due to natural and man-made disturbances has been eroded, due to a combination of environmental pollution, persistent accumulation of pesticides and severe water stress in the summers. Even resilience to climatic variability from one year to the next can no longer be taken for granted. The combination of a variety of factors caused successive hard hits in most regions, including Luxembourg. These factors included: landscape fragmentation, preventing species migration in response to climate change (e.g. trees can move up slopes in response to climbing temperatures); reduced water quality; reduced species diversity, and increasing climate variability evidenced by wild fires, storms, and periods of drought. The system had no time to recover from one hit before the next one came. Vertebrate populations that had already declined by an average of 60% between 1970 and 2014, took another huge hit in the following decade declining to on average less than 80% compared with their estimated population sizes in 1970, with complete extinctions in many species.⁴ Invertebrates also suffered large-scale declines and mass extinctions.⁵ This decline was accelerated by the droughts, as well as by the large-scale use of potent and chemically stable pesticides and their distribution through the water. It was recognised that urgent investments in ecosystem regeneration were required in order to fight for food security, at the regional, national and international level.⁶

In the 2020's insect populations further plummeted such that hand pollination of vegetables and fruits became the norm, which was reflected in escalating food prices. Empirical evidence in a large-scale study in 2025 suggested that countries that had invested in making forests more resilient by planting drought-resistant species also had larger insect populations and that orchards in proximity to these forests needed less hand pollination.

Countering the collapse of forest ecosystems: As early as 2020, at least 70% of all global forested areas (about 30% of the total land area) were in a degraded state. Intact, extensive and connected ecosystems stand better chances of recovery after stress than do degraded and fragmented systems. Designing a network of wildlife systems across a fragmented landscape became a key strategy. In forests, as in environmentally protected areas, ecological 'memory' required for resilience and adaptive capacity of transitioning to new resilient species combinations had to be engineered by introducing exotic drought resistant species in temperate forests. In the United States in the 2030's, the Department of Agriculture and the Environmental Protection Agency pioneered the introduction of genetically modified drought-tolerant plants— an idea that would have caused shock and horror to most ecologists in the 20th century.⁷

Regenerative finance: The costly facilitation of the movement of certain species became the new norm in conservation policy.⁸ Accordingly, in the 2020's investments in the regeneration of nature, and in particular biodiversity and forests, became a clear priority. These developments demanded the design of fundamentally new quality criteria for investments and indicators for performance assessment of regenerative investment funds. After 2025, governments alone could no longer carry that burden and had to call on pension funds and other large-scale investors, developing sustainable land bonds. Crowdfunding by citizens to finance solidarity agricultural schemes for transition to agro-forestry became the norm. These investments paid off in those regions that had had the foresight to develop them. For example, Austria invested over 100 Million Euros in the regeneration of forests in the Upper Austria region alone between 2018 and 2020. This was just the first of many such large-scale investments across all of Europe.

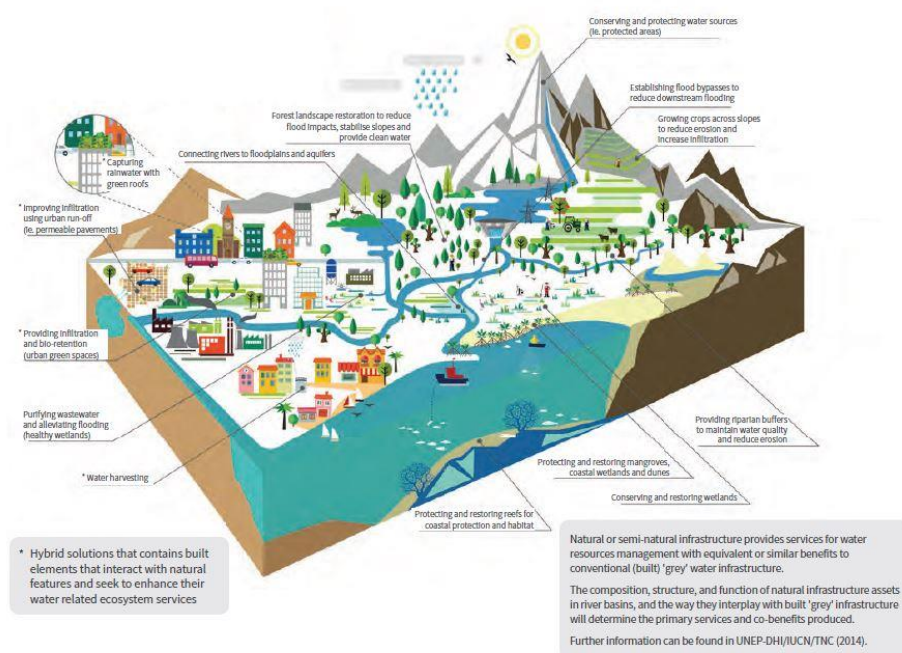
Water security in the 2020's: Global water demand has been estimated in 2020 at about 4600 km³ a year,⁹ with about 70% of this being withdrawals for agriculture. Since the 1990s, water pollution has worsened in almost all rivers in Africa, Asia and Latin America; until 2025 a couple of rivers, which were evilly contaminated in the US and Europe and were the target of focused regeneration efforts

working closely with industry, remained the exception to this sorry trend. Furthermore, almost 15% of groundwater monitoring stations in Europe recorded that the standard for nitrates established by the World Health Organisation was exceeded in drinking water. Monitoring stations recorded that approximately 30% of rivers and 40% of lakes were polluted to such an extent that their ecosystems were deeply disturbed and not diverse (EC 2013a; cited in WWAP, UN Water, 2018). These trends are also caught up in a vicious feedback loop, as intact aquatic and soil ecosystems help to degrade pollutants, to regenerate water quality and to retain water in soil during drought periods, delaying its run-off into the sea and making it available for other life forms for longer.

Nature based solutions for water management use or mimic natural processes in the 2030's.

This can involve regenerating natural ecosystems or designing artificial ecosystems in cities or elsewhere in order to create a target outcome for water management at any scale (ranging from dry toilets at the building level to river renaturation at the landscape level). These practices were developed millennia ago (in particular for irrigation systems in traditional societies) but started being rediscovered by science in the new knowledge field of eco-hydrology that was founded at the turn of the millennium. Mismanagement of the precarious relationship between ecosystems, hydrology and human well-being is thought to have contributed to the collapse of several ancient civilisations, including the great river civilisations of the Tigris-Euphrates and the Mayans in central America. For the first time however these changes are taking place at the global scale. Already as early as 2011, UNESCO contributed to demonstration projects of applied eco-hydrology for water quality improvements, retention capacity and flood mitigation enhancement. In this approach water and biodiversity need to be taken care of and considered as part of the same system as the cultural and social dimension. (Annex I lists ecosystem services that are water-related or water-dependent (p. 30 WWAP). The management of vegetation and soils, as well as wetlands, rivers and lakes in rural and urban landscapes, became a priority for societies across the world as the basis for food and water security.

Today, in 2045, it is fully recognised that access to water is limited by seasonal and regional variations in rainfall and that technological fixes might help but not remove these constraints. Early warning systems for droughts have been implemented in all continents and are internationally cross-connected. Moreover, the role of healthy diverse biomass, including bacteria and plant cover above and below ground for water retention and regeneration and cleansing capacity has led to drastic changes in spatial planning principles, in particular in Western Europe and the densely settled core of the EU. Priority is given to regenerative programmes for building up biodiversity, biomass and biosphere integrity in extensive and as far as possible undisturbed ecosystems in rural areas, as well as in densely settled urban areas.



Source: Infographic 'Natural Infrastructure for Water Management', © IUCN Water 2015.

Figure 2. Natural solutions for water management (source UN Water, 2018 ask Stephan copy right)

1.2. Geo-politics, governance and Gen Z

Geopolitics – navel-gazing nations: Given hard-hitting prolonged summer droughts and heatwaves, and the regional nature of water management, there was less tension in geopolitical relationships as most countries turned their attention inward towards measures to address existential challenges and resilience building. However migration pressures also increased as rising sea-levels drew new maps across the globe. International trade still existed, but on a smaller scale. In the face of massive increases in food prices and decreases in food exports, most world regions started to rebuild food production with a view to ensuring food security for their own people first. A network of distinct and divided national walled fortresses arose between 2025 and 2035. After BREXIT, the EU slithered narrowly past FREXIT, and the Italian Northern league would have succeeded in pulling Italy out from the EU had it been economically feasible. National and cultural identities became more highly valued than so-called universal norms.

Even in scientific research there was a new focus on place-based knowledge as essential to informing a rapid transition to more resilient, locally-adapted ways of thinking and doing that focus primarily on local environmental and social circumstances. These locally-centred approaches then serve as a basis for local negotiations on which of the globally available technologies make most sense at this time for this place. Global cooperation was however required to handle disruptions caused by global environmental change, and artificial intelligence and machine learning. The UN and the EU received fewer funds but continued to function with a strong focus on concerted environmental action for regeneration of the planet's life support system.

In the US, following the debacle of the Trump presidency, in the early 20's the ideas and philosophies of the Justice Democrats gradually gain greater influence on US policy. Corporate sponsorship of the US electoral system is severely diluted, and Green New Deal policies emerge. The new government sets out to transform the American system with a focus on eradicating the basis for growing inequity and disrespect of the workforce. A wide range of regulations forcing the private

sector to act more fairly were adopted. These included for example a licence from government that mandates to consider the interests of employees, customers and the communities in which the enterprises are embedded. Many countries followed suit and such rules became the new norm across the Western world to temper capitalism's tendency towards inequity. Such licences can be revoked if the targets are repeatedly missed. Workers now elect 3/5 of board seats.¹⁰ Targets are now required to be set for clean energy as well as for biodiversity regeneration. Many countries watched the once so liberal US in awe and followed suit: placing primacy on environmental protection and equity was finally widely recognised as a matter of survival.

China, in a far-sighted and systematic manner, continued to focus on providing the necessities of life for its population for generations ahead, thereby stabilising its empire. Since the turn of the century, in view of possible future geopolitical tensions due to resource shortages, China had invested in building the new silk-road embedded in the transcontinental railway logistics system. Land-grabbing practices spread from Africa, where they had acquired strategically important land around ports, to Europe, strategically anticipating and avoiding areas of desertification and pollution hotspots. These practices were often carried out by inconspicuous middle-men, native to the country containing the targeted areas, who wished to gain a quick buck. Moreover, both China and India had 10's of millions of young men with no realistic possibility of marriage. Due to China's one child policy and the dowry culture in India, both countries forged proactive policies to send young men abroad to seek wives, to counter risks of rises in criminality and social disruption as a result of these demographic shifts. This is another important aspect of these silk-road policies.

Europe in the world. *"Europe must lead the transition to a healthy planet and a new digital world."*¹¹

The 2020's saw the first decade of regenerative politics, reinforced by the summer droughts.

In Europe, since the first female president of the European Commission, Ursula von der Leyen, took office and announced her strategy and political priorities in 2019, the European Commission sees environmental regeneration as a main strategic focus. Von der Leyen's 'New Green Deal' took the United Nation Sustainable Development Goals (UN SDGs) as the overarching political priority.¹² She and her staff worked hard to make the EU a leader in the global 'just ecological transition', whilst promoting democratic values in the global political arena.

Climate neutrality targets for 2050 and the 2030 EU biodiversity strategy have equal priority.¹³

The clear priorities are: global climate regulation as an ecosystem service; carbon sequestration, and pollination (a service for which the potential is significantly decreasing, whereas demand in Europe is rising in line with the area dedicated to vegetable and fruit production). The pursuit of these priorities has far-reaching and transformative consequences for the economy and for the personal lives of all citizens. In the 2020's public resources, across the Member States and consequently also at EU-level, dwindle. The EU functions at a level closer to that of the 1990's and returns to spending most of its budget on the agricultural transition and on water management. Spending on the common agricultural policy again approaches 50% of EU budget (1% of EU GDP) 1 Trillion, second in line are the cohesion and development funds, the third spending priority is research and development.

Fresh water scarcity and rising sea levels increase population pressure from immigration

(climatically and politically), in particular in the core of the EU. Desertification throughout the 2020's drove massive migration, not only from outside of the EU, such as North Africa and Albania, but also from large areas of Spain and Croatia. Globally, in line with predictions dating from 2019, by 2030 over 700 million people had been forced to leave their homes because of drought.¹ The desperate were exploited terribly, extreme forms of criminality and corruption were on the rise. The UN Convention to Combat Desertification had estimated that already in 2017, the first drought of the series, about 20 million people were close to starvation.

However, the international focus was on ‘the war on carbon’ and emissions reduction targets, such that these circumstances passed largely unnoticed.¹ Consequently, the consecutive drought years in the 2020’s had detrimental impacts on the economy and public finance in many nations across the globe. One significant contributing factor was that most if not all of the few (large scale) farmers left in the 2020’s had to be bailed out of debt in order to be able to continue producing food and fibre.

The single market and the free movement of capital have been undermined. In 2010, the EU still aggressively pursued goals of further enhancing the free movement of capital investments across national borders. Chinese land-grabbing practices highlighted the need to restrain provisions for the free movement of capital. Already in 2015, also in response to land grabbing in Europe from foreign investors, the language of first rulings of the European Court of Justice foreshadows the fact that public interest, such as food security, could take precedence over private property and national decisions on usufructs on arable land - albeit given appropriate compensation.¹⁴

Taking measure of nature’s whims: An environmental monitoring system for evidence-based policies and action on environmental health and biodiversity, that is both effective and cheap to implement, has become a priority. At the start of the 2020’s, with the realisation of the importance of water quality as a substrate for diverse life forms, the awareness grew that drawing single point measurements to infer water quality of rivers equated to drawing single notes from Wagner’s opera *The Ring of the Nibelungs* in order to understand the opera. Whilst policies now focused on the UN SDGs of water quality, biodiversity and land degradation, monitoring of changing quality in these domains in order to assess policy was not feasible. Official data and statistics for accounts and indicators proved inadequate, given the limited resources and top-down processes available and permissible in the European Statistical System of that time. In societies with developments driven by measurement regimes, such an environmental monitoring system was a prerequisite for regenerating a healthy web of life on earth. The European Commission, hand in hand with the European Environmental Agency and EUROSTAT throughout the 2020’s, had the guts to radically innovate the design and use of official statistics, indicators and accounts concerning the state of the environment, with profound implications for the meaning of democracy in a networked knowledge society.

Today in 2045 regenerative policy priorities benefit from an integrated system of participatory measurement of environmental quality and biodiversity, by citizens with mobile devices, on a daily basis across the EU. This time-tagged and geo-localised data is fed into national and EU databases, providing a rich medium from which to draw reliable (non-redundant) data concerning environmental statistics and accounts, in particular as they relate to the SDGs. New quality criteria and control processes have been implemented for this new generation of co-created evidence offering a basis for policy decisions. Most importantly, the entire environmental monitoring system was designed for 2 purposes: (i) evidence-based policy-making; (ii) to serve as knowledge for action by actors across governance levels, in the private sector and in personal lives. The information can be disaggregated flexibly across spatial scales and as such is usable as place-based knowledge.

Place-based science over universal models: Place-based knowledge informs regenerative activities.

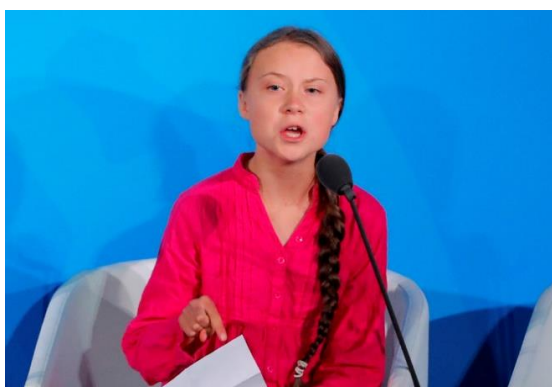
Deep culture – as reflected in measurement regimes: Experiencing rapid environmental change in most areas of the world contributed to a transformation in the behaviour of the global human population. They had been a global consumer population seeking scientific certainties. They became a race of navigators, seeking to negotiate the conditions of their existence in harmony as far as possible with the ebb and flow of the seasons. They were now closely attuned to their environment and understood their dependence on other life forms, like pollinating insects and soil-producing earthworms. The stark cognitive dissonances of the 2020’s of a society expected to pursue green growth on a limited and obviously increasingly polluted planet, that had led to large-scale disengagement of young people from politics, had not however gone away. These radical but also

existential changes in the value attached to diverse life forms, material and energy flows, as well as their products and services, were reflected in society's measurement regimes comprising data, statistics, accounts and indicators. Performance indicators for private and public organisations and policies were now reflecting regenerative goals. Through the expansion of citizen science, these measurement regimes that were intricately intertwined with a new range of societal values now pervaded the life of all citizens. At first, environmental and social impact reporting was an add-on to financial reporting, but after 2025 the attention of central banks, pension funds and investors turned primarily to the sustainability reports and only thereafter to the financial bottom line. Citizen science ensured that new windows of accountability targeting both political leaders and private firms could be opened at will. The priority accorded to regenerating the web of life, of which humans constitute just a part, was reflected in a measurement regime developed and evaluated by citizens. This was integrated into democratic processes, directing attention and leading to a further raising of consciousness. Regenerating nature soon became more than simply a justification for receiving the UBI – it became the felt priority of a meaningful life to many citizens and led to a deeper value change in society, with shifts of consciousness towards finding sense in life through a focus on interdependencies and flows of water and nutrients, energy and information across webs of diverse species.

Generation Z stands for valuing environmental protection and regeneration ahead of freedom of use of private property. The road for these courageous new politics and the traction and success this path developed in the following decade, was paved amongst other things by Greta Thunberg's youth movement Fridays for Future, which managed to shake and awaken more people than activist movements had done over the previous three decades. The demands of this movement, and others including Extinction Rebellion and Ende Gelände, were in the end taken seriously by politicians. Of course there were important counter-movements – including the 'just pensions league' and clubs of large land owners and the real estate industry.

Youth has engaged in voting since the 2030's. Already in the mid 2020's many countries, including Luxembourg held well-organised and successful referenda attributing voting rights from the age of 16. By and by, as GenZ started to move into the job markets and start families, the sentiment of intergenerational injustice declined and this helped to engage youth back in political processes rather than spending time on planning actions of civil disobedience to get their say. They firmly and effectively took over leadership positions in politics as well as in public and private sector organisations. Leaders of this generation had begun to develop political awareness in the years that Donald Trump was president of the USA. Already in their teens many were leading or engaged in the world's most impactful and peaceful global protests, which had a massive influence on the politics of the day. In consequence, by 2035, stringent climate and biodiversity policies to reach ambitious targets set in the 2020's, demanding climate neutrality by 2050 in the EU and in Luxembourg, were well on track.

Today in 2045, GenZ leaders are dedicated to the regeneration of the integrity of the biosphere in order to reverse the environmental destruction since the industrial revolution. Intergenerational and inter-species justice remain of great concern. Environmental taxation as well as public and private investments based on new sets of indicators that assess the regenerative capacity of products, services and projects are common. Eating vegetarian most, if not all the time, has moved from exception to social norm, and in some countries there are up to 10 % vegans.



“This is all wrong. I shouldn’t be up here. ... Yet you all come to us young people for hope. How dare you? You have stolen my dreams and my childhood with your empty words, and yet I’m one of the lucky ones. People are suffering, people are dying. Entire ecosystems are collapsing. We are in the beginning of a mass extinction and all you can talk about is money and fairy tales of eternal economic growth. How dare you? For more than 30 years, the science has been crystal clear. How dare you continue to look away and come here saying that you’re doing enough when the politics and solutions needed are still nowhere in sight? ...”

Figure 2. ‘This is all wrong’. 16-year-old Swedish Climate activist Greta Thunberg speaks at the 2019 United Nations Climate Action Summit at U.N. headquarters in New York City, September 23, 2019. Photo by Lucas Jackson/Reuters



Figure 3. Priority to wild life corridors. **Source pixabay – creative commons.**

1.3. The economy and technological innovation

Macro-economics: Changing global norms: Since the 2020’s, markets, including finance, have progressively been regulated and supervised in order to protect the people. Tech giants became utilities. For example, firms providing social media and connectivity services on the world wide web came to be viewed as providing services that were in the common interest of human and other life forms, given the additional role the web now played as the repository for widely accessible stocks and flows of data on the state of the environment. These approaches quickly became the new norm for business across the West. Online market places with global revenues of more than 25 Bn USD would be regulated as platform utilities and prevented from offering their own products and services on the regulated platforms. Large corporate actors in the ICT and logistics domain providing platforms with

search engines and internet shopping were required to divest their online advertising exchange and to stop selling on its market place. Gig economy companies are now required to treat their workers as employees.

For the regulation of national and global financial markets, measures included: the complete separation of banks' investment banking from their commercial operations in order to prevent speculation with people's savings; full liability for private equity holders; shareholders' responsibility with respect to environmental liabilities. Markets are now deemed to function well if they are efficient and fair, not faster. To this end, a periodic single price auction (SPA) trading mechanism was introduced replacing the continuous system, creating space for reflection, analysis, ethics and good intentions. This trading mechanism also resulted in more liquidity, as it concentrated trading in time and place. IT also allowed the execution of trades to become a regulated utility that behaved more predictably and could be taxed in a fairer manner.¹⁵ Whilst GDP growth stagnated across most of the planet, so did the rising inequity and associated Gini co-efficient measures.

The energy system and EU integrated grids. In the 2020's, torn between the 2050 climate neutrality targets and commitments to phase out nuclear power plants, Germany delayed the decommissioning of its nuclear capacity. This decision met with the fierce anger of anti-nuclear activists, including nuclear physicists and ICT specialists. A 9-day black-out occurred in 2027 after a series of cyber-attacks on the integrated networks that run electricity and internet, as well as interconnecting power plants across the continent and to which the water supply is also tagged. This demonstrated clearly the extent of vulnerability of our societies due to grids that are integrated across entire continents. 9 days without grid in the winter of 2027 sufficed to cause a death toll of over 1000 people in the EU. The extent of costs incurred, private and public, were astronomical. Food spoilage, broken logistics chains, traffic chaos and accidents, breakdown in public transports and flight travel, breakdown of health care in hospitals and homes for retired people, and last but not least, breakdown in back-up energy systems for nuclear reactors and other power plants had not been anticipated and definitely not been prepared for.¹⁶ Policy reactions included the re-nationalisation of the energy, water and internet systems in the EU, in a new rush for national autonomy.

AI impacts on job markets: At the turn of the century, societies and researchers across the globe were mesmerised by the huge transformative potential of artificial intelligence, machine learning and robotics on the economy and our personal lives. After the first two serious waves of unemployment, the focus shifted to the huge potential of constructing information and communication technologies to harness the collective intelligence of humans and learning machines together – that is, to create hybrid super-minds capable of taking better decisions in re-designing and regenerating the biosphere for greater resilience.¹⁷ It was clear these superminds had to be at the service of the life force embodied in species diversity, if human civilisation were to be able to continue to thrive at the brink of the mass extinction whose onset it had caused by the development and scaling of short-sighted industrialisation practices. How did we get here?

Technology and innovation in the 20's and 30's: Intelligent machines now have better natural language processing skills and can now cope better with some types of uncertainties than the human brain. The use of computers and mobiles at school resulted, in Japan as early as the 2020's, in students' no longer being able to type on entering university, as they rely almost entirely on word suggestion algorithms. We have become cyborgs. Machine learning, natural language processing and robots have fundamentally changed the functioning of the economy and in particular the nature of the job market as well as the welfare system. Privacy is a concept of the past.

In the 2020's the divide between skilled and low-skilled workers increased and exacerbated inequalities. Governments across Europe took several measures. First, several super-laboratories were funded from public resources to offer the computing capacity necessary for researchers and

SMEs to develop AI algorithms and process data sets. They included super-laboratories dedicated to learning systems monitoring and improving biosphere integrity, combining citizen science and geospatial data on water quality, land degradation and biodiversity. Secondly, as the distinction between workers and service providers became increasingly blurred, social protection was shifted from the labour contract to the individual.¹⁸ The possibility was made available at EU level to open a European personal account, linked to national personal accounts and financed in part by a general social contribution levied on all services provided through platforms. Traditional social contributions also continued to be collected. A board was created at EU level to monitor against discrimination.

The EU adopted a Charter on our common digital future modelled on a German Charter for a sustainable digital age based on the premise that one of the objectives of all digital technologies and infrastructures should be that of maintaining the natural life support system, and that digitalisation should be used specifically to monitor the UN SDGs. All countries should contribute to developing the digital commons for this purpose.¹⁹ The charter takes account of the UN SDGs and the Charter of human rights. It posits rights and responsibility of individuals and groups towards using and contributing to properly-functioning ICT infrastructures, including stocks and flows of information for the common good. Ethical guidelines and appropriate education for all are key.

The adoption of the **Universal Basic Income** in a number of Member States, as a consequence of instabilities in the job market associated with AI technological development and innovation, constituted a fundamental change in the way society functions.²⁰ It was clear that AI would displace jobs. **A series of three waves of artificial intelligence-related innovations in the service sector** and in production-related industries triggered three severe waves of unemployment in Luxembourg. It caused unemployment in the accounting and audit sector and other auxiliary services for the finance industry, and the closing down of offices of large players in the accounting and audit services sector. Luxembourg thus followed suit and adopted a UBI scheme in 2033. Main sectors of the economy contributing to the finance of the welfare system include green finance, eco technologies and leading actors in the digitalisation of the economy including multinational corporations providing large internet platforms who remained and thrived in Luxembourg.

2. A closer look at Luxembourg in 2045

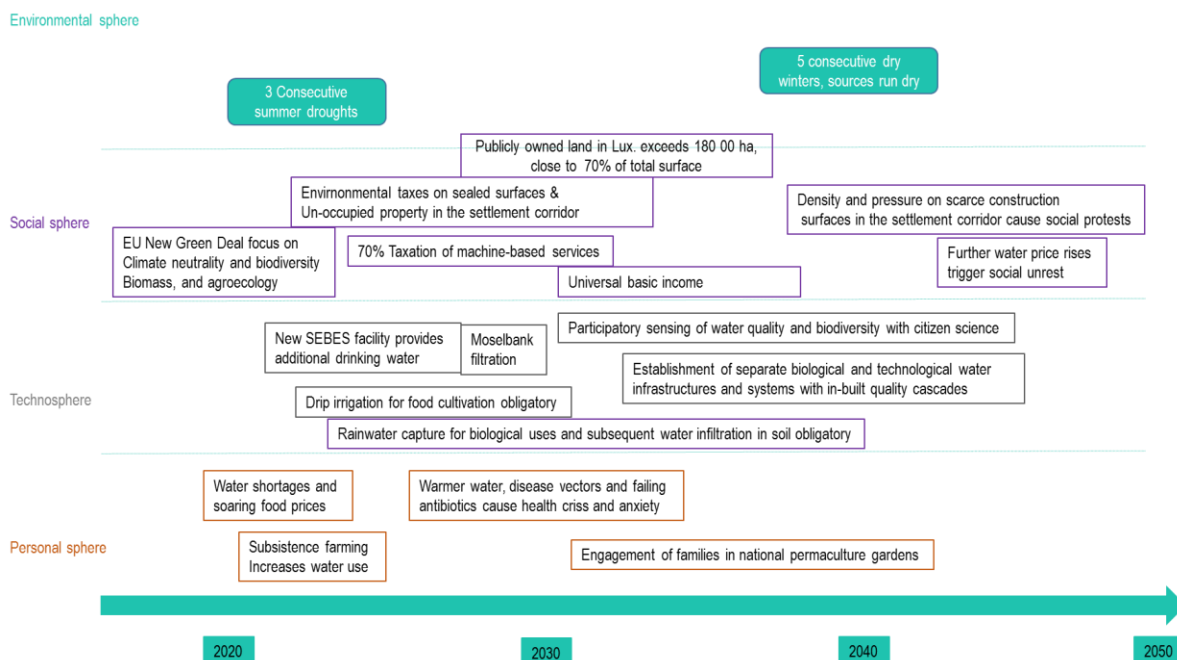


Figure 3. Timeline

2.1. The government's goals and governance

Today's leaders' goals and values are clear: Time and money are spent on regenerating the natural environment and reversing the damage of 150 years of industrialisation. These leaders in their teenage years clearly saw that 'to continue with policies for incremental change is a delusion. A first focus was to address all contradictions and stark policy incoherence hidden in the green growth agendas from the 2020's head-on. Growing older and arguably also more conservative, leaders in Luxembourg still proved skilful in navigating existential challenges associated with turbulent global changes in environmental conditions, power structures and trading systems. Already in the 30's they put a clear STOP to spending money on privileged pensions, preferring instead to enable current and future environmental health-focused life styles required to enhance food security in Luxembourg. A broad range of legislative and regulatory reform promoted a regime that started to control land use and land cover change on private property with restrictions and conditions, placing primacy on the implementation of measures for nature regeneration. This reduced the owners' freedom of action, with a real impact on the value of land on the market in Luxembourg. Counter movements included the 'just pensions league', associations of large landowners and the real estate sector.

The new coalition contract proposes the ideal of a participatory social democracy that is supported with AI systems. The development of policies and implementation measures relies on a

complex system of citizens' councils inspired by Alexis de Toqueville, 'to establish a people's rule and teach them how to rule' (unlike referendums). The 20-25 members of the council are usually determined by ballot for periods of five years.²¹ There are citizens' councils on all major policy priority areas, including one council for water and food, and another on biodiversity. These councils have the power to tell elected officials which issues matter. Furthermore, for selected issues they have the power to task a Citizens' Assembly (also chosen at random from volunteers). These Assemblies can make recommendations on how to develop measures, and determining desirable and undesirable impacts. They can also establish main criteria for impact monitoring systems to make government accountable for 'good governance' according to standards and measures determined by the people.²² Citizens' councils run in parallel to the existing parliament and will set its legislative agenda. Parliamentarians must consider every proposal that wins support from 80% of the council, and must publicly defend any decision to take a different path. The system seems slow and cumbersome to many, but arguably decisions are more socially robust.

The machine learning supported social learning systems of networked living laboratories play an important role in pooling, structuring and storing these webs of knowledge flows and resulting stocks, and making them both accessible for decision-making and visible for making decision-makers accountable.²³ Today's leaders are digital natives, who have grown up from infancy in a web-based world, tapping into collective intelligence and networked knowledge flows for homework at school, learning to think together with peers and with machines from their toddler years onwards.²⁴ Participatory sensing and measurement of the state of the environment with mobile devices, and environmental and social impact assessments of policies and practices are integrated in this system. Digital natives are at ease with embedding their work and creative flow in such systems for harnessing the collective intelligence of machines and humans, including in policy-making, and development, fund-raising and implementation for measures in practice. Most interestingly, given the obvious plurality and at times contradictions of information sources on the world-wide-web, knowledge that serves as basis for local regenerative action is always evaluated in a participatory process and negotiated taking the local situation and interests into account. The times of universal models providing predictive certainty as a basis for mankind's dominion of nature are over.

In the area of water governance, river partnerships established on the basis of the EU Water Framework Directive and the 2008 Luxembourg act concerning water have become an essential tool for calling citizens' assemblies by river basin in order to provide recommendations and judgements on proposals by the national water citizens' council. Accordingly, river partnerships now have their own legal statute and legal standing and can initiate judicial action. This system paved the way for implementing more aggressive policies to limit the primacy of individual choice about the use of private property over environmental protection, even in the small fiefdom of Luxembourg. However even in this system, in the end policies, measures and rewards for their implementation are still defined by government officials, which is far from ideal; technocrats in offices removed from people and business operations still wield a lot of power. In spite of citizen science, councils and assemblies, the technocrats often seem oblivious to the everyday concerns of the majority of the population.

Many citizens complain that the state of the governance system in Luxembourg is a long way from that ideal, and that technocratic officials synthesising outcomes of participatory processes into policies often do not understand the real impacts of those policies on the lives of affected people. Nevertheless it should be acknowledged that the structures offering citizens a direct say have evolved over the last three decades. The new institutions, web-based knowledge flows, and participatory processes represent a clear improvement compared to the first attempts at participatory policy-making envisioned in the 'Accords de Coalition' from 2013 and 2018, when complex tri-partite coalitions came to power after decades of conservative rule.

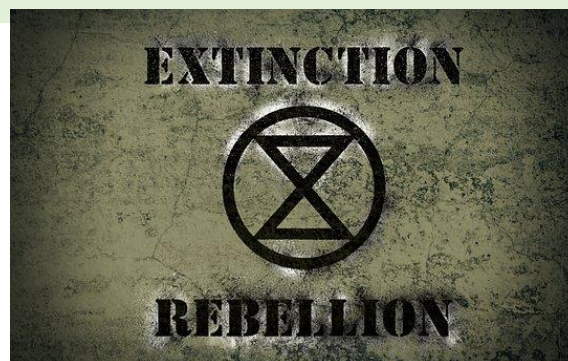
Constitutional reform: However, one effect of this approach to governance was to further drain power from the municipalities and parliament the ‘Chambre de Députés’, as selection by lottery was deemed more democratic than elections, which were from the 2030’s increasingly seen as a way to further strengthen historically grown capitalist power structures (*Don’t understand this sentence – SM*). Luxembourg was one of the first small countries who implemented this model at the national level, following a successful experiment with this approach to a more direct democracy in the East Belgium province, giving the German minority population more direct say.

BOX 1 Time witness account: A testimony of a parent of one of the Ministers in 2045

‘Climate devastation demands to be up-standers not bystanders - system change means personal change’ “As a lawyer and activist I

had realised in my career since the 1980’s that however hard I tried to effect change from within, the system seemed to have become too rigid to respond. The necessity became clear for radical reform by combining non-violent civil disobedience and disruptive action with diligent work within the system in parallel to create alternative approaches and redirect attention and resources to these. With the motto that climate change needs up-standers, not bystanders, I raised my three children, including Josiane who has now been Minister of the Environment since 2043, to develop their capacity for ‘transgressive thinking’.

From their early infancy I also did everything in my power to help them find joy in the experience of conscious embeddedness within the web of life as the main source of pleasure in life, rather than being fixated on gathering status symbols, in the form of material wealth or titles. From the age of 14, Josiane was very engaged in the youth movement Fridays for Future and in Extinction Rebellion.²⁵



Picture from pixabay – a creative commons website.

2.2. Welfare and taxation

The welfare system: It is remarkable to remember that just two decades ago, in 2015, national welfare systems providing for health care, education, unemployment benefits and state pensions all worked together to create a sort of structural lock-in to highly unhealthy sedentary life styles, significantly burdening the health care systems and expenditure. At the same time people gave their attention to computers and mobiles, whilst living on unbearably reductionist and impoverished diets full of empty calories. These lifestyles contributed to the systematic erosion of bodily and mental health during what should have been people’s most productive years. The school system, with its (both explicit and hidden) economic growth-focused national curriculum, prepared people perfectly for their roles as passive consumers and silo thinkers. A narrow capacity for abstract thought was selected for and rewarded, both in most schools and in the salary structure of the economy. This focus tended to produce people with a greatly restricted range of both motion and diet for well over a third of their lifetimes, resulting in huge costs for hip and back operations and expenditure on treating diet-related chronic disease. Overall mental health declined and there was a steady rise in numbers of people withdrawing into long-term convalescence or even disability from the 1980’s to the 2020’s.

After 2010 as the impacts of artificial intelligence increasingly affected the job market, several countries, including Finland and Ireland, already started to experiment with introducing a Universal Basic Income in the 2020’s. Starting in limited regions, these experiments proved successful in terms of surveys of quality of life indicators, and were thus scaled up in these countries, leading to

fundamentally differently-structured welfare systems. In most world regions, countries started to place up to 80% taxes on services provided by machines with minimal supervision; these tax revenues were dedicated to contributing to finance the UBI. Luxembourg followed suit and implemented the Universal Basic Income in 2028. Because of its first-mover advantage on offering very attractive conditions to set up business, in the previous decade it had attracted a large Google Europe headquarters, and the headquarters of Amazon Europe, helping to secure a financial base for the UBI. (Check orders of magnitude of expected revenue vs expenditure on UBI and how else it might be supplemented). Case study combining UBI with agricultural production TERA in FRANCE

The new leadership in Luxembourg in the 2030's took some tough decisions and completely overhauled this welfare system. The central innovation was the adoption of the Universal Basic Income at a significant level of 25% of the average income (then as in the 2020's about 4000 Euro/month). Now this was not the liberal idea of an income without 'nanny strings' to make up for the growing inequality associated with neoliberal systems. This 'opt-in' UBI was attainable for citizens in exchange for at least 10 hours a week spent on regenerative activity, largely by taking care of ever-increasing public areas that were fashioned as permaculture gardens, but also in the more menial jobs of rebuilding the water system and irrigation system, both in the permaculture belt and in the settlement corridor.

Overall then, this design of the UBI is intended to provide men, women and children with meaning, structure and identity, arguably more so than jobs and derived spending power at the service of the market economy in the 20th century, as people are united in their existential struggle for transformation to provide resilience to rapid global change. 90% of all families across Luxembourg have signed up to this scheme. Freedom and dignity are however understood in very different terms from the humanistic ideals prevailing in the 20th century. This is discussed at greater length in the section on the personal sphere, health and life styles.

Strong government compensated with new mechanisms for a more participatory governance at the national level by co-created evidence base with citizens and citizens councils on core issues – but still ongoing tensions between government as big organisation and too often remote from people's concerns incompetent, capture by powerful insiders, and Kafkaesque indifference to plight by ordinary men and women. (*I don't understand this – SN*)

The discontinuities leading to this system were politically acceptable not only because of the new environmental awareness and the drought and water crises. Repeated waves of unemployment from massive displacements in the blue- and white-collar workforce (*I don't understand this – SN*). Powered by a tremendous growth in data collection and availability as well as computing power and accessibility, AI and machine learning applications became commonplace in many aspects of modern society, as well as in a growing number of scientific disciplines. Key AI technologies including machine learning, natural language processing and robotics led to multiple transformations in the work place (see section on technology below). These technologies were of course also instrumental in profoundly transforming the way all citizens are engaged and networked together in sensing the environment, thereby co-creating knowledge and experience for more effective regeneration of life and living substrate such as fertile healthy soil and water. (These changes are discussed in greater detail in Section 2.5. on the economy below).

Box 2. The new UBI-based welfare system: Design for prevention, learning and equity

The UBI and preventive health: Prior scientific studies suggested health benefits for body and mind much greater than regular visits to the gym. Moreover, harvests could be taken home and the gardens were designed to provide for complex and varied plant foods, throughout the seasons, that fundamentally enriched existing protein and starch-based diets, as well as contributing to food and water security and carbon sequestration by the targeted rebuilding of biomass above and below ground in these areas.

UBI and experiential learning with citizen science for participatory, evidence-based governance. The programme was closely designed in combination with redesigning the school curriculum. This was sold as an attractive family activity with guide books and optional skill building courses, so the experience also served as an engaged learning activity in systems thinking and understanding webs of interdependence in terms of material, energy and information in complex ecosystems that we are part of. The entire endeavour was paired with scientific experimentation. Observation and data collection was handled by mobile citizen science tools. The analysis and interpretation of the data was then included in the school curriculum and database architectures were designed such that the data could be used for developing environmental statistics, accounts and indicators for the United Nations Sustainable development goals.

By leveraging an entire nation for the first time in participatory sensing it was possible to collect meaningful data on biodiversity and water quality, as well as land degradation/regeneration. The previous top-down approaches had failed due to scarce public resources, with time-intensive research yielding too few samples when compared to the high levels of natural variation in all dimensions of what was being observed. Citizens and schoolchildren could now contribute directly to evidence-based policy making on moving towards Sustainability goals for which it had previously been difficult to set measurable targets, let alone to understand either beneficial or adverse policy impacts. Accountability! The mental health benefits of meaningful engagement in participatory governance should not be underestimated.

UBI and unemployment, convalescence and disability payments: All these social security measures were seamlessly integrated into the UBI.

UBI and pensions: staying true to their initial slogan of ?, the UBI has absorbed and is in part supported by earlier spending on unsustainable privileged pensions.

BOX 3. LUXEMBURGER WORT 15.9.2045. WITNESS ACCOUNT ON THE UBI. *Interview with our correspondent Bernd Niessen in German*

Reporter Bernd: Guten Tag, mein Name ist Bernd Niessen, ich schreibe nebenbei fürs Luxemburger Wort. Darf ich dir ein paar Fragen zum Themenbereich luxemburgische Umwelt und Flächennutzung seit 2019 stellen? Wir recherchieren nämlich über die Auswirkungen eines alten Projektes der Uni Luxemburg aus jenen Jahren. *Wenn ja, dürfte ich den öffentlichen Teil deines Persönlichkeitsprofils einsehen und zitieren?*

Passant Bill: Ich heiße Bill Smart. Worauf beziehen sich denn deine Fragen - auf die Auswirkungen eines Umweltprojektes aus den Jahren 2018-2019? Du hättest mich auch gleich nach der Zeit von 1991 befragen können! Aber frag mich ruhig, ich habe genau sieben Minuten Zeit, bis mich mein hLifter (Anmerkung der Redaktion: autonomes wasserstoff-betriebenes Ruf-Flug-Taxi) abholt; (Er zeigt unserem Reporter ein Hologramm seines öffentlichen Schlüssels zu seinem Persönlichkeitsprofil, welches der Reporter mit seinem Personal Communicator scannt.)

Reporter Bernd: Danke, dann also meine erste Frage: Was führte dich nach Luxembourg Ville?

Passant Bill: Ach, ich arbeite als KI-Berater bei einem Finanzberatungsunternehmen und treffe mich einmal monatlich mit meinen Kollegen zum persönlichen Austausch; alles andere regeln wir übers Netz.

Reporter Bernd: Du arbeitest also – wie die meisten Leute – im Home Office; und wo wohnst du?

Passant Bill: Mit meiner Familie wohne ich im Grünen, im preiswerteren und umweltfreundlicheren Nordteil des städtischen Gebiets Luxemburgs, etwas hinter Ettelbrück, fast schon in der Eifel. - Die gigantischen Wohntürme im Süden des städtischen Gebiets mögen wir nicht, obwohl die dortigen vielen Sozialwohnungen kaum anders zu bauen gewesen wären. Im Ösling leben wir gesünder, versorgen uns weitestgehend selbst, leben meist vegan, kaufen nur einmal wöchentlich all jene Dinge ein, die wir gerade nicht selbst erzeugen können. Etlliches, was auf unseren Permakulturböden ohne Pestizide nicht gut wächst, lassen wir uns aber auch von DeliverNow (Anmerkung der Redaktion: ein Dronen-gestützter Liefer-Service) kommen.

Reporter Bernd: Von wo kommen deine Arbeitskollegen?

Passant Bill: Natürlich wohnen die meisten meiner Kollegen und Kolleginnen immer noch im (größeren) Umkreis der Hauptstadt, aber einige arbeiten auch von Brüssel, Frankfurt, Amsterdam, Mailand, ja sogar von Madrid aus eng mit uns zusammen. Entfernungen spielen ja nicht mehr dieselbe Rolle, wie das 2019 mal war. Die alles durchdringende Digitalisierung hat eben vieles vereinfacht, jedoch „sieht“ und „hört“ sich fast nur noch über Video-Konferenzen, kann sich dabei aber weder anfassen noch riechen.

Reporter Bernd: Welche Schwierigkeiten ergeben sich aus diesem Mangel an persönlichem Umgang mit Arbeitskollegen?

Passant Bill: Oh, da trifft du einen wunden Punkt unserer heutigen Gesellschaft! Wir entfremden uns immer mehr voneinander. Denn jeder erwartet heute von den Mitgliedern der Global Society, dass sich jeder sich ordentlich in die Gesellschaft einbringt! Es gibt jedoch auch leider zahlreichen reinen Nutznießer. Denn heutzutage erwartet man ja von uns, dass wir wenigstens ein Drittel unserer Arbeits-Zeit für regenerative Aktivitäten im öffentlichen Garten sowie um die Sauberkeit und Effizienz der Infrastruktur. Dazu gehört selbstverständlich die aktive Mitgestaltung und Kontrolle der Arbeitspläne für jedermann. - Weil wir eingesehen haben, wie wichtig der Beitrag jedes einzelnen Bürgers ist, machen die allermeisten auch bereitwillig mit; und den Drückebergern machen wir das Leben mit einer Kaskade von Schulungsmaßnahmen schwer, bis auch sie nach Kräften mitmachen.

Reporter Bernd: Welche Schulungsmaßnahmen sprichst du an?

Passant Bill: Alles beginnt mit der persönlichen Bestandsaufnahme, warum sich jemand der Gesellschaft verweigert. Welche schlechten Erfahrungen hat jemand gemacht, und wie kann man ihn/sie aus dieser Verweigerungshaltung heraus holen. Jede Aktion fußt ja auf (mindestens) einer Emotion. Hat also jemand erst einmal gespürt, wie gut es sich anfühlt, wenn man helfen kann, dann wächst auch bei ihm/ihr das zarte Pflänzchen der sozialen Fürsorge, und durch die erlebte Freude steigt die Motivation zu (noch) mehr Engagement für die Gemeinschaft.

Reporter Bernd: Aber das kann doch noch nicht alles sein!

Passant Bill: Richtig, die weitere Schulung findet heute natürlich nicht im Schulgebäude statt! Wir bieten die Teilnahme an Arbeitsgruppen zur naturnahen Landschaftspflege an. Es macht ja richtig Freude, die Bäche und Weiher seiner eigenen Gemeinde gesund zu erhalten, statt nur über die ausbleibenden Aktionen des Gemeinderates zu schimpfen. „Mitmachen – Mitgestalten“ ist heute kein *rein* akademisches Thema mehr. Selbst unsere Kläranlagen pflegen wir in gemeinschaftlicher Arbeit.

Reporter Bernd: Also doch eher eine positive Entwicklung! - Gilt gleiches auch für Luxemburgs Entwicklung aufgrund der vielen Klimaflüchtlinge aus Südeuropa?

Passant Bill: Jetzt wird's brenzlich! Unsere Gemeinde hat die jährlichen Flüchtlings-Quoten aus Portugal und Spanien zwar erfüllt, aber so richtig integriert sind all die Leute noch lange nicht. Der Gemeinderat veröffentlicht alle Mitteilungen jetzt neben Luxemburgisch, Französisch und Portugiesisch auch noch auf Spanisch und Griechisch. Aber es kamen bis jetzt zu wenige KI-Leute (Künstliche Intelligenz Spezialisten), und alle anderen tragen recht wenig zum finanziellen Gemeinwohl bei.

Ach, da kommt mein hLifter!

Reporter Bernd: Vielen Dank für deine offenen Worte! Guten Heimflug, Bill!

Taxation for regeneration

So how was all this financed? This government took its role in redistribution seriously, since a multi-speed sustainability in which families with lower incomes simply couldn't afford sustainable goods and services was no longer an option. As paying the UBI to all citizens is equivalent to 25% of GDP, there was a need to increase government income, largely from taxation, by an equivalent share of GDP. Pensions were integrated into the UBI – most citizens had a combination of public and private pension plans as no-one in the 2020's felt safe in placing all their eggs in one basket....

In 2031 a fundamental tax reform enabled the Luxembourg state to collect taxes amounting to 45% of GDP by combining first and foremost new taxes on machine-derived services and wealth with environmental taxes, and a pension reform that consisted in the levelling of pensions above a certain threshold. A stamp duty for share purchases was reintroduced to tax the wealthy and consumption taxes were increased. Hidden subsidies related to the carbon economy were also removed. Taxes were levied on all fuels, including aviation fuels.

The UBI was earmarked for residents only. This provided the basis for introducing an opt-in scheme for a national Universal Basic Income, which was however tied to time spent on regenerative activities on public land, such as the permaculture garden. In fact, all citizens signing up to the UBI were attributed a plot and had the responsibility to regenerate the soil there thanks to composting practices integrated in their household management. They were also however attributed the right to a fair share of any harvest produced in the value co-creation process - jointly with the plants themselves who had the right to a share of the harvest nutrients being given back to the soil. What other welfare system has prevented all the strain from being put on unemployed or lower-class workers, whose income levels had stagnated since the 1980's in spite of considerable GDP growth?

The gamble the old government in 2015 had taken on perpetual growth to finance pensions was now in part shifting to an expectation of significant health benefits and thus lower costs in the health care system in a rapidly ageing population.

Total – 45% of GDP

- 15 % from taxing machine-derived services
- 10% from the sales of goods (also with the objective of curbing material flows)
- 20% on income and profits
- 5% from taxing wealth
- 5% eco taxes
- other

Governments, companies and citizens are fully aware of nature's limits in providing ecosystem services and re-absorbing emissions and waste. All economic activities take these constraints into account. This awareness is reflected in high taxes on (non-renewable) resource consumption and even more on pollution which damages ecosystem services. This includes measures such as a 15% social security levy on those earning more than € 250 000, 2% annual wealth tax, 3% tax for all over 1 Bn and 7% levy on corporate profits. Tax goods (material flows) and machine derived services (decrease labour tax to allow circular economy to flourish and become more competitive (*Not clear, please review – SN*). Whilst close to doubling the national income from taxation might have seemed outlandish to some in the 2020's, it should be remembered that, even in the liberal US, following the introduction of the welfare state at the turn of the 20th century, by 1960 the percentage collected had tripled from the initial 10% to over 30%.

Luxembourg being one of the few countries with a really agreeable climate and relatively little concern over water stress compared to other areas and neighbours like France and German, or indeed the USAI – Luxembourg's wealthy decided to remain.

2.3. Luxembourg society

Population growth, demography and culture: The resident population in Luxembourg grew at a steady pace between 1990 and 2025, gaining an addition of about 10 000 residents per year until the population had risen to 700 000 residents. In 2025 radically different immigration policies were implemented, such that resident growth experienced a plateau effect, slowing to just 735 000 in 2035 and 750 000 in 2045.²⁶ **Ageing population:** The population has accordingly aged significantly quicker than models with growth assumptions had suggested in the 2020's. Today every fourth person on the street is over 60.²⁷ Fiscal costs relating to health-care, pensions and long-term care seemed untenable given that even optimist forecasts predicted a ratio of working population to pensioners of only 2:1 compared to a ratio of over 3:1 in 2020.

Culture and nature: Over 50 % of citizens have accepted the UBI and are active in cultivating biodiversity in garden plots in the permaculture belts around settlements, or on their balconies or gardens at home. These regenerative activities are conditions of the Universal Basic Income Scheme that provides a basic salary that can be supplemented by other jobs in the private sector or public authorities. Over 60 % of the population have adopted largely vegetarian, and 10% of the population even vegan diets. Water saving measures including rain and grey water capture and usage are commonplace. The welfare system and taxation (???) – SN

Education within a web of life

The education system encourages an attitude of respect, humility, self-critique and reflection about our place in the web of life and the web of minds, and in view of our limited cognitive capacities of sensing life forms around us compared to some other animal species or to the diverse, highly interconnected, sharing and communicative plant life in forests (Peter Wohlleben on forests). We are just tiny nodes in a hugely complex and interconnected web of life and web of minds. We are not in a position to control our environment, but are rather transformed by it - or at best navigate stormy unknown seas. History has taught us our main lesson for the 21st century - that unwanted side effects of today's intentional actions may govern our lives and self-understanding of tomorrow (Beck, 2019, metamorphosis). Life as flow, we can at best influence the transfiguration of ourselves and our lives qualitatively for ourselves and other life forms in our surroundings. The flipside was that individual self-trust and pride associated with the ability of social critique declined, further eroded by fear of the social control (see also Huxley, Brave New World). Many families withdraw into themselves for self-reliance in terms of social needs. Given the important role of life experience in all matters concerning cultivation of diverse life forms and preservation of home-produced foodstuffs, elders and multi-generational families regained in importance.

The national curriculum places emphasis on trans-disciplinary work embedded in practice and has tied former curricular contents of physics, biology, sociology and chemistry to urban gardening for food and fibre and water capture and treatment projects as well as energy cooperatives. Trans-disciplinary projects help to integrate formerly abstract disconnected subject silos into a curriculum for effectively learning systems thinking in practice, and negotiating best courses of action in diverse student and teacher groups. The citizen science approach is integrated in the school curriculum and provides an important framework for quality control by teachers and learning on how to collect and interpret and evaluate data by families. Whole neighbourhoods are engaged in such school projects so as to keep them running over the summer holidays, this is perhaps another proof that UBI works. The operation of school canteens and restaurants is integrated in resulting material flows through composting. All is geared to enhance our consciousness that we are one part of the web of life, our observations as conditioned by the place and time and circumstance we find ourselves in, and that we can learn by mindfully observing nature and how diverse life forms cope with their varied predicaments.

Science, religion and art as rooms and mirrors for reflection on accelerating societal transfiguration

Art: (based on the book Sustainability in an imaginary world, Chapter 1 Hopeful Monster? Art, sustainability and the imaginary world Maggs & Robinson , 2020; and Wijers and Pijnappel, 1989)

As an increasing number of artists jumped on the bandwagon of seeking to influence human-nature relations, and as political pressures on artistic communities from governments and foundations grew for more and more such instrumental art, there was a growing counter movement of painters, poets and musicians. They chose to caricature the often monstrous entanglements of the social, technology and experiences of nature in our understanding of our nature and cosmos. More and more artists focused on questioning core assumptions about the nature of our reality in a way that became increasingly unsettling and disorienting for many people. The school system had to adapt and the national curriculum strengthened efforts on teaching subjects such as theory of knowledge to bolster our certainty in the face of emotional uncertainty, contributing to the cultural shift from controlling to riding the waves of a rapidly transforming world.

Science in society : Whilst international data networks and flows are crucial in understanding progress as realigning social practices and values with the bounds of the earth's biophysical carrying capacity, it is clear that such data has to be disaggregated and considered in local contexts – and that

the meaning of any numerical measurements of indicators of the state of nature's elements and flows has to be translated into the local context in order to become actionable. In this way, sustainability becomes more than just a moral compass; it is empirically rooted in our changing environment and its life giving capacities.

Rites and rituals, societal cohesion and control: The new experientialist existentialism has helped new meanings for old myths to emerge. The old natural pagan traditions such as Easter plantings, fertility rituals, and thanksgiving have gained new momentum and significance and as they are practised in large groups in nature they contribute to social cohesion (but also to social control) in terms of who engages in what way.

These three spheres witnessed and contributed not only to transformation of the social order associated with new ways of knowing and social values, but also to altering our very understanding of what makes up our world and what agency we have (an ontological transformation).

Life and leisure in Luxembourg

The relative value and quality of an individual human life, as well as individuality per se, has decreased compared to the 2020's – in terms of the associated social norms and of priority in policy making – in comparison for example to the existential need to rebuild diverse insect populations including pollinators.

Stringent social norms and social control on individuals spending their time on nature-based regenerative activities further encroaches on and delimits notions of 'freedom' and individuality. Subscription to the UBI with associated garden plots provided some independence from unreliable supermarkets and more room to creatively shape one's dietary intake through subsistence activities. It was also accompanied by monitoring and self-monitoring obligations concerning the regenerative performance of one's allocated land and one's own social practices. The ultimate sanction for negligence by not regenerating, or even inflicting damage on, the nation's existential basis was expulsion and the withdrawal of citizenship or one's residence permit. Sporadically there were well-orchestrated media reports of a few controlled deportations of those in violation of UBI regulations, as had been customary with illegal immigrants at the turn of the century.

Disease vectors are increasing in prevalence due to the shortening hydrological winters. At the same time antibiotics are failing, partly because of over-use of antibiotics up to the 2030's and selection for multi-resistance plasmids in the water system and sewage treatment plants. There are also serious repeated bacterial contamination issues in the water distribution system due to warming combined with riverbank filtration practices to source water.

The health focus is on optimal balanced living conditions for a strong immune system. Living with beneficial bacteria and cultivating fermented foods for enhanced gut biodiversity and enhanced immune system are key – a high diversity of fermented foods and drinks reflect a highly cultured household. Effective and thorough knowledge of medicinal plants with more complex mixtures of antibacterial and antiviral agents than the old industry used to produce as 'silver bullets' - as otherwise incurable infections and the risk of limb amputation looms. (*Something wrong with this sentence – SN*)

The new digital divide: By no means everybody in this generation has benefited from growing up immersed in digital media. The digital divide has widened in Luxembourg, not because of differential access, but because of the quality of content accessed in the web of the 2020's - a decade in which personalised suggested contents often became a further brick in the wall around mobility across socio-economic levels. Luxembourg's cultural diversity and multi-lingual environment continues to

prove demanding and selective for wealth creation. Whilst many of the new Gen Z leaders take advantage of a subtle intellect that is at ease in the face of complexity and uncertainty and has crystal-clear visual and communication capacities, arguably, the proportion of the population who have trouble in creatively and proactively shaping their living conditions and futures is smaller than ever before. The gamers and more passive citizens, who still in adulthood spend more time in virtual realms than interacting with others in the physical world, are well provided for though. Solidarity between members of a generation who from their earliest years were continually bound up in social media networks like Snapchat and Instagram and who were exposed from infancy to unifying viral memes is less questioned than in previous generations. Cultural homogenisation, the flip-side of cosmopolitanism, is another side-effect of these social media penetrating all aspects of school, social and personal lives.

Box 5. Witness account II: Diary entries by budding architect Nadia Turmelo

Dear Diary,

May 25th 2025

One more week until the holidays! Finally! But finals are in three weeks... I know it's going to be stressful, but at this point I really want to get it over with. Today I have a lot to do - after all, I still have a lot to study for - so my writing may be a little rushed. I don't think I will have time to get breakfast either as I still have to run to pick up my books at the library before I meet Valeria. It doesn't really matter anyway... breakfast isn't that exciting... Especially since they stopped serving fruit other than the local apples back in 2023. Apple season ended two months ago, and I know it may sound picky; but the left-over apples we have now don't taste as good.

I really wanted to arrange to meet Valeria at Itsu (the sushi place) but that closed last week. Some people say it was because they could no longer supply the fish? Or maybe it was the rice? But I don't know. It's a shame really - it was my favourite place to eat. Instead we're going to the Italian place around the corner, they have good food there as well.

So now that I have lunch settled already... I'm wondering what I should have for dinner. I'm probably just going to make myself a salad from the things we have on our 'green wall'. I think we have some lettuce and radishes left. Oh! And that reminds me: I have to find someone to water my section of the wall while I'm gone next week.

It's starting to get warmer already - I just hope this year's heatwave doesn't arrive during finals! If it gets as warm as last year - I can't imagine what it would be like to sit still in that big room for hours on end in the 40° heat. We would probably have to move to an entirely different building in that case considering that we can't use air conditioning as we did a couple years ago since it uses too much power.

I really haven't been motivated to study the past few days, but I hope that today will get me back on a roll. Wish me Luck!

Nadja

Dear Diary,

May 25th 2030

I just found you back after I made a first entry exactly five years ago in the second year of my university studies in architecture! Well, that comes from tidying cupboards in order to procrastinate study for the final exams! In three weeks are my final exams of my architecture degree - I can't believe I will ever enter the real world with real responsibilities! Our projects are fun, and the internships were incredible - I still find it mind boggling that we have to integrate everything from biology, to agriculture, to the most recent energy technologies and water capture and recycling systems for the biological and technological circuit in each building! Whilst the first demo-projects exist, I can't imagine all these grids will be overhauled to make these fancy ideas of our professors implementable in real life! It's currently 43 degrees and all I want to do is sleep in a cold tub of ice. But I'm going to the campus natural water pool in an hour or so with a couple friends. The water in there isn't that cold either but it should be fun anyways. I gave in my architecture project to the professor yesterday and he said it looked promising. I am particularly proud of my idea to have the natural ventilation system with the indoor greenhouse. I really enjoyed that project (especially drawing the plans, that is always my favourite part). Tomorrow is going to be exciting as well! My friends and I have been involved in a project for a while now. We're planning to grow our own edible mushrooms (champignons, porcini mushrooms etc.) in the washroom downstairs. The campus board only approved our idea last week but we're already getting started. Our equipment should be arriving at noon tomorrow. Students and teachers can then pick mushrooms for their meals - this should be beneficial since meat is getting more expensive and most dorms here only have a microwave. It shouldn't matter if we start eating mushrooms every day then, after all most of us are vegan or vegetarian now anyways. I just wrote a letter to family back home since the one week holiday starts in two days. This year I'm staying here since I don't want to take the plane and the train takes too long for such a short stay. I miss them a lot, but we will probably skype or something soon. I have to go now! I'm helping Julia with her project on bioluminescent plants for her biology class and I still have to eat lunch beforehand. I hope mum and dad had time to take care of my permaculture plot and my facade garden. I am craving a good boost of vitamin C and mineral boost from the water cress - not sure how long it will survive this heat - we should harvest and eat it up quite quickly now! I really should not indulge much in writing my own diary here - quick back to study, perhaps I'll pick up this thing in the big summer hols...

Dear Diary,

May 25th 2040

Found you again! It seems always in the first days of the heat wave, staying mainly indoors I am overcome by this huge urge to tidy everything, at least the apartment looks good when everything feels sweaty and glibb. Five years ago it was just as hot in May, we are again experiencing a heat wave and the thermometer has climbed over 39°C already several times this week --- how hot will it be next week when we are sitting the exams? I hope they will

allow us this year for the first year to sit our exams in our bikinis – as air conditioning is no longer an option. At least the mushrooms in our basement with our novel cultivation system based on wood pulp and coffee filterremnants are thriving and we will have a great mushroom steak for dinner! Today I'm on duty in checking the pipes of the triple grid... I would much rather take care of the plot in the belt – but hey... Reading back all the uncertainties of my situation at the end of my degree in the above entry, I feel so lucky in having gotten this job for the government in developing the corridor's more densely settled districts food provision plans in seeking more opportunities for facade integrated food cultivation....

2.4. Spatial planning for land-use- and land-cover change: Investing in rural development for resilience

In the 2020's a first series of droughts caused major disruptions in the economy. Since the 2030's the new focus in spatial and urban planning is on implementing nature-based solutions for improving water retention and regeneration across the whole territory of Luxembourg. This strategy to rebuild the very substrate of our existence demands policies that emphasise investment in the regeneration of biosphere integrity, in terms of living soils and more diverse terrestrial and aquatic ecosystems with greater cleansing capacities for surface and ground water. The National 'Plan Directeur pour l'Aménagement Territorial' was fundamentally revised in 2030, hand-in-hand with a thorough review of policies on urban and rural development.

The 2030 Plan Directeur pour l'Aménagement Territorial: In order to maximise large areas with ecosystems as undisturbed as possible, the country was divided up into three different zones with three different strategies to reconcile human needs with the regeneration of biodiversity, water quality and degraded land: the central urban settlement corridor; a permaculture belt around the corridor; and nature protection zones (See Figure 5. Below).²⁸

Development along one catchment area for human activities and related material and energy flows: Investing into the green urban catchment area. As for the old-style municipalities, which still largely exist on paper, there have been some minor rearrangements, particularly some mergers, mainly in the decreasingly densely settled more rural areas, resulting in fewer but larger municipalities. The rigorous focus of national investments in infrastructure (in particular of the triple grid and transport structures), together with the densification of the built up area and district settlements along the entire urban catchment area, made Luxembourg into something akin to a city-state (already a widely-held perception internationally anyway).

Luxembourg identity and difference – the frontiers: This central catchment area did not stop at the French border, but continued beyond the limits of the source and Alzette basin in the Southwest well into France, connecting to Metz and extending as far as Nancy along the French motorway. The Luxembourg border became more noticeable than previously, as cars were now required to be left at the border. This was where the monorail embedded in the centre of the Luxembourg urban catchment area had its southern terminus. Border controls were also reinstated for a number of reasons: more profound changes to immigration rules reflecting ever-increasing immigration pressures; a scramble for food and water and some other natural resources; and the reversal of some EU rules on integration and the free movement of people, goods and services, that had been introduced with the Treaty of Maastricht.

The frontier to the North-East of the urban catchment area, leading to the still sparsely populated Eiffel, reinforces the sense of a nationally delimited urban zone that aims to develop somewhat autonomously from its neighbours. Culturally however the villages of the Eiffel are looking closely at new regenerative approaches and agro-ecological cultivation methods being developed in Luxembourg. They take note and adapt.

Transfiguration of the urban space along the Alzette valley: the journey from the 2020's – upsides and downsides:

One upside of this spatially restricted development of infrastructures and settlement districts that started in 2025 is that Luxembourg has gained clout and international standing as a player in networks of cities for sustainability. It was in the early 20's that cities found it easier to promote their metamorphosis towards sustainable societies with engaged citizens, compared to the national level. City networks for change were the most effective internationally networked knowledge flows for sustainability transformations of life styles, the economy, and the built environment, mutually reinforcing each other. But it was clear that the meaning of the knowledge driving metamorphosis related to sustainability had to be negotiated locally by the people, and that proved to work most effectively at the city level (citizens). These international developments and changing dynamics about who had power and say in shaping prevailing social practices and forms of built environment, fully support analogous developments in Luxembourg. These shaped it into practically one large tubular city-state flanked by a quiet food garden area which in turn is embedded in an extended wilderness zone.

The transport system and connections

The transport system is focused firstly on the provision of excellent multimodal public transport connections and bicycle and walking infrastructure within the settlement corridor, and secondly on its connection to the neighbours in the greater region. Changes in mobility patterns and saying 'Àddi' to car ownership as status symbol have freed up close to 20% of the land in urban and residential areas, in particular also from former parking spaces in houses and residential areas, buildings with dedicated parking, green space between roads and the like. The narrow parking strips not suitable for 'densification of inhabitable space' are now largely dedicated to urban gardening activities. Significant investments were made to tear up the artificial materials from these ubiquitous parking strips and to convert them into permaculture strips.²⁹

Over 45% of all trips are nowadays made by bicycle (this was already the case for the Copenhagen city area in 2020), with associated health benefits. The urban catchment area and its adjacent food garden zone was interwoven with over 400 km of bicycle paths, many of which were left unpaved in the garden zone. Both transport-related carbon emissions and days of sickness leave were reduced drastically (these statistics compare to measured benefits in Copenhagen in the year 2019). Cars were banned to one central route through the urban catchment area, flanked with multi-modal public transport solutions including the tram and a high-speed monorail. As most car parks had been converted to green and food areas in the city –also needed to improve the micro-climate and resilience against summer droughts and extreme weather events – only very few car owners were left and few cars were to be found in the urban catchment area. There was a small fleet of shared electric cars for emergencies.

Urban development in the green urban catchment area

Following radical political changes after 2025, Luxembourg positioned itself at the forefront of a group of cities morphing into sustainable green cities by limiting all investments, innovations and further development of district settlements within its urban catchment area. Only passive housing standards were allowed, with high standards for modular reusable building materials with high levels of embodied carbon. Beginning in 2025, a green layer began to extend into all three dimensions. It grew pervasively through the entire built environment of the urban catchment area, along façades, on roofs, and replacing former car parking areas. Densification and increasing prices of habitable space mean that today the average living area per person is just under 50m², close to half of the Luxembourg average in 2020. This has resulted in significant saving of energy and natural resources.

Human activities, including economic activities and residential areas, are today heavily concentrated along a central 'urban settlement corridor' between the three growth poles in the North, the Centre

and the South (ref. from Kai paper). Today this corridor counts about 750.000 residents, close to 90% of the population of Luxembourg. The corridor is very densely settled; population density in the area has increased by 38% compared to 2020. This relatively high density benefits sustainable district design, allowing for a good mix of residential and office spaces, with shops and excellent concentrated transport and multi-modal mobility infrastructures. At the same time, the proximity to nature along the relatively sharp border between the urban corridor and the permaculture belt offers a proximity to nature of rare quality worldwide.

Whilst the urban corridor is the one zone in which by design human needs are serviced, urban spaces are also designed with an eye to engaging in regenerative activities. At regular intervals, wildlife corridors link the two permaculture belts on either side (West and East) of the central corridor with the renatured riverbanks of the Alzette. The river, flowing through a large part of the corridor, and its banks, play a key role in making the city liveable. Some former settlements in the flood-plain have been dismantled to make room for richer aquatic ecosystems that provide for an improved urban climate and water quality. This matters particularly during the hot summers, when temperatures exceeding 40°C and tropical nights over 30°C are no exception.

Integrated overhaul of the three interdependent grid systems of water, energy and ICT: The concentration of the infrastructure in the central urban corridor provides important strategic advantages for investment in state-of-the-art water, ICT and energy grids covering as small an area as possible. Smart planning systems looked at the three grids as an integrated structure requiring constant maintenance. The backbone of the system is kept above ground and runs parallel to the Alzette along the North-South Axes of the central corridor, alongside the N7 road. The completion of works on the state-of-the-art water infrastructure in the urban corridor in 2045 is Luxembourg's most recent achievement in its programme of regenerative investments. The water infrastructure is now adapted to separating biological and technical water cycles, each subdivided into circuits of three different quality levels, and offering water at different degrees of purification for different uses at differential prices. This corresponds to the cascade logic of the circular economy (for details see section 2.4. on the water infrastructure).

The corridor's two main design principles for urban planning and construction: *Green instead of grey*, in order to develop urban spaces for subsistence and regeneration of diverse life forms in the city; and the *design logics of the circular economy* help to close material flow loops in local production and consumption processes as far as possible. The early establishment of a Man and the Biosphere project in 2021 in the fairly densely settled PROSUD Region, a large share of which was integrated in the central corridor, helped to develop suitable practices to reconcile urban development with regenerative activities.³⁰

Green instead of grey: Architects, planners and promoters started going beyond passive energy design to harness artificial ecosystem services that are expressly designed to deliver what cities need most: clean air; production of oxygen and sequestration of carbon dioxide; filtration of fine particulate matter; an agreeable microclimate; noise abatement; biodiversity regeneration in the city; clean water; protection from flooding during extreme weather events; food production.

Circular design of the built environment in cities: Beyond food production, the built infrastructure of this urban corridor was designed and re-built in order to come close to the ideal of a closed loop in terms of all material and energy flows that occur there. The objectives were: to reduce resource consumption to a minimum; to come as close as possible to autonomy in terms of food and water and energy; and to reduce emissions of greenhouse gases and pollutants to a minimum. The collection,

recycling and reuse of waste – both solid and liquid – were central. This approach was facilitated by entirely revamping the water infrastructure (see section 2.4.).

Food in the city: The need for clean, locally grown and seasonal food produce to enhance the food security of the corridor’s residents, in a context of increasingly unreliable supermarket provisions and without logistics and food waste, was growing. At the same time the fact that pollinating insects came close to extinction at the end of the 2020’s focused minds on the need for comprehensive ecosystems for food production to be developed and integrated in exterior walls, roof tops and public areas in cities. Entirely new concepts evolved for integrating urban food production and ecosystem design into urban design. These nature-based production systems and building infrastructures were closely intertwined, such that energy and material flows, including water nutrient and light flows, could be used for the sustainable cultivation of fruits, vegetables, as well as mushrooms and aquaponics.³¹

Buildings and cities more broadly started to be seen in a systemic manner as resources for regenerating plants and entire ecosystems in cities. Roofs and façades furnish space, rain, grey and waste water, nutrients and off heat and other forms of energy, all of which can be used for food production and the regeneration of biodiversity in the city. The design of lighting took far more account of optimal wavelengths and lighting cycles for diverse nearby crop plants than of the earlier and outdated technical ‘human comfort norms’ that had governed building standards at the turn of the millennium.

The new generation of architects, planners, promoters and builders of the 2030’s took to this task with enormous creativity and many new ideas. Several seeds of forward-looking research projects such as those of the Fraunhofer Institute in the 2010’s were taken up and left to germinate and take root in this central corridor, which now provided a concentrated place of experimentation, with a multitude of ideas for systemic transformation and monitoring and analysis in place to assess which ones cross-fertilised each other and which ones were counter-productive to regenerating biodiversity in urban space.³² However, just like in the farming activities of the permaculture belt and rural zones, drought and heat resistance remained a primary selection criterion for crops. Moreover, sealing of surfaces (eg by building roads) was avoided where possible. Some such sealed surfaces were even torn open again, to enhance the natural water cycle and retention even where the ground had been covered. This allowed for maximum root growth, promoting a favourable microclimate by encouraging as much trans-evaporation and tree shade as possible. One result of this removal of hard walking surface was that high heels now became totally unfashionable and became seen as one of many aberrations in past human tastes.

Small spaces in dense settlements proved particularly fruitful breeding grounds for radical innovations around sensor-driven water and light provision, the use of companion plants, breeding stations for beneficial insects and insect hotels, and other nature/technology synergies. Various rooftops became home to diverse ecosystems with different heating and lighting patterns, glass houses or open air. The urban corridor developed itself by interested citizens’ experimenting and learning from each other; they became interconnected through citizen science into a living laboratory. Food experiments range from mushrooms in cellars to strawberry façades and offer diverse approaches to drip-irrigation of UV resistant growbags with different substrate contents for different food crops. Urban ponds and natural swimming ponds become small farms for water cress and other vitamin and mineral rich water greens.

The local foods garden sphere

The urban corridor is flanked by an agro-ecological garden area that offers land not only for leasing to agricultural production and subsistence farming activities, but also those areas which citizens who

sign up to the UBI possess a legal right of use. These small gardens provide more opportunities for subsistence farming, which has a direct impact on quality of life and spending capacity because food prices in the shops are exorbitant. A maximum amount of foods is cultivated sustainably in the closest proximity to the city. A trailblazing project that provided rich experiences for building the local foods garden flanking the urban corridor was the subsistence farming project based on permaculture practices on the high plateau of Eich above Dommeldange, in which most participants were involved in community-supported agriculture. The organisation TERRA began this practice as early as 2017.

The agro-ecological garden area adjacent to the densely settled areas also gained in the more peripheral areas on its Eastern and Western sides significantly in quality in terms of developing into a calm zone, in which only walking and biking were permitted as transport modes, to slow the speed of life and enhance beneficial health impacts from time spent in these public food gardens.

Science-based holistic grazing management for grass-fed livestock and regenerative practices were adopted.¹ Livestock kept in large dense herds that remained on specific smaller plots of land for three to four day to graze and fertilise the ground are largely constituted of sheep and some goat, also important for the Luxembourg wool industry. Spinning and garment knitting became a an activity that was also electable in return for the UBI, for the less mobile elderly population. The sheep and goats cheese production gained in importance.

Agro-ecology belts: Recycling of nutrients and energy in nature is a function of many species. In the local food garden zone, citizens are invited to contribute actively to producing rich living soils by integrating our food wastes with compost and mulch. They support biomass enrichment above and below ground by planting heat- and drought-resistant species and caring for them until they have adapted to their new Luxembourg home and can help us towards re-establishing the integrity of our biosphere.

Other projects in the food garden targetedly served for reforestation based on agroforestry practices, intermingling food crops such as berries growing on acid soils with drought-resistant pine trees. Natural forested landscapes serve to provide the condenser leaves and clouds to keep rivers running with clean water, to maintain the global atmosphere, and to lock up our gaseous pollutants.

Droughts brought about radical changes in crops cultivated in Luxembourg – drought resistance or at least tolerance became an important factor of choice. Demand-side change in nutritional preferences arose out of people eating reduced meat and dairy and a higher proportion of the population (60% by 2045) becoming vegetarian of which about 12% were vegan.

What might be grown here? What might be the yields in the city and in the permaculture belt? What is realistic in terms of yields, areas required for subsistence on a vegan or vegetarian diet, and areas required for additional food supply to the urban corridor?

The wilderness zone – investing in rural regeneration and resilience

Beyond the permaculture belt are the nature protection zones that first and foremost present contiguous larger scale ecosystems in which the regeneration of diverse webs of life is the highest priority. As far as they can be made consistent with this priority, limited ecotourism offers are available. These include combining tourism with making empirical observations on biosphere integrity and biodiversity parameters from dedicated tents and tree houses. On some other areas there are also renewable energy generation systems, such as photovoltaic systems on stilts. Although these areas make up the major part of the land area in Luxembourg, only 12% of the residents live there. This corresponds to about 100 000 people, about 50% less than lived there in 2020. (siehe **Fehler! Verweisquelle konnte nicht gefunden werden.**)

1

Water and energy grids and roads are only maintained if they are relevant for the provision of the central corridor. Otherwise, some of these infrastructures are even dismantled to make room for nature and prevent pollution from their decay, and to recover some of the building materials for the circular economy. In rural areas transport infrastructure is reduced to the minimum necessary for eco-tourism and regenerative activities in the extensive forest and meadows.

Ein Teil der Natur - Landnutzung

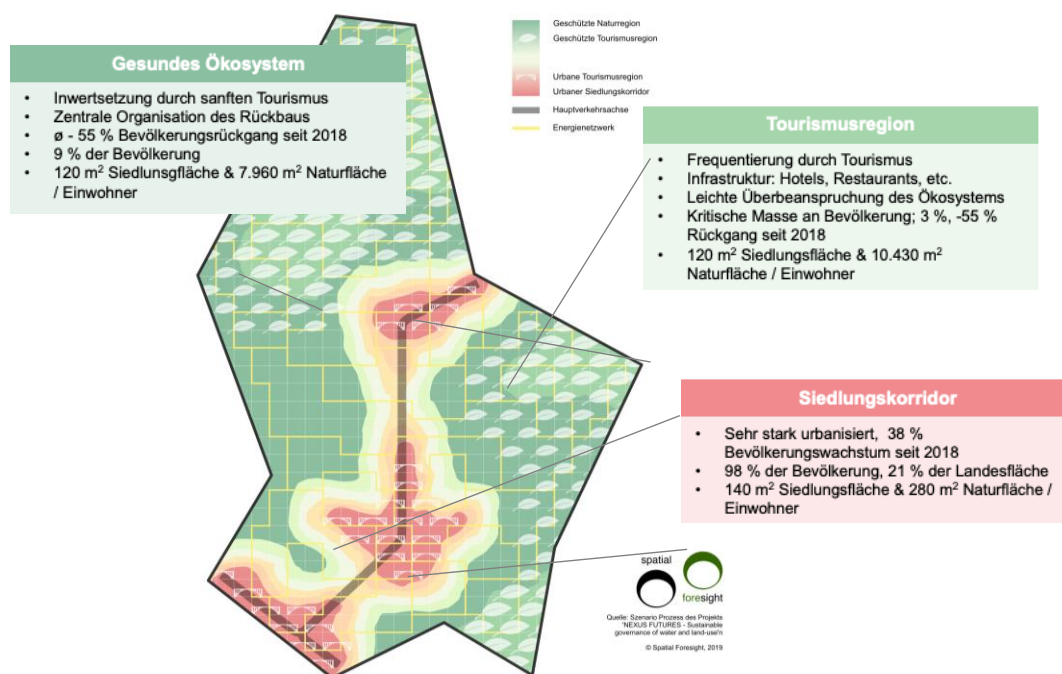


Figure 4. Ideal national development planning map

This plan serves to direct all investments in urban and infrastructure development to one central urban catchment area since its inception in 2025. In 2045 implementation is not perfect, but is considered to have reached 70% completion. The plan depicts in red the urban catchment area in the centre of the country as the priority area for all investments in settlement district and infrastructure development. In the yellow area and a bit beyond is the local foods garden zone that is destined soon exclusively to harbour activities for intense regeneration of biodiversity, largely with agro-ecological practices that also serve for food cultivation. This area flanks the city like a belt. Beyond this is the wilderness zone. **NEED TO REWORK THIS FIGURE A BIT TO BETTER FIT THE NEW TEXT – add garden zones and develop it in English language**

BOX 6. WITNESS ACCOUNT ON THE UBI. LUXEMBURGER WORT 15.9.2045 Interview by correspondent Bernd Niessen part II.

Reporter Bernd: Wie sieht es deiner Meinung nach mit der Bodennutzung in Luxemburg aus? Wie wirkt sich die von 5 auf 20 Jahre erhöhte Anti-Spekulations-Frist aus? Und hat der massive Landkauf durch Staat und Gemeinden zu einer Entspannung auf dem Wohnungsmarkt geführt?

Passant Bill: Zwei heiße Eisen! Seit 2019 sind meines Wissens die Quadratmeterpreise für Miete und Kauf immer weiter um jeweils 3 Prozent pro Jahr gestiegen. Aber der Soziale Wohnungsbau hat sich doch sehr positiv entwickelt; und so kann eine junge Familie sich auch in Luxemburg endlich wieder Wohnungseigentum leisten. Denn in jeder Gemeinde wacht ein eigener „Wohnungs-Ausschuss“ über die gerechte Vergabe von Wohnungen und Grundstücken auf 99 Jahre-Pacht an „Bedürftige“. Diesen Begriff hat man allerdings auf ein erstaunlich hohes Niveau angehoben.

Reporter Bernd: Du hast recht: Der Anteil an neuen Sozialwohnungen am gesamten jährlichen Wohnungszuwachs hat sich seit 2019 verzehnfacht. Ohne den systematischen öffentlichen Landkauf mit stringenten Umweltauflagen in den Jahren 2020 bis 2040 wären solche positiven Entwicklungen kaum möglich geworden.

Ein weiterer wichtiger Aspekt des jahrelangen staatlichen und kommunalen Flächenerwerbs liegt wohl in der angestrebten Gesundung unseres Wassers. So konnte die Einbringung von Schadstoffen in unser Grundwasser seit 2020 drastisch gesenkt werden. Dazu trug

natürlich auch die Umstellung der Flugzeug-Turbinen von Kerosin auf Wasserstoff positiv bei. Dennoch gab es ja nicht nur Gewinner. - Wie steht es um die Landwirte?

Passant Bill: In meiner Gemeinde im Ösling arbeiteten 2019 noch fast 10% in der Landwirtschaft – direkt oder indirekt. Heute sind das nur noch 2%. Erstens erzeugen sehr viele Haushalte im eigenen oder gemeinschaftlich bewirtschafteten Garten ganz viel selbst, und zweitens lohnt sich der Ackerbau und die Viehzucht in Luxemburg kaum noch. Würde man den Landwirten nicht mit großzügigen Zuschüssen aus EU-Mitteln auch weiterhin unter die Arme greifen – und dies sowohl für die Erzeugung von Lebensmitteln als auch für die Pflege einer nachhaltigen Landschaft – gäbe es vermutlich überhaupt keine Landwirte mehr. Manch einer von ihnen hält sich mit regelkonformer Landschaftspflege über Wasser, und das kommt der Umwelt sehr zugute.

Reporter Bernd: Zum Glück bringen die Landwirte ihr Fachwissen in die vielen Arbeitsgruppen ein, in welchen sich immer mehr Bürger zur gemeinsamen Gemüse- und Obstproduktion auf Gemeindeflächen zusammengeschlossen haben. Seine eigenen (!) Gurken, Tomaten, Kartoffeln, Radieschen, Salate usw. aufzuziehen, selbst mit der Familie und Nachbarn zu ernten und daheim zu verspeisen erhöht einfach die Lebensqualität! Du sprachst von deinem eigenen Garten; was pflanzt du dort an?

Passant Bill: Das wechselt natürlich mit den Jahreszeiten. Unsere Gemeinde empfiehlt uns – auch auf ihrem Web-Service - bestens, in welchem Monat wir Heimgärtner welche Früchte säen oder pflanzen sollen, damit auch alles gut gedeiht. „Perma-Kultur“ ist das Grundprinzip, damit wir die wechselseitigen Schutzmechanismen der Pflanzen nutzen und folglich keine Pestizide benötigen. Auch hier haben sich die (ehemaligen) Landwirte zu einem Beratungskreis zusammen geschlossen und geben ihr Wissen systematisch weiter. Man kann sich sogar fachkundige Hilfe stundenweise in seinen eigenen Garten holen! Außerdem - und mit wachsender Freude – beteiligen wir uns an einem der vielen kollektiven Gärten, wie sie schon 2019 in etlichen luxemburgischen Gemeinden (wie z.B. der „Aanwer Gaart“ in Niederanven) ein reges Nachbarschaftsleben bewirken. Auf etwa einem Hektar haben wir uns kleine Beete für eine breite Palette an Gemüse und Salate, Obst und Blumen angelegt; auch Bienenstöcke und ein Gerätehaus haben wir gebaut, dessen Dach wir als Zisterne für Regenwasser nutzen, welches eine größere Tank-Batterie für unser Gießwasser füllt. An einem langen Tisch finden wir uns gerne zu gemeinsamem Picknick ein und planen die nächsten Pflanzungen. - Ja selbst die angrenzenden Schulen beteiligen sich aktiv, nutzen für ihre Schüler eigene Beete; das Maison Relais bringt uns ihre Küchenabfälle zur Kompostierung.

Reporter Bernd: Nun aber zu einem anderen brennenden Thema, den öffentlichen Finanzen. Seit sich Staat und Gemeinden mit dem Ankauf großer Flächen zur Durchsetzung stringenter Umweltauflagen riesige Schuldenberge aufhäufen, stehen für andere Aufgabenbereiche deutlich weniger Mittel bereit. Welche Konflikte ergeben sich daraus?

Passant Bill: Du legst den Finger in eine klaffende Wunde! Denn nicht jeder wollte eine solch radikale Politik mittragen; Populisten bedienen auch heute diese Haltung und suggerieren die üblichen Vereinfachungen aller Probleme: „Wir schaffen einschränkende Gesetze ab, jeder denkt (nur) an sich selbst, Umwelt ist ein aufgebauschtes Thema für Bedenkenträger, usw.“ - Aber so einfach ist es eben nicht! Dennoch spüren wir alle, dass für Bau und Erhaltung von Straßen sowie für kommunalen Transport ausserhalb des Städtischen Gebiets längst nicht mehr genügend Mittel zur Verfügung stehen. Auch die Altenpflege leidet, weil in Sozialkassen Ebbe herrscht; es sind eben immer mehr Alte von immer weniger Jungen zu unterstützen. Und früher konnten Staat und Gemeinden deutlich segensreicher helfen. Jetzt müssen sich Familien und Nachbarn gegenseitig deutlich mehr unterstützen. Ach, da kommt mein hLifter!

Reporter Bernd: Vielen Dank für deine offenen Worte! Guten Heimflug, Bill!

Downsides of this spatial planning practice of rigorous delimitation of investments into the central catchment area that became more evident with increasing ranges of temperatures and weather variability, included all negative aspects of dense settlements including rapid spread of infectious diseases such as regular outbreaks of coronavirus-like viral infections in winter. This risk was exacerbated through the practice, widespread in many households even in the urban catchment area, of keeping one's own chickens or quails in very small spaces. The intention was to be less dependent on purchases of eggs and meat from the unreliably-stocked supermarkets, in which food products were subject to wide price variations.

Those who had settled in the rural areas felt the decline of infrastructures, most painfully probably in the differential municipal pricing of water and in the decreasing drinking water quality in the rural areas in comparison to the urban catchment area.

Some of these investments are also intended to help to build communities with stewardship responsibilities for these ecosystems and innovative ways of living on the land. The communities organise themselves in 'living rural laboratories' which serve both to experiment for regeneration of the biosphere in well-defined areas at the river basin level, and to monitor impacts on biosphere integrity, whether beneficial or adverse.

Impacts of these policies and associated investments and changes in practice are monitored with the help of a new set of biosphere integrity indicators. This builds on Steffen et al's initial ideas but further develops these to include sophisticated material stock flow modelling (carbon, nitrogen, phosphorus

and water) and a local set of adapted biodiversity indicators covering the main classes of animals as well as fungi and bacteria.

Biosphere integrity is measurably on the rise in Luxembourg since the early 2040's: The 2020's saw the onset of extensive forest die-back. Reforestation areas were flanked with permaculture surfaces and forested areas were enriched with heat- and drought-resistant species. Germans and Belgians observed and followed this example in the Ardennes and the Eiffel, such that this broader region developed into one of the most resilient areas anywhere in Europe. To sum up, the Plan Directeur pour l'Aménagement Territorial delivered the successful result that Luxembourg is now net positive in its water and carbon balance, and is keeping the nitrogen and phosphate cycles within the country largely in balance.

2.5. Regulatory reform: Regenerating ecosystems for water and food

In view of the high level of threat of unprecedented and unpredictable annual, regional and seasonal extreme weather events to water and food systems, far-reaching legislative and regulatory reforms were enacted in the two decades between 2025 and 2045³³. Their objective was greater resilience through the regeneration of biodiversity, water, and soil ecosystems. The main achievements include the fact that today, in 2045, over 70% of the country's land surface is defined as a protected area. Two types of protected areas can be distinguished. On the one hand, in EU Natura 2000 zones, some human activities can take place without threatening the pursuit of nature regeneration targets. On the other hand, there are also more stringently restrictive dedicated nature protection zones, the aim of which is to allow nature's diversity to regenerate itself with only very limited disturbance from humans. One third of the land in the North is defined as nature protection zones. There are also wildlife corridors at regular intervals across the urban settlement area, allowing the Eastern and Western protected areas to be connected. By 2020 close to 30% of the country had been declared Natura 2000 zones (see Annex 3 with the map of Natura 2000 zones). How, then, did we come to this substantial change in land-cover, land use and land ownership patterns, in that relatively short period of just over two decades?

One of the first requirements in order to give this regulatory reform traction in Luxembourg was the breaking up of long-established governance practices which subsumed the public interest to private demands in an "old boys' network" of those in powerful positions. A second requirement is a new and more effective evidence-based approach, with improved approaches to monitoring and environmental impact assessments. Where possible these are carried out *ex ante*, before new projects with implications for land use and land cover changes, or water use or emissions, can be elaborated and approved.

A third requirement was the development of stringent and ambitious spatial planning targets (see section 2.4. below), followed by successful measures for their implementation, requiring a regulatory reform. The new Plans Directeurs pour l'Aménagement Territorial that were adopted in the 2030's are set out in section 2.4. Planning goals included:

- the development of 30% of the country's area into a wilderness zone, most of which is subject to stringent protections;
- a 30% local food garden and biodiversity zone (within which some pockets are leased to commercial agricultural activities, including agro-forestry), organised in a manner that is reconcilable with a Natura 2000 area;

- 30% along the Alzette basin is developed into a large dense green urban area in which the three growth poles of Luxembourg (Esch sur Alzette, Luxembourg city and Diekirch/Ettelbrück) have grown together into one green but densely settled urban area interwoven with protected water courses.

The section below first describes the regulatory reform in more detail, before setting out the shift in interpretation of the law *from* defending the individual right to property *to* defending the public interest in terms of environmental regeneration.

Regulatory reform

Whilst politically courageous political leadership was necessary to carry through such changes, this alone was not sufficient. One main driver was the development of policy changes along the same lines at EU level. EU and Luxembourg law on environmental matters have been closely related since the passing of the Single European Act in 1986. Following the summer droughts, the New Green Deal of the EU was also adopted as the main guidance document for relevant policy making in Luxembourg. It not only set up targets relating to a carbon-neutral Europe by 2050, but also implemented the 2030 Biodiversity strategy for the regeneration of biosphere integrity as a central priority. Central measures in the strategy include the provisions of the revised ‘Habitat Directive’³⁴, which established the EU-wide [Natura 2000](#) ecological network of protected areas, with legal provisions requiring the evaluation of human activities in terms of their potential adverse impacts on the environment.

Nationally, a series of legislative measures were taken to reduce the pressure on non-settled land. In the 2020’s and the 2030’s the provisions for government control and decision-making concerning land use and land cover change were further strengthened in favour of environmental protection. The state, as well as municipalities and syndicates, progressively acquired more land for the purposes of environmental and water protection.³⁵ The law of 2018 on nature protection includes a whole chapter on the possibility of “servitudes” and, in case of non-compliance, also expropriations in the general public interest of the regeneration of environmental quality.³⁶ Land areas owned by public bodies were already estimated in 2015 to amount to over 50% of the country (as could be estimated from a quick look at the geoportal when searching for government and municipally owned land - www.geoportail.lu). By 2045 over 60% of the land is owned by public bodies. The church owns a further 15%.

Protection of water quality and regeneration efforts: By 2020 most if not all aquatic ecosystems right across Europe showed starkly diminished species diversity, largely due to elevated levels of nutrient run-off from agriculture and human settlements. The EU Water Framework Directive from the year 2000 is the most comprehensive instrument of EU water policy and was for a long time one of the most future-oriented sets of environmental laws. Its main objective is to protect and enhance freshwater resources with the aim of achieving good quality in EU waters; its scope extends beyond lakes, rivers, and ground waters to transitional and coastal waters. The main tools to implement the Directive are the River Basin Management Plans (RBMPs) and the Programmes of Measures, which are prepared in 6-yearly cycles.³⁷ In Luxembourg, the directive was transposed to a national law on water on 19 December 2008.

The Luxembourg water law was progressively expanded in scope and reach as the state of the water - not only of surface water, but in particular in ground water basins - deteriorated and diverse and conflicting demands on water grew in line with Luxembourg’s population and economic activities.³⁸ The first more far-reaching modifications with strategic regenerative objectives pertained to the establishment of drinking water protection zones around water sources that were adopted in 2018 and 2019.³⁹

In the 2020's, the focus shifted from drinking water protection to the regeneration of aquatic ecosystems and associated ecosystem services. It was considered necessary to declare entire surface water bodies, including rivers and their tributaries, as protected zones with reference to much lower thresholds for chemicals such as nitrates, phosphates and pesticides. This reflected the need to rebuild webs of fragile aquatic and amphibian species (building on Article 20, § 2 of the law).⁴⁰ Furthermore, these areas required renaturing to rebuild entire biotopes in more natural habitats. By and by, all waterways that were linked to or influenced by Natura 2000 zones were declared protected zones.

This caused enormous tensions and debates concerning for example all sewage treatment plant projects, as all plans for enlargement and modification had to undergo a cumbersome environmental and social impact assessment.⁴¹ Within the framework provided by this law, and the increasing provisions for environmental protection, the reorganisation of the infrastructure for provision of water for human uses and waste water treatment in the settlement corridor described in section 2.4 led to more far reaching amendments and the implementation of further regulations. Provisions related to water pricing are detailed in section 2.5 on water infrastructure and use below. The reorientation of public finance towards sustainable development and regeneration had already been included in the coalition accord resulting from the national elections in 2018.⁴²

Evaluation and enforcement

The great success of the system of NATURA 2000 zones, which was maintained for its pragmatic approach, is based on 2 qualities:

- its reliance on target setting to improve the quality of the environment and biosphere integrity;
- the way it subjects to assessment and evaluation all human activities that could potentially interfere with attaining these targets, whether they be urbanisation, areas of economic activity or tourism – and whether they be in the area itself or in adjacent areas.⁴³

A sustainability check was introduced in order to foster coherence between policies, associated measures and decision-making on agriculture, environmental protection and water quality. Environmental impact assessment and evaluation approaches, including indicators and procedures, were completely overhauled. They are geared to assessing net positive regeneration outcomes rather than just taking stock of damages and liabilities (2045).^{44, 45} Furthermore, plans are required to be approved *ex ante*, rather than just before or during implementation.⁴⁶ In these assessments, meticulously calculated impacts on biodiversity have to be calculated and compensated for through the purchase of compensation Certificates; the funds generated enable investments to be made in regenerative activities on dedicated land surfaces. Similarly, any greenhouse gas emissions are costed at 50 Euro per ton of CO₂ equivalents. A wide range of business projects fail this test combining both economic and environmental viability. Today, enforcement is tougher and fines are heavier – before the summer drought occurrences these were mere paper tigers.

Establishing the primacy of environmental protection over private property

Fuelled by food and water security concerns, regulatory decision-making and jurisprudence on property rights pertaining to land and water have fundamentally changed over the last two decades. Environmental protection has gained primacy over private property in policy-making and jurisprudence, as the progressive large-scale environmental destruction associated with over 150 years of industrialisation needed to be reversed. No significant changes in legislation and regulations were however necessary. The underlying basic international legal provisions including the 'Charter of fundamental rights of the European Union', the 'European convention for the protection of human rights and fundamental freedoms', as well as the Luxembourg Constitution and the Luxembourg Code Civil, all foresee the right to property, but also reserve the right of expropriation in the public interest, as long as timely and proportional compensation for the loss is provided. Moreover, the use of

property may be regulated for the public interest. All four sets of fundamental rights have articles on environmental protection. The EU Charter even states the need for the improvement of the quality of the environment, thus explicitly indicating this as a legitimate public interest under the law.⁴⁷

Probably the best case in point was the adoption of the new 'Flurordnungsgesetz' (Loi sur le Remembrement) in 2022, which attributes much higher importance to environmental protection in the public interest.⁴⁸ The proposal for this law was posited to the Chambre de Députés in July 2010. It took well over 10 years before it was finally adopted, after the summer droughts, with further modifications making it even stricter than what had been foreseen in the first decade of the 21st century. When finally implemented, the law required first that an environmental impact analysis is conducted before any other analysis, in response to a request concerning land-use and land cover change. Furthermore, all proposed human activities that entail a land-use and land cover change are now subject to a cost-benefit analysis. This takes into account the cost of CO₂ emissions at a price of 100 Euro per ton of CO₂ equivalents, as well as any reduction in biomass above or below ground in view of their carbon sequestration function, and any impacts on biodiversity.

Sustainable land management is now a legal duty. If an important public interest is at stake, the Minister can take a decision himself, without being required to call for a vote involving the owners. Further significant simplification and speeding up of land-use change procedures was achieved, because the 'national office of land use change for resilience' ('Resilient land use office', or RLO for short, formerly called the 'Office National du Remembrement' in 2019) can now develop its own notary accords.

Furthermore, the Resilient land use office now possesses the competency to develop and administer a "pool" of plots of land for environmental compensation measures that are deemed necessary in view of the goals of keeping carbon, nitrogen and water cycles close to neutral across Luxembourg's territory and to regenerate biodiversity. The office can, on its own initiative, buy new plots to add to this pool and evaluate these surfaces according both to their agricultural value and to their bio-regenerative potential. At first, the pool was built up largely based on buying plots of minor agricultural value.

Since 2025, the Resilient Land-use Office (RLO) started buying all the land that was to make up the permaculture belt around Luxembourg. In the following 15 years it bought close to 70 000 ha around the urban settlement corridor to establish the permaculture belt (this land was owned largely by municipalities, most of which were scrambling for resources to implement river-renaturing projects, build intelligent water storage and allocation systems, and level IV water treatment plants all at the same time). The municipalities were coaxed or volunteered by the Minister of Agriculture to sell the land at reasonably low prices to develop a climate change resilient innovative ecosystem that was amenable to permaculture and highly diverse, as well as drought resistant.

Furthermore, of the 55% of forest in private hands in small parcels mainly in the Guttland area of Luxembourg, the office purchased about 25 000 ha (about half of those areas) between 2025 and 2035, as, due to repeated drought periods, a majority of ecosystems in small forests threatened to collapse. Due to their strategic proximity to the permaculture belt, their regenerative role was now defined to be of national importance for developing a resilient and secure national food system. The Minister therefore took these decisions without very much consultation with the owners. Owners were given the choice of expropriation with some compensation decided by a court, or restrictions on the use of their land. If they agreed to such restrictions, (i.e. no construction, agriculture, tourism or access on paved roads), then they could keep the property. In this case the value of their property would be reduced for tax purposes and financial compensation for the loss of usage rights would gradually be paid out through the tax system. This land would also be exempt from inheritance tax. Many landowners may prefer to go this way in the hope that the situation will change in the long term. Some cases of compensation for expropriation after repeated infringements of usage rights, however, whilst considered 'fair' with regard to the public importance, were considered unfair by some forest owners who made claims in the media that they had been dispossessed.

Over the same decade these government decisions were hotly and controversially debated in the media. (See time witness account in Box 4 below.) Right from the beginning of its extended role in 2022 the RLO gained support from an unexpected quarter. The sister movement of Fridays for Future, 'Ende Gelände', started to engage in the most controversial cases of alleged misappropriation in support of the RLO. Over the next two decades, public debates on ownership, freedom and the commons finally brought about a promise of greater freedom with respect to public property and common goods. More attention was directed to processes for value co-creation and that all who contribute can rightly claim a share in the jointly co-created value (as in subsistence farming on municipally owned land for which one has gained the usage right, known as "usufruit").

The strict separation between urban planning and nature protection from the 2000's that prevented the adoption of so many environmental measures was cancelled. Following the example of some German Länder, the same authorities nationally and in municipalities are responsible for both. This fusion of responsibilities enables a more strategic approach: intentions and plans have to be evaluated at an earlier stage. These provisions entailed further legislative changes, affecting municipal law. A second measure aimed at furthering the densification of existing settlements in the urban corridor was to introduce a national tax on non-occupied buildings and building terrain that is not used for construction.

BOX 8. ISSUE: Changing notions of freedom and property – the basis for a societal transformation

'Letter to the editor, LUXEMBURGER WORT' 15 September 2045

Looking back historically to the times of the signature of the UN SDGs in 2015, we need urgently to draw attention to the question of what freedoms we are giving up in view of the progressive reduction of our rights to control the use, development and transfer of private goods, in particular private land property, and the associated increasing risk of expropriation because of infringements on public restrictions. Already in 2019 in Germany there were initial calls for a public debate to adapt our



understanding of the notion of freedom, including individual freedom, to new challenges with respect to scarce natural resources and the existential mandate to humanity to rebuild resilient ecosystems.⁴⁹ Fundamental rights to self-determination, material self-determination and self-sufficiency are in theory still guaranteed through the universal right to own private (material) property. This used to serve as the basis for the empowerment of individual citizens to sustain their livelihoods, free from paternalistic allocations from the State. This earlier notion of private property was questioned in view of sustainability challenges with a growing world population and hence the realisation of the need for more equitable arrangements of distribution of property and access to it. Rights and responsibilities with respect to private property are increasingly shifted to rights and responsibilities with respect to owning of the shared products from value co-creation processes involved in caring for and regenerating and harvesting nutrients from public land. With increasing public property, more widely distributed access and well-defined usage rights, people have obtained the right to ownership of a share of the fruit of their labours.

Following provisions in New Zealand and Ecuador, it was written in the constitution that nature and its goods of soil, water and biodiversity are not there for humans to use and consume, but that they also retain the right to be rewarded for their contribution to value-co-creation processes from which humans also benefit. As such, nature was also attributed property rights, thereby providing an adequate legal basis for the legal standing not only of future human generations but also of nature itself. The job of nature advocate became very popular in the 2030's. These constitutional changes also provided the basis for introducing a voluntary Universal Basic Income scheme, under which each citizen was attributed a plot of public permaculture garden to care for and harvest from for subsistence.

2.6. Re- designing water infrastructure, reshaping supply and demand

Looking back at design principles for water infrastructures – both water supply and waste water and water treatment systems before the 2030's seem ludicrous today! All water provided to households and industry for all uses was heavily treated - requiring significant energy and material inputs - to drinking water quality although less than 1% of that water was actually drunk or ever came into contact with any human body! Similarly, all used water, regardless of the type of use, was turned into waste water, and even, incredibly, mixed with rain water that flowed into gutters to create waste water streams, then into treatment plants. This meant that all the substances dissolved in water, be they nutrients or chemicals, were mixed together and then diluted, so that, as technologies for nutrient recovery were developed, their removal was made virtually impossible, or at least very inefficient.

In the 30's, along with the radical decision to completely redraw the national 'Plan Directeur pour l'Aménagement du Territoire' to focus ALL development on a central corridor, it was realised that the triple grid system for information, energy and water flows and stocks needed renewal and integration. This included an overhaul of the drinking water distribution pipes - which had been in the ground for over a century - was up for renewal, as were large sections of the waste water pipes. Both circulatory systems were becoming leakier by the decade and constant repairs proved insufficient. Smart planning helped to redesign the national grid system with a central pipe along the Alzette above ground, with main branches off it at strategic places leading to the densest settlements. There was therefore a decision - also driven by the fact that the capacity of the new SEBES drinking water plant was no longer sufficient - to invest xxxx Euro into building a brand-new drinking water distribution system for the corridor, as well as a brand-new waste water clearing system. Both systems had subsystems that could distinguish between the biological and technological cycle.⁵⁰ The energy grid was adapted for more decentralised provision and renewed in view of policy goals for national security and autonomy.

A highly differentiated water network

A focus on the population corridor and on the infrastructure in this corridor made this possible. At the root of these fundamental changes in how we engage with water was the decision to draw a clear distinction between two main categories. The first is 'organic' water consumption, which is related to the health and well-being of people and animals, and includes any water for drinking, food preparation and other ways in which water comes into direct body contact, as well as hygiene and recreation. The second category of water usage is technological water utilisation, for cooling purposes in industrial processes or for washing machines or dishwashers at home. These two fundamentally different needs then formed the basis for designing two different water cycles and processes – one biological/organic water cycle and one technological water cycle. In the "smart growth" mode in the first two decades of the 21st century, the government invested in trams and mechanised mobility. However in the second two decades of the 21st century, following several summers of hard hitting droughts' curbing economic activities, spending was switched to investments in a fundamental redesign and refashioning of the century-old water system, including distribution of water and waste water.⁵¹

The crucial role of water in maintaining the biological cycle is fully recognised in this scenario and human needs are adapted to preserving this cycle. The abstraction of water for technological processes is thus strictly limited and advanced treatment technologies are applied for keeping this water (used e.g. for cleaning, cooling or as a solvent) in the technological loop. The major part of the water abstracted from nature is used for irrigation and food production. Alternative sources have also been developed, with a focus on rainwater capture and storage. The capacity is limited as this is also water abstracted from nature and therefore subject to restrictive regulation. Harvesting depends on metrological conditions and storage and transport capacities are limited.

Treated blackwater and metabolites from anaerobic digestion of biological waste. The relocation of large parts of the infrastructure and the high population density in the urban corridor

have enabled a switch from economically and energetically unattractive centralised (aerobic) wastewater treatment to decentralised (anaerobic) treatments. These allow for production of energy and very efficient recovery of nutrients from wastewater. This means that the nutrient cycle is closed, since these nutrients stem mostly from human faeces and can thus be re-used in food production⁵². This is only possible because policies have been implemented rigorously restricting the human use of antibiotics.⁵³

The adoption of this system alleviated the vexed problem that Luxembourg faced of water shortages and expensive purification, along with limited and slowly-replenishing ground water reserves. It meant that the purely technical circuit could also be serviced with Moselle water for industrial and technological uses. Moselle water had previously been deemed unfit, even when filtering water from the river by drilling deeper boreholes along the river banks. In summer this water would enter the circulation pipes at a temperature still above 23°C and therefore be prone to bacterial contamination; this is however not an issue for most industrial uses.

Reshaping demand and supply to stay within biophysical limits

This approach could then lead to the public offering of water as a service, for which citizens pay according to the quality level of the resource that they are using.⁵⁴

A massive water shortage in 2020 and 2021 sensitised the community and politicians to the importance of water management. Many people, communes and companies became obsessed with managing with the minimum amount of water. This led to a reduction in demand of 10 %, coinciding with an extra 7,000 m³/day (regulator approved) production from existing sources in the space of five years. Rainwater storage became the norm and companies were vilified in the press for high water consumption. Some of these companies, who had only located in Luxembourg for the tax environment therefore relocated to areas where they could use more water without being criticised (+5%). Other, more locally rooted, companies outsourced server farms to Germany. Water consumption per person (including industry) dropped rapidly from 202 l/p.p. to 125 l/p.p. between 2026 and 2035, a decrease of 38%. However, the changing focus on agriculture and the demand for local crops that consume a lot of water during their production (lettuce, cucumbers, tomatoes etc.), together with the drive to bring rivers back to their original state, increasingly put competing pressures on water resources. This resulted in another water crisis in 2032, after which many sources which had long been offline (>25 years) were slowly taken back into production and another 5000, possibly even 60000, m³/day came from the Moselle. (Who wins? Agriculture or drinking water demand?).

Water price and regulation of water use : Several municipalities attempted to introduce differential pricing depending on consumption rates in 2015,⁵⁵ but were denied because the central administration felt this was too difficult to administer and control. After this the introduction of smart metering systems on the household level, combined with artificial intelligence systems, enabled a nationwide monitoring of water stocks and flows across municipalities.⁵⁶ After finding a solution to take account of income disparities and not to impact low-income households, a progressive differential pricing system was introduced by law in a new Règlement Grand Ducal. **In terms of pricing there were three periods:**

2025 – above a certain threshold of additional usage the price goes up proportionally to usage levels; a nationwide smart metering system for water use at the household level makes this possible.

2030 – seasonally differentiated prices are implemented – high cost during summer; this hits industry in particular.

2035 – the infrastructure allowing a circular economy differentiation between biological and technological water cycles is implemented – each of these cycles has additional pipes allowing two

quality levels – and pricing is adapted to this regime and quality level of water used. The days of using drinking water to wash your car are finally over.

Box 9. ISSUE: Water use in households is 38% less compared to that of 2015

- Rainwater capture and grey water recycling measures and targets are set towards ‘passive water houses’ in the building sector, heavily subsidised by the state.
- Private gardens are rated and taxed according to estimated root volumes and biodiversity indicators to contribute to water retention and remediation on built-up land.
- Architectural and urban design relies on bio-mimicry, and nature-based solutions and design.
- Most citizens are engaged in subsistence farming and proof of home production of vegetables and pulses in particular is a requirement for claiming the UBI.

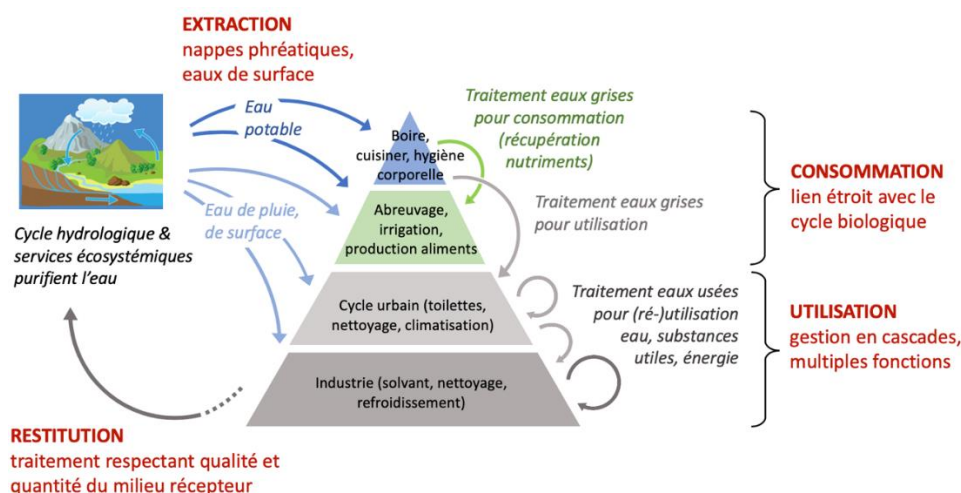


Figure 6. Water management in the circular economy of the web of life. An infrastructure designed to be at the service of the regeneration of life. This approach distinguishes strictly between biological and technological water cycles (Figure by Paul Schosseler first developed for the report for the Administration de Gestion de l'Eau.)

2.7. Transfiguration of the agricultural and food system

Agriculture: It may be hard to believe, but just twenty years ago the EU and Luxembourg were still trapped in an agricultural system with a rigid cage of perverse incentives to destroy nature with farming, rather than reasonable rules and measures. Three years of consecutive droughts then highlighted the impossibility of proceeding with that cage - for farmers, for national governments and at the EU level. Harvest losses, soaring food prices and large-scale farm operations that had to be bailed out of debt to secure at least some continuing agricultural production in Europe, caused havoc to the trade balances and public finances of Member States, as well as to household budgets.

The EU started fundamentally rewriting the Common Agricultural Policy, favouring diverse smallholdings, agro-ecology and experimentation with permaculture, as well as trying new food crops that were heat- and drought-resistant and needed little water. Subsidies were focussed on practices for biomass accumulation above and below ground, to improve the regenerative capacity for cleaning and retaining water in soils, and to enrich soil life to greater depths than had been imagined possible.

Agro-ecology and permaculture practices became highly prized and subsidised, in particular to retain water and prevent soil erosion in more arid and less fertile regions. These practices soon also started to reverse widespread problems of nitrogen deficiency in soils across Western Europe. The quality of the produce became central. There were massive efforts to school farmers in these new practices and to finance conversions of farming systems privately, publicly and with the help of crowd sourcing and community supported agriculture.

The cultivation of maize was however forbidden. The reasons included: methane releases; high demand for water; intensive cultivation practices with high inputs of fertilisers and pesticides; shallow roots, and contribution to soil erosion. Similarly, the drought year's harvest losses finally brought home the message that dedicating fertile agricultural land to growing biomass for combustion into hot air was not reconcilable with sustainable land management in the 21st century.^{57,58}) Luxembourg followed suit.

Before 2020 Luxembourg agricultural policies had already adopted the target of transforming agriculture to 100% organic production by 2050. However this target was already reached in 2045. How could that have been achieved? Several important factors drove these changes; in fact, they enabled a metamorphosis of our food and agricultural system:

Reframing prevailing sets of assumptions, rooted in intensive monocultural practices, on what land can be cultivated with what crops: A new assessment of the human potential to regenerate infertile and lifeless soils given time, quality of attention and care, and the right composting and tilling or no-till decisions.

Changing priorities in agricultural research: Scientific agricultural research focused on better understanding relationships between companion plants in general and covering legumes in particular. Possibilities and limitations to the densification of agro-ecological cultivation were another core topic. Continued improvement of clear guidelines for the spacing of fruit and nut tree species, and frequencies, density and species compositions of passing herds of grazing livestock remains a priority, and has been for two decades. These guidelines also need to be continually adapted to changing environmental conditions and weather patterns over time.

Fertilisation technologies are focused on creating regional closed loops of nutrient constituents, and diversification of fertilisers and precision application of these. Imports of feed and fertilisers were largely phased out by 2045, with a very few small-scale exceptions.

Digital technologies that matter for precision agro-ecology include participatory sensing and monitoring of changes in water and soil quality and biodiversity. These help create detailed agro-maps informing cultivators about requirements of nutrients and natural pesticides, and drip irrigation settings for enhancing carbon storage and diversity of life forms at a resolution of below 1m².

Changing dietary preferences in the resident population in Luxembourg

The environmental and health benefits from adopting a diet based on largely complex and diverse plant foods are now understood by the majority of the population. Food culture and social norms have evolved such that this diet is considered highly satisfactory and enjoyable with lots of room for culinary creativity. This understanding already started spreading in the 2020's. 70% of the population have turned vegetarian, of which about 10% are vegan. Understanding of risks related to ill-informed veganism undermined its further spread in the 2020's among the GenZ. Seasonal changes in diet became a reason to rejoice rather than being perceived as a loss of choice.

Social organisation

Community-supported agriculture built on the difficult first experiences gained from the TERRA cooperative and the Grengé Kuerf initiative, which already started before 2020, with community audits (see also Tattersall, 2010). The result was that production and regeneration activities were split between: a growing farming community and groups of citizens providing secure markets at fair prices

on a local and regional basis; and subsistence farming activities on UBI garden plots in the permaculture garden flanking the urban catchment area.

Urban gardening for subsistence had already been successfully promoted with the LUGA in 2022. Today in 2045, much of life for most citizens revolves around gardening. Over 60% of families have now signed up to the UBI, which requires at least 5 hours per week to be spent in regenerative activities, whether in the city or in the permaculture belt along the corridor. In the cities, the best possible use is made of any 100m² patches, which are densely planted in true permaculture fashion, providing for harvests of over 400 kg produce over the whole year, and for vegetables on average for three adults across the four seasons.⁵⁹ Urban gardens include green façades, roof-tops and former parking spaces. Watercress is favoured for its high vitamin and mineral content; various sprouts, tomatoes, zucchini and bell peppers; growing potatoes and carrots in growing bags on the balcony, as well as keeping quail and chicken are all proving particularly popular these days. Plots in the city garden area serve to grow fruit and vegetables that need more space such as pumpkins...

Changes in cropping patterns and cultivation methods on agricultural land and pastures: Agro-ecological methods and agroforestry practices, with integrated fast-rotation pasture models, have won primacy. The job of shepherding goat, sheep and cattle herds through orchards and agroforestry areas has gained in importance. These herds, that are kept grazing in dense groups for short periods of time on small plots, offer the now highly-valued services of intense grazing and of enhancing soil life through providing manure and trampling this effectively into the earth. Pastures were refashioned to remain attractive to grazing herds whilst improving their services as carbon sinks by enriching plant species with long roots and stem length.

National targets for cultivation of nuts that were set in the mid-2020's were reached in 2045. These included walnuts and other oil fruits, and legumes to provide methionine-rich proteins for more balanced vegetarian diets in addition to their existing nitrogen-fixing services for fertile soils. (WHAT MIGHT THESE BE _ WHAT PRODUCTION LEVELS ARE REALISTIC HERE IF WE SPEAK OF EXTENDED AGROFORESTRY AREAS ALONG THE ALZETTE RIVER BASIN?).

Closing local and regional material flow loops of constituents of organic materials

Here also, the goal is to develop a more autonomous Luxembourg food system through minute attention to closing material and nutrient flow loops. This approach builds on far-sighted models, developed at the turn of the century, for farm gate accounting, aiming for local and regional balances of nitrogen, phosphorous and energy flows (ADD Jean Stoll reference farm gate model).

Changing environmental conditions and the role of and design criteria for technology

The intended use of insect-like drones for pollination services to compensate for loss of insect pollinator populations proved not to be reconcilable with regeneration of complex, diverse and resilient ecosystems. Because they were sensitive to wind, their use was confined to glass houses, controlled artificial technology-rich environments, that only proved adaptive up to a tipping point and were more vulnerable to damage from extreme weather events and the like. Meanwhile, agroforestry practices were aimed at building dense flexible leaf canopies that could better shield surface-near plantings from the more and more frequent tornadoes and hail damage in a flexible and self-regenerative manner.

Missing – soil fertility map and data from soil analysis from 2020- to make decisions on spatial arrangement of cultivation and the need and intensity and possibilities of regenerative practices in the extended food garden area flanking the urban catchment area.

Seasonal food deficits and food trade

Early in the 2030's food wars started and the Chicago board of trade of grains and other global food commodities had to close down. This made room for a new food culture without reliance on food commodities. Luxembourg made a bilateral trade pact with South Africa and two other smaller countries in the southern hemisphere to give each other precedence in trading with foods during

periods of seasonal or drought-affected scarcities. South Africa, having been inflicted with serious droughts and water scarcity since the turn of the century, had by the 2030's developed a vibrant, highly diversified and resilient quasi-autonomous water and food culture that again drew heavily on traditional knowledge from ancient tribal wisdom. Luxembourg became seasonally, during spring and autumn, a net exporter of high-quality cow, sheep and goat cheeses and meat products, and value added products like cheesecake - and also of preserved fruits and some vegetables, although to a much lesser extent given that 70% in the population were vegetarians.

Meeting the challenge of food production in summer drought periods: Drip irrigation systems have become the norm. Agro-forestry uses drought-tolerant plants, some of them genetically modified for drought tolerance. These drought-tolerant plants include some sterile large trees like the Tamarind, which it is now possible to cultivate here, partly because of the shortened hydrological winters.

The standing of the farmer in society

All in all, farmers and shepherds gained hugely in prestige and standing in society, as the population finally became conscious of their enormous dependence on these caretakers of the food and water system in all its dimensions. Risks related to farming in the face of extreme weather events and droughts were spread through solidarity farming funds and between 2025 and 2035 crowdfunding helped farmers to transition to agro-ecological practices. There was a lot of trial and error, but the insurance industry developed specific farmer-friendly packages cross-financed from insurance plans for other sectors of the economy, out of recognition for the existential role of farmers in the 21st century.

2.8. The economy: From productivity targets to regenerating nature

Labour is no longer an economic commodity, but people seek intrinsically meaningful occupations that are not dehumanising. Fast fashion is out of fashion... Any hour of labour spent should be a significant investment of time beyond the mere interests of humanity. Given the scarcity of qualified young labour, those who seek employment have much more leverage than in the 2020's, where youth unemployment was a growing problem.

Accordingly, today in 2045, economic development in terms of production of goods in Luxembourg is organised around the principle of maximising resilience against changes in water access during the summer months. Development policies draw a clear distinction between **urban and rural resilience, biodiversity regeneration and climate change-adapted economic development**. The greatest importance is given to rural economic development that emphasises particularly the goal of regenerating biosphere integrity for national resilience, above economic productivity or growth. There is no GDP growth (0%), and productivity measures from the turn of the century are no longer thought of as relevant to the situation in 2045, as explained in the following section on the economy.

The underlying principles for all economic activities are an excellent understanding (thanks to research) of material flows in the biological and technological cycles (C2C approach), as well as inspiration from natural processes (biomimicry). Industrial production is now regulated seasonally, largely because of seasonal water price variations – the price changes significantly in the summer months when water is scarce.

AI is very present (and has contributed to the waves of unemployment), with the following consequences: capacity to monitor closely the state of ecosystems and in/out material flows; highly automated and efficient production of technological goods, as well as services (e.g. linked to data), thus enabling the financing of a UBI through taxes; local production and repair capacities, e.g. through 3D printing.

The economy relies heavily on locally harvested resources, with the following distinctions: natural resources, mainly for food production and some fibres; national natural capital was deemed too low to invest in much renewable bio-building materials, particularly as food prices skyrocketed. Technological resources remain available through intense urban mining and reuse of resources in the technological cycles, e.g. in the construction sector.

International trade is restricted to high value goods, due to integration of externalities in the prices for freight transport (e.g. high fuel prices). High value goods include some natural products such as coffee, tea or cotton (which cannot be grown under European climatic conditions). Other exports such as dairy products or wood are strictly limited, due in part to an increased awareness of the value of natural products and balanced nutrient cycles. A Trade Related Environmental Tariff regime focused on nutrients, mainly phosphorus, was implemented. In view of an anticipated phosphorus peak⁶⁰, in the early 2020's Morocco simply stopped exporting phosphorus for production of fertilisers, but issued bonds which were used to invest in a very efficient phosphorus recovery industry, not only in Morocco but also in Europe. Countries such as the Netherlands,⁶¹ which had already anticipated this issue, set up strategic collaborations with Morocco, in view not only of better technologies for recovering phosphorus, but also a global regulatory and financial framework for phosphorus balance sheets at national and international level, supported by China (another major phosphorus producer) in a second phase. In the end these balance sheets were integrated as a key measure into international trade agreements for natural raw materials and products.

Many production-oriented industries decided to adopt strategies aiming at qualitative growth and value added rather than quantitative growth. The same holds true in agriculture with many value adding activities being integrated back on the farm, such as dairy production with the help of immigrants and climate refugees. Some water-intensive industrial production facilities have seasonal limits of operation, such as the Greek yogurt producer and global exporter, which only operates between November and April, as the operations were relying on milk powder imported from China.

To sum up, the main pillars of economic activities remained; the financial sector and ICT still produce most of the fiscal revenues. **INSERT estimates on earnings from green finance and ICT sector, tourism, and eco technologies** – what does Luxembourg export? Value added that is not as water intensive as dairy... The knowledge economy has been transformed thanks to skillful design for effectively combining human intelligence with the technologies of machine learning, natural language processing and robotics. Google, the banks, and the “Big Four” have chosen to stay in Luxembourg, as regulatory reforms in the US and elsewhere in Europe are similarly tough, and setting up new or expanding existing headquarters is increasingly becoming a choice between a rock and a hard place. The services they offer are important to Luxembourg's decision to offer a high UBI.

However one major economic problem that has not changed from the 2010's to 2045 is that a highly-qualified work force for the green financial sector and ICT still needs to be attracted from outside Luxembourg. The high wages have had further adverse impacts on rental prices.

AI transformed the job market: This was particularly true of medical and caring services, negotiation based jobs including lawyers, and regenerative jobs unsuitable for machines. In the construction sector demand for manual labour has been minimised through the use of increasingly sophisticated Lego-element-like building blocks. However, increasingly nature-integrated buildings require gardening services and regenerative tasks on green façades and roof structures.

The following section considers industrial activities and activities of the knowledge economy in turn.

Industrial production - Sectoral activities⁶²

Food sector: Sustainable food production for covering the needs of a large part of the population is a key pillar of the economy. However agricultural practices focus on healthy soils as well as closely monitored and well-equilibrated water and nutrient balances. A high level of food self-sufficiency is made possible thanks to the choice of a large proportion of the population to live on vegan dietary regimes or strongly reduced meat consumption. All organic waste from food production or residues is collected and recovered directly for composting or indirectly (e.g. blackwater) for anaerobic digestion, with a view to maintaining a healthy soil.

Water use legislation is now very restrictive. Water consumption for economic activities is very much oriented towards agriculture, using water-saving techniques such as AI-controlled drip-irrigation. Abstraction of water from rivers or groundwater bodies is strictly controlled and limited. Alternative sources for irrigation are also common practice, with a focus on rainwater (stored in large permanent or temporary tanks⁶³), but also treated greywater and black water (see water section).

Insect farming based on plant waste as a new industry: alternative proteins source for humans and animals (fish, chickens), as well as some raw materials for industry (e.g. dyes, natural cosmetics). In the same line of thoughts: algae production.

Food processing industries in general were phased out in Luxembourg, due to their water intensive nature and skyrocketing basic food prices. Living 'hand-to-mouth' became very trendy again, trying to outcompete your neighbour in cultivating your own very green veggies and red berries. Greek yoghurt is not compliant with strict regulation on phosphorus balance sheets, leading to higher taxation and reduced production.

Construction sector: The construction sector, including the industries providing raw materials such as concrete and steel, was already well developed in the early 2020's. A range of regulatory and financial measures, based on the Government's priorities for supporting the circular economy, became the basis for building up unique competences in designing "circular" buildings and boosting a market for recycled and reused building products and materials.

The concept of BIM (Buildings as Material Banks) was supported by advances in ICT and AI, existing know-how in confidential data management and storage (Tier IV data centres), and financial engineering. The limited availability of natural construction materials such as wood, the presence of strong industries active in steel and concrete, but also the renaissance of Luxembourg Sandstone as a building material, together enabled the development of a highly competitive "primary and secondary raw materials" construction sector, supported by focused research and innovation efforts at the University of Luxembourg and LIST.

These innovative construction approaches were boosted through public procurement procedures for the large infrastructure projects in the economic and urban central areas.

Tourism and HORESCA sector: Luxembourg is a unique laboratory, with international visibility, for subsistence farming and permaculture. Furthermore large parts of the country have been integrated into the Luxembourg National Park (similar to the Swiss National Park, with practically no human intervention) and have now become part of the UNESCO Biosphere Reserve. This combined tourism infrastructure based on healthy and meaningful living and leisure activities attracts high-value generation Z tourists.

Manufacturing industry: In a manner analogous to the construction sector, a competitive expertise in maintenance, repair and refurbishing services has developed, enabling the prolongation of the useful life of materials and products in the technological cycle. This includes innovative welding techniques,

e.g. for plastic repair⁶⁴, 3D printing, etc. These activities are supported by higher workforce availability because of the UBI (as for the construction sector).

The logistics sector, which was being developed fairly successfully between 2000 and 2020, experienced setbacks due to increasing and harmonisation of fuel prices and environmental taxes across the EU. For example this was a big blow for Cargolux, as margins no longer permitted shipping fruit and veg across continents (in 2045 the old practice of having mangos from South America stopping over in Luxembourg on their way to China is ancient history; at best it causes some sorry grins). The same was true for the road transport industry, which stopped rerouting its lorries through Luxembourg. CFL secured a role on the Chinese silk road under the condition that it would monitor against food exports from Europe to China.

The knowledge economy in the urban corridor

GDP and employment, and the UBI and earnings: Urban economic development in the ‘Economy-corridor/Wirtschaftskorridor’. In the urban zone economic growth remains a primary goal, priority areas for economic development are Green and Impact Finance, building on the early establishment of the Green Exchange, the ICT industry and the development of eco-technologies.

Urban economic development and economic productivity as it was historically conceived of and measured in 2015, is confined to a narrow corridor from the three country-corner with borders to Belgium and France, through the capital and centre of Luxembourg up to the border with Germany close to Trier. Priorities in this part of the economy have changed since 2015.

Unemployment: There were two waves of increased unemployment: firstly as white-collar jobs in service industries such as accounting, audit and banking were largely replaced by learning machines; and secondly when, as a result, leading multinational accounting and financial services firms closed their operations in Luxembourg, leading to massive dismissals. The public finances were hard hit by having to pay significantly increased unemployment benefits in those periods. Public policy responses in the EU institutions and most EU Members states introduced improved measures for worker protection guaranteeing access to retraining to keep pace with technological change. Several Member States introduced a Universal Basic Income, led by Finland and Ireland, which was financed from taxes levied on mainly machine dependent services and transactions. In Luxembourg, the ADEM introduced clear differentiations in rights and responsibilities between the resident and cross-border unemployed people, and developed a special care and coaching for empowerment programme for unemployed resident youth.

Several super-laboratories were funded from public resources to offer to researchers and SMEs the computing capacity necessary to develop AI algorithms and process data sets. These included those dedicated to learning systems monitoring and improving biosphere integrity - combining citizen science and geospatial data on water quality, land degradation and biodiversity. Now, as the distinction between workers and service providers became increasingly blurred, social protection was shifted from the labour contract to the individual.⁶⁵ At the EU level the possibility was offered of opening a European personal account. This was linked to national personal accounts and was in part financed by a general social contribution levied on all services provided through platforms, while traditional social contributions also continued to be collected. A board was created at EU level to monitor against discrimination.

Furthermore, firms that were global leaders in the ICT sector, and that had settled regional headquarters in Luxembourg, decided to stay and grow here. They faced a fairly level - if harsh - playing field across Europe anyway, and were attracted by the relatively high quality of life and excellent conditions to raise children. They also benefitted from the expert hub of the Interdisciplinary

Centre on Security and Trust of the University of Luxembourg. As Luxembourg started to apply taxes of up to 80% on services provided by machines with minimal supervision, these tax revenues were dedicated to contributing to finance the UBI. Luxembourg implemented the Universal Basic Income in 2028, taking advantage of its first-mover status to offer very attractive conditions to set up business. In the previous decade it had attracted the Europe headquarters of a large internet platform provider, and that of the largest multinational web-based sales platform in Europe, thus helping to secure a financial basis for the UBI. (Check orders of magnitude of expected revenue vs expenditure on UBI and how else it might be supplemented).

There are two main areas of tension undermining this whole welfare model: Tensions are high between the EU and internet platform corporations that are threatening to leave the EU altogether (their machines learn mostly in other world areas with less restrictive data privacy provisions). It is also becoming increasingly difficult to justify taxation in the firms' headquarters location, as opposed to where its services are actually delivered.

Environmental taxes on firms and households particularly target water consumption and land uses that are not amenable to regenerative practices. The environmental taxes also help to finance the UBI. This is reasonable as, in order to claim the UBI, citizen have to provide proof of participation in permaculture and other regenerative activities, particularly in the summer months during the drought.

Definitions of 'economic productivity' have changed substantially between 2015 and 2045. The biggest change is that weekly working hours for all who receive the UBI are fixed at 40 over the winter - from November to April - and 20 hours over the summer - from May to October. Semi-voluntary work that has to be proven in order to collect the monthly UBI is now labelled as 'UBI-related productivity'. It includes subsistence farming, medium-scale food preparation and preservation, regenerative work in forests and the permaculture belt around the corridor, and voluntary work on farms in the river basins. Salaries and pensions are lower than in neighbouring countries, helping to explain the reduced numbers of immigrant applications, and public finance is precarious.

Green finance

The reorientation of the national budget towards the United Nations Sustainable Development Goals was already clear in the 2018 coalition agreement.⁶⁶ The public sector started working with the financial sector in a targeted manner to develop measures and instruments, private and public, in order to fund sustainability initiatives and measures.⁶⁷ The transformation of the energy economy and the regeneration of water resources have been priorities ever since.⁶⁸

Whilst many banks had to downsize, and some left Luxembourg, the Green finance sector and the Green stock exchange that had been set up as early as 2015 were thriving here, also thanks to very positive synergies with the European Investment Bank and Fund and access to its expertise in impact finance and green finance.

In the 2020's, cross-sectoral funds that take into account Environmental, Social and corporate Governance (ESG) criteria, applying positive and negative screening strategies, remain the biggest category of sustainable funds, with €423.3 billion of assets under management in Luxembourg (Luxembourg Sustainable Finance Roadmap, 2018). Empirical evidence demonstrating the effectiveness of financing for sustainable development in terms of measurable performance was scarce and hard to come by, and in some cases difficult to interpret (Clark, 2018). In the 2020's it became clear that there were fundamental problems with ESG indicators, as developing such comprehensive data sets is extremely expensive. The lack of reporting standards or agreed audit methodologies is one problem. More fundamentally, managers or fund recipients with more traditional expectations do not usually expect to see any immediate direct gains from dedicating time and resources to ESG reporting practices, in particular not in the short term. In such conditions, the focus

on quantification of social development and well-being, when these measures are arguably not well quantifiable, can often create wrong incentives.

“Whilst top-down green finance initiatives that remain anchored in the capitalist growth logic have the potential to shift large volumes of funds into the domain of green impact investments, the bottom-up/grassroots approaches of local businesses can create a whole range of new ideas for conducting economic activities in local environments in a more just way.” (A transformation of the current economy away from “resource-intensive growth and profit-maximisation logic through new forms of organisation, cooperation, product design and ways of distribution” is closely linked to the pragmatic re-design of the current finance system to support sustainable economies).⁶⁹

The Forestry and Climate Change Fund (FCCF) the B.A.U.M. Fair Future Fonds (BFFF), an equity fund that invests primarily in small and medium sized companies initiated by the Bundesdeutsche Arbeitskreis für Umweltbewusstes Management e. V. in cooperation with the Green Growth Futura GmbH served as models to develop and scale up finance for regenerative practices of water and soil ecosystems we depend upon. Both models were already started before 2020 and share a vision of inclusive sustainable economic activity in an ecologically effective, economically meaningful and socially just manner. Whilst the FCCF enables access to responsible financing sources for local actors and supports the development of viable enterprises and giving different types of investors the opportunity to invest, the BFFF is a traditional equity fund and invests in selected stocks of companies which use resources so carefully and gently that the earth's ecosystems are not damaged and their regeneration capacity is maintained.

Other interesting examples exist of successful crowd-funding platforms that were started in Germany and in Luxembourg, with aims including building resilient food systems. Regional Wert AG is an early example of bottom up investment endeavours by citizens for citizens with regenerative goals.

3. Critical features of this world

This scenario was developed based on the identification of a few critical seeds for change that started to become more notable around the year 2020.

A first seed of change concerns global environmental changes that cause severe stress and eventual collapse of the global food system, triggering a food crisis that presented one of the ‘game changers’ in the scenario. Food prices soar ever quicker (the average proportion of income spent on food has already been increasing rapidly over the past decade). Increasing areas of the world suffering summer droughts, together with further ecosystem collapses - including farmed ecosystems - and losses of ecosystem services for food cultivation; all of these together become an existential threat in most world regions, including in most of Europe and Luxembourg.

Accordingly, the whole political and societal focus is concentrated on approaches to land cultivation supporting the regeneration of biodiversity in combination with producing food. These include new approaches, inspired by nature, to livestock herd management, agro-forestry and permaculture, as well as urban farming in groups and by individuals. The new European Commission’s Green New Deal places at least as much, if not more, emphasis on regenerating biodiversity, ecosystem and water quality, soil and reversal of land degradation as on combatting climate change... The war on carbon was a technological one, this new societal priority mandates mimicry of nature.

A second seed of change springs from information and communication technologies and mobile devices offering unprecedented interconnectedness of global citizens. A new approach

to previously unmeasurable policy goals of biodiversity regeneration, land degradation and water quality mandates citizen science and the involvement of the whole population in a variety of new kinds of activity. These include experimentation with regeneration of diverse life forms where feasible, as well as the monitoring and sharing of impacts of one's actions, combined with societal learning networks and events designed to evaluate what works, when and how - and what may have unintended adverse impacts outweighing the benefits realised. Already in 2019 The European Commission Directorate General formally instructed EUROSTAT in a meeting to consider building up non-traditional data sources such as citizen science, in order to produce empirical data for use in official statistics, accounts and indicators on the changing state of the environment.

A third seed of change was the growing dissonance felt in society between, on the one hand, people's lived experience of an increasingly unstable and deteriorating environment and, on the other, the kind of behaviours encouraged by most employers and by design logics in the built environment and infrastructures. These behaviours prompted certain types of action over others - consider the absurdity of all citizens and cross-border commuters pulling a toilet flush three times a day in periods of serious droughts. The second dissonance of social norms and moral preferences was expressed by youth movements in the 2020's. This was about the blatant intergenerational injustice, which kept on increasing until a new generation of leaders felt legitimised to take drastic measures. These included the overhaul of the entire welfare (and pension) system, including retro-active changes that forced redistribution, ignoring past commitments that were now felt to be too unjust.

In developing this scenario, several critical insights were gained that the working group recommends as important considerations for sustainable policies and practice on how we engage with water and land in the future. Some points are raised, but not elaborated in the scenario, as they were not considered directly relevant to the main purpose. Finally, the scenario also highlights some key challenges we may face in the future. All three aspects are considered in turn.

3.1. Main insights gained

First, Luxembourg's resilience to accelerating global change directly depends on resilient, diverse and healthy soil and water ecosystems. The more dense and diverse is the web of life that pervades them, the more resilient will Luxembourg become. Insect drones and farming robots will not give resilience – they may need glass houses and push further the kind of on-farm developments that undermine resilient ecosystems further and bring us closer to collapse. The scenario also clearly demonstrates the interwoven nature of our food and water system, not only in terms of obvious relationships (eg we need water to cultivate food), but also in terms of biodiversity. Policies must not only get better at anticipating the possibility of a food system collapse that would have direct implications for water stress regionally and locally, but also take account of the needs for healthy water and soil systems in terms of biodiversity, to maximise ecosystem services that we derive from them. The primary limiting factor to resilience will be water – we are very dependent on rainfall, but preferably not as part of extreme weather events, in which case it simply washes rapidly and straight through rivers into the sea.

Water is highlighted as one of the primary factors that is starting to limit economic development on a regional and seasonal basis, as Luxembourg's continuing development comes up against the limitations of the biophysical carrying capacity of its territory.

The scenario also highlights the potential of rethinking prevailing approaches to food and fibre production in order to place as much value on the regenerative effects on managed ecosystems to make them diverse and resilient, as on the actual food and fibre crop yields. Furthermore, the promise and possibilities of cultivating food in the city in combination with nature-based water solutions – to cope with heat amongst other issues – are put in the spotlight. Such solutions are important not least because they will limit potentially large health impacts and strains on the public healthcare system from summer days over 40°C. Design against heat islands in cities is already becoming crucial now, because they risk becoming deadly for the elderly and for babies in a context of high temperature fluctuations in summer.

Secondly, the scenario also clearly demonstrates the interlinkage of society's understanding of national identity and borders, spatial planning principles, governance structures for citizen engagement, power distribution and how we define progress in relation to science and technological development. Luxembourg's small size, which makes it akin to a city-state, in an era in which governance of cities proves much more nimble in fostering true engagement and resilience measures compared to nation states, proves to be of definite advantage. The national government and administration starts to act more like a municipal government, in close cooperation with citizen councils, and with the Chambre (parliament). In an era in which nation states may no longer be the most effective level of governance in global multi-level governance systems this proves to be a definite advantage. Occasional transversal thinking across all these diverse policy realms is necessary. The scenario also highlights the clear limits to the free movement of capital in the EU: Links between land ownership, interpretation of laws in relation to uses of property, and climate resilience. (*This paragraph appears repetitive – SN*)

The governance challenges and approaches to solving them (each with its merits and limitations) are set out. Governance is organised to address the primary concern of how truly to engage citizens in regenerative activities through self-motivation and learning about the state of the environment they depend upon. How can we imply and interconnect as many minds as possible in participatory sense-making and action in a rapidly changing world? The main approach of this scenario is to harness the full potential of a networked society by both designing citizen science systems based on the use of mobile devices, and applying co-created measuring and monitoring approaches, as a basis for societal learning in which all who so wish can engage. This method will clearly only work if technological and virtual networks are complemented with excellent social networks - and the real workshops and meetings needed for good communication about uncertainties and the real meaning of data (date points, data sets and data in databases) in a learning by doing approach.

Thirdly this scenario demonstrates the intricate intertwining of design principles for technological innovations, in particular of information and communication technologies that structure the way we interact and gain access to services and resources, within the prevailing social order and social norms. Digitalisation for nature regeneration places more weight on responsibilities to feed environmental data into common pools rather than human rights related to data. Privacy is a concept of the past. Artificial Intelligence is designed with the goal of creating hybrid super-minds that are networks of machines and human minds. In these, machines may do pattern spotting but decisions are taken by human actors who negotiate the meaning of the patterns seen in machine-processed data *in the light of* their experience and sense-making of actual living conditions. After 2030, advances in artificial intelligence are thus also designed in order to make the Universal Basic Income work.

Similarly in this world, care is taken to design intelligent water systems in such a way that when decisions on distribution, treatment and regulation of access are required from these hybrid super minds including both machines and humans, it is actually humans who by default take the ultimate decisions. Human judgement and deliberation in groups and councils is important, decisions are no longer based only on abstract quantities calculated by black-box computer models.

3.2. What is not addressed

Attention was paid to complex systemic interactions between societal transfiguration, technological design and behaviours it makes us enact, and changes our environment – built and natural. In addition, emphasis was placed on illustrating the interplay between a new sense of purpose, power distribution, new emergent social norms, and infrastructures and behaviours with how we engage with water and land. In consequence, not all issues mentioned are addressed in adequate depth to necessarily ensure their plausibility.

Redressing intergenerational injustice: For example, in thinking about the emergence of this new society with its new sense of purpose, we decided not to describe in more detail what were the legal and real-life repercussions of fundamentally changed pension plans. Some of these changes had to be made retroactively in such a way that former contractual commitments were not honoured, bringing the possibility of litigation ensuing from this, as well as possible social upheaval and tensions. Not only would laws need to be changed; huge outcries at this entirely new form of intergenerational injustice are to be expected if such drastic changes are ever introduced. Some would argue that this needs to be done sooner rather than later – and raise the question of whether this is another form of intergenerational injustice or just a poor first step to redress the much more profound injustice of the Raubbau by those in power now of the natural resources on which future generations also rely.

Restrictive immigration policies- but how? A second key issue, immigration, also relating to equity, was not explored in further detail. But fundamental policy changes were mentioned and necessary to make this scenario work. On what basis are climate refugees accepted into Luxembourg? Probably based on their level of education and/or wealth. How are streams of refugees kept out?

Public vs private ownership of land, pricing, and affordability of real estate: Third, we have not considered some aspects of the economy and business that are important in Luxembourg today. For example, questions were neglected concerning the relations between increasing public ownership of land, land pricing, and at what level salaries are paid - and who might in the end be able to afford to settle in the urban catchment area ... Similarly, in the economy, numbers of employees, levels of salaries etc. in the new green financial sector and ICT service providers, were not calculated with any precision.

Health: Fourth, there are a couple of health issues that are hinted at but not attended to in greater detail: The heat waves: we really just touched on the issue of an ever-increasing number of days in summer with temperatures above 40° Celsius. In cities that are designed without air conditioning... The majority of buildings remain fairly badly adapted to high temperatures, as they lack appropriate built-in design measures (such as were found in old Arabic architecture). What are the health repercussions? How might this even affect average life expectancy? This might have significant repercussions, and cynics might call this a welcome additional natural selection pressure tending towards the survival only of the fittest, another source of substantial savings compared to what is currently a huge burden on the health system.

Furthermore, how can a health system really work without antibiotics, what are the real repercussions on the risk of flu pandemics, and on life expectancy (particularly in the dense urban catchment area)? And to what extent would all these water bodies cared for and extended within and beyond the urban catchment area, the food gardens, and the wilderness, and the targeted regenerating insect populations everywhere, contribute to the spread of diseases from insect vectors?

Substrates for cultivating biodiversity and foods: Last but not least, as we consider changes in our natural environment, perhaps the most significant neglect to date (we might fix this in a future version of this working paper) is that we have not yet included a map with soil analysis on areas that are amenable to agroforestry practices and agro-ecological practices. From experience of gardening, one might assume that these practices are in principle possible everywhere; what might vary is the number of years taken to regenerate the soil with life and roots and compost such that more drought-tolerant plants can survive the tough summer months.

3.3. Challenges

The scenario highlights significant challenges for some aspects of society and the environment that have emerged in this constellation of interactive and self-reinforcing dynamics of changes in social norms and values, technology and the environment. Many of these attributes appear at first sight desirable for sustainability. However if driven to their extreme, without checks and balances, deeper questions about sustainability are raised again...

One shocking but scientifically well-argued and seemingly well-founded concern and challenge the author of this scenario came across is that **for resilient biodiversity regeneration in these times of accelerating global change, working with endogenous species may not be enough**. This was a huge revelation from diving into most recent studies of ecosystem integrity in the face of more turbulently changing weather patterns. How can we import exotic drought-tolerant or even drought-resistant species into establish balanced webs of interdependent life in local ecosystems? That is perhaps the hugest challenge we face.

A closely related challenge is the time required for regenerative practices to take root in nature, in particular on poor and/or depleted soils. A related social challenge is then the incredibly large amounts of human working time needed **to rebuild resilient ecosystems on a large scale**: One major challenge that hauntingly pervaded the writing of this scenario is the consciousness of how much time and accumulated experience it takes to make new life forms grow in areas that have been depleted of a rich, resilient ecosystem and have a nutrient poor soil. What society, and, possibly, what form of welfare system, will allow people's time to be freed up so that enough of them can engage in this chore in a sustained manner? And who are all these people who will spend substantial amounts of their time on such chores? This scenario makes the assumption that caring enough to act will be tied in some way to a sense of belonging and that an approach would thus develop such that all residents are invited to assume this duty by signing up to the UBI. And that then the nature of the work self-reinforces the sense of purpose and fulfilment from doing it. But how does this start? How can people be brought on board? And what training can be organised at a national level, available and accessible to all, to help to avoid the most basic mistakes?

Barriers to market entry from internalising externalities vs. locally driven regenerative design: In terms of business models, it is clear that Certificates for CO₂ emissions and biodiversity, water quality and land-degradation impacts will make most new business projects unrealistic. In particular if

permission are granted only based on ex-ante impact assessments, this will become very restrictive. Moreover, such high technical and administrative hurdles to establishing a new business, presenting significant barriers to market entry, will very much favour large international players that already have a production facility. This is also why these barriers could be established so swiftly if the large global players lobbied for them. What forces in society might then support locally adapted innovation and experimentation? There is an unresolved contradiction here: who is given power by the system and what is needed for 'regenerative' design, eg on the market?

Freedom vs serving the needs of ecosystems: Governance is quasi "eco-Stalinist", the central national administration and its bureaucrats play an important role in policy making and allocation of resources. There are however innovative approaches to informing decision making in this social democracy with citizen councils, members of which are chosen by drawing lots, and who can call on citizens' assemblies to propose recommendations on measures and actions on specific topics. Citizen science-based participatory sensing of environmental change and human impacts on it open new windows of accountability. They allow a more democratic approach to policy impact assessment and evaluation compared to the pure technocracies of old. 'Freedom', especially as associated with 'private property' is not the same as it was in humanist or neoliberal ideologies. Teachings about the limits of human agency in a web of diverse life forms, in which our intentions and actions are inextricably entangled with changes in society, technology and the material and natural environment, and on the need for humility and uncertainties in all we know, are starting to undermine individual capacity for critique. This is preparing the ground for a new form of ideological totalitarianism – eco-Stalinism. Property does not have the emancipating value it once had... does this foster a culture of dependence – what repercussions does this have on the flourishing of human character and on values in society?

Immersed contemplation of seemingly unlimited and interconnected possible life forms and the nurturing of a critical human spirit: Another main challenge is akin to one of the brave new world's challenges so aptly described by Aldous Huxley in his novel. There is an inherent tension between on the one hand subsuming the interests of humans to that of regenerating complex webs of diverse species as an existential need, educating for that and spreading meditation practices to develop a quasi-religious sense of being part of a greater whole, and on the other hand stimulating the human individuality and critical reflection required in a learning society and a societal system perpetually probing for new and improved self-organisation to become even more resilient. The strong redistributive role of government will give those in those jobs much more power to call the shots than the others... who find themselves engaged in lifestyles that tend to stifle critique...

In sum, keeping in particular these challenges and possible unwanted side –effects in mind as we enter the next decisive decades will hopefully help developing flexible and nimble policies well-adapted to a world in turbulent change with foresight.

ANNEX I. The scenario in figures

Disclaimer. Prognosis and modelling over this time frame are deemed impossible given huge uncertainties and the possibility and arguably even the need for disruptive events, and innovations as well as tipping points and thresholds that might be exceeded making todays more predictable environmental processes unpredictable.

These figures are just assembled from best available professional prognosis today paired with the development pathways that have been picked out for the purpose of this scenario, to complete the picture.

The world in 2045 in figures.

Radiative forcing in 2045 (W/m²)	4,5
Geopolitics – Intergovernmental Cooperation	+ (Fair)
Global population and migration pressures	8,5 Bn + (Climate refugees)
Urbanisation	65%
Illiteracy	5%
Economy	
GDP (10 ¹² \$2005)	250
GDP/capita (10 ³ \$2005)	30
Gini Index	0,4
Landuse (10⁶ ha)	
Cropland	200
Pasture	100
Forest (Reduction since 2005)	-70
Other (Reduction since 2005)	-200
Energyprices	+++
EU – cohesion	+ Focussed on environmental policy due to environmental crises
Technology and Innovation Artificial intelligence and machine learning	EU und Staat setzen sich für Ethik in technologischer und sozialer Innovation durch frühe Bürgerbeteiligung ein. Individuelle Freiheiten werden eingeschränkt.

* Werte in Anlehnung an die Erstellung von globalen Entwicklungspfaden im Rahmen des IPCC (Riahi et al., 2017)

Facts & Figures. Luxembourg in 2045.

Bevölkerungspolitik und Anzahl**	800 000 25% > 65 years 60% 16-64 Jahre
GDP Growth**	0%
Productivity	
Jobs	600 000
%Cross- border	

commuters	40% cross-border commuters= 250 000
Working hours	30 hours/week is the annual average- there are seasonal variations: 40 h from November – April; 20 h from May until October)
Nationale Akteure mit Macht	Ministries and citizens
Interkommunale Zusammenarbeit	+++
Well-functioning national Networks**	Water, Energy,
Landownership and use**	70% of the surface is owned by the national or local government – most surfaces outside of the growth corridor have usage restrictions for regenerating ecosystems on land and in the water
Nationale Besteuerung	Important environmental taxes and taxation of services by learning machines help to finance the Universal basic income

ANNEX II. Regenerative sustainability for resilience: Measures and monitoring for social learning

After a decade of critical analysis of environmental impact indicators and impact finance practices targetting environmental protection and climate action, it was finally decided that Biosphere integrity and regenerative measures can only be monitored and made sense of at the local level or municipal level, by investing into communities that provide stewardship services and innovative ways of nurturing biodiversity and labour intensive and extensive uses of land and value co-creation models that are reconcilable with biosphere regeneration, such as perma culture. Accordingly, impacts of these policies and associated investments and changes in practice are monitored with the help of a new set of biosphere integrity indicators that builds on Steffen at al.'s first ideas but further develops this to include sophisticated material stock flow modelling (carbon, nitrogen, phosphorous and water) and a local set of adapted biodiversity indicators including the main classes of animals as well as fungi and bacteria. River basins proved the most natural and logic boundary to develop these effective ecosystem accounting systems for. EUROSTAT with LUCAS and COPERNICUS, as well as the implementation of the Directive on on-farm input/output statistics in 2020 provided a strong basis, on which the system was built.

The evidence base for regenerative policies places primacy on place-based knowledge and data from citizen science engaged for social learning in living laboratories embedded in river basis, which also serve to estimate and monitor local material stocks and flows and biodiversity. The nature of the evidence base is regularly evaluated and renegotiated in participatory processes, as well as targeted actions and measures.

Integration of data from non-traditional sources in the production of statistics?

One way to reflect on this question is to look at the structure of demographic statistics that has evolved over decades (what would it be without a solid, however very costly Population Census?).

1. The place for citizen's participation

Active involvement of citizens may be envisaged in two sites of the statistical factory in particular: Firstly (at the end of the production line) in the design of the final product in the form of indicators (which are used for monitoring and political assessment of target achievement) and secondly (at the beginning of the production line) in the generation of raw materials in the form of valuable data bases. Assuming that this participation at the beginning and at the end takes place successfully, it is the task of the statistical 'engineers' to create the desired end products from the good raw materials by means of effective/efficient production.

2. The place for GIS

Geospatial data, GIS-supported aggregation, overlap analyses etc., as well as GIS-supported visualisation / communication naturally have a place in all stages of production. However, it serves to clarify that these different applications are not mixed and confused.

3. Political support and finances

We are now (politically) talking about the problem of endangered species, biodiversity, ecosystems health etc. and do not think that we completely lack sufficient qualitative information bases. Compare this with demography: here we spend a relatively large amount of money on it, so that we can have solid reporting on population, migration, families, etc., based on which political-administrative planning can be done. A comparable approach would have to be pursued for ecosystems and biodiversity, namely the compilation of a statistically representative, comprehensive map of European landscapes with their individual land cover and land use, their state of ecosystems and their biodiversity. This would be the opportunity for a smart combination of remote sensing, data crowd sourcing and intensive field surveys for small, selected but statistically representative samples (see the KIP INCA from above).

Conclusion: The need for good statistics could be met by modern data and advanced methods. But not for free! Like the Population Census, the 'Biodiversity Census' will cost money. If the politicians are prepared to finance such a project, very good! But if they believe that with Big Data and AI all this would be available for free, very bad! So we should not give politicians this wrong impression by making misleading promises, generating unrealistic expectations, or neglecting the issue of costs. We would be doing a disservice to the cause and would continue to waste time that we do not have.

A first set of reflections from Walter Radermacher, former Director General of EUROSTAT, affiliated researchers at the University of Sapienza, Italy, October 2019

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Footnotes

- 1 Padma, T.V., 2019 *Nature* (news in focus section) 'African Nations take UN to task: Countries urge higher priority for drought research' *Nature* 573: 319-320.
- 2 Ramankutty, N., A. T. Evan, C. Monfreda, and J. A. Foley. 2008. Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000. *Global Biogeochemical Cycles* 22(1). DOI: 10.1029/2007gb002952.
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- 3 IPBES (Intergovernmental Policy Platform on Biodiversity and Ecosystem services) 2019. www.ipbes.net
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- 4 IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services). 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: IPBES Secretariat. <https://www.ipbes.net/news/ipbes-global-assessment-summary-policy-makers-pdf>, accessed August 2, 2019.
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- 5 Hallmann, C. A., M. Sorg, E. Jongejans, H. Siepel, N. Hofland, H. Schwan, W. Stenmans, A. Müller, H. Sumser, T. Hörrén, D. Goulson, and H. de Kroon. 2017. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PLOS ONE* 12(10):e0185809. DOI: 10.1371/journal.pone.0185809.
- 6 Already hinted at FAO, 2013a cited in WWAP, UN Water, 2018
- 7 Turner, M. G., K. H. Braziunas, W. D. Hansen, and B. J. Harvey. 2019. Short-interval severe fire erodes the resilience of subalpine lodgepole pine forests. *Proceedings of the National Academy of Sciences of the United States of America*. DOI: 10.1073/pnas.1902841116.
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- 8 A possibility suggested in National Academy of Sciences and The Royal Society (2019). *Climate change and ecosystems*. <http://nap.edu/25504>
- 9 Burekt et al. 2016. Cited in WWAP (United Nations World Water Assessment Programme) UN Water 2018. *The United Nations World Water Development Report 2018. Nature Based Solutions for Water*. Paris, UNESCO. <http://www.unesco.org/new/en/naturalsciences/environment/water/wwap/wwdr/2018-nature-based-solutions/>
- 10 Inspired by Elisabeth Warren's campaign strategy for the 2020 US elections.
- 11 Cite von der Leyen's personal strategy document.

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- 12 European Commission strategy adopted xxx on the New Green Deal link:
- 13 2030 EU Biodiversity strategy.xxx Weblink:
- 14 European Court of Justice case -235/17 - Commission v Hungary (Usufruits sur terres agricoles) from 15 May 2019. Judgment of the Court (Grand Chamber) of 21 May 2019. European Commission v Hungary . Failure of a Member State to fulfil obligations — Article 63 TFEU — Free movement of capital — Article 17 of the Charter of Fundamental Rights of the European Union — Right to property — National legislation extinguishing, without compensation, the rights of usufruct over agricultural and forestry land. The judgment itself ruled Hungary to be guilty, but the language suggested the one important aspect of the failure was the neglect to pay compensations.
- 15 Economist 25 October reader letter
- 16 A scenario of such a black out that is deemed fully realistic by leading experts and is now used to inform policies for resilience at EU and national level is published by Marc Elsenberg in his fiction book Black Out.
- 17 Thomas Malone (2019). Superminds. MIT Press.
- 18 Servoz, M. 2019. AI the future of Work ? Work of the future! Brussels, The European Commission. <https://ec.europa.eu/digital-single-market/en/news/future-work-work-future> last accessed 10 December 2019.
- 19<https://www.wbgu.de/en/publications/publication/towards-our-common-digital-future#section-4;>
<https://www.wbgu.de/en/publications/charter>
- 20 MIT Technology Review Vol. 121. 2018. Artificial Intelligence: Tech companies should stop pretending AI won't destroy jobs. Kai-Fu Lee. Pp8-9.
- 21
- 22 Jasanoff, S. 2003. Technologies of humility. *Minerva*, xxx
- 23 Malone T. (2018) Superminds. MIT Press. Chapter 12.
- 24 Malone, T. (2018) Superminds. MIT Press.
- 25 A quote from a fictive mother of the environment minister inspired by [Farhana Yamin in her comment in Nature 19 September 2019 volume vol. 573, pp. 337-339](#). See also <https://rebellion.earth/>
- 26 (ELABORATE: These policies remain to be defined in consultation with immigration experts at the UL to see what changes are challenging but still plausible enough in the Luxembourg and EU context.)
- 27 https://ec.europa.eu/info/news/economy-finance/policy-implications-ageing-examined-new-report-2018-may-25_en
- 28 This section has been developed in large parts based on the NEXUS FUTURES Expert Working Paper B on spatial planning in the three scenarios by Kai Böhme and Sebastian Hans from Spatial Foresight.
- 29The reference https://transportgeography.org/?page_id=4613, [Urban Land Use and Transportation](#) by Dr. Bernd-Paul Rodrigue states that “There are also [variations in the built-up areas](#) that is commonly a function of density, level of automobile use and planning practices. In automobile dependent cities, 35 to 50% to land use footprint is accounted by roads and parking lots. These variations are the outcome of a combination of factors that reflect the unique geography, history, economy and planning of each city.”
- 30 INSERT REFERENCE TO MAN AND HTE BIOSPHERE SUBMISSION TO UNESCO
- 31 <https://www.umsicht.fraunhofer.de/de/presse-medien/pressemitteilungen/2019/einweihung-altmarktgarten-oberhausen.html> 26.9.2019

32 <https://www.umsicht.fraunhofer.de/de/referenzen/ufo-system.html>

33 This section has been developed in large parts based on the NEXUS FUTURES Expert Working Paper A on legal and regulatory reforms in the three scenarios by Edgard Arendt.

34 Adopted in 1992, the [Council Directive 92/43/EEC](#) of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements. It forms the cornerstone of Europe's nature conservation policy with the [Birds Directive](#)

35 Actuellement notamment: la loi du 17 avril 2018 concernant l'aménagement du territoire; la loi modifiée du 19 juillet 2004 concernant l'aménagement communal et le développement urbain; la loi modifiée du 16 août 1967 ayant pour objet la création d'une grande voirie de communication et d'un fonds des routes; ainsi que le Programme de développement rural 2014-2020.

36 C.C. article 649. - Les servitudes établies par la loi ont pour objet l'utilité publique ou communale, ou l'utilité des particuliers. Bien qu'elles ne soient pas expressément qualifiées comme telles, des servitudes de ce genre sont actuellement déjà prévues par plusieurs lois: - Loi du 18 juillet 2018 concernant la protection de la nature et des ressources naturelles; - loi modifiée du 19 décembre 2008 relative à l'eau; - loi modifiée du 30 janvier 1951 ayant pour objet la protection des bois; etc.

37 [Water Framework Directive](#) (WFD, 2000/60/EC), and its 'daughter Directives': [Groundwater Directive](#) (GWD, 2006/118/EC) and [Environmental Quality Standards Directive](#) (EQSD, 2008/105/EC); [Floods Directive](#) (FD, 2007/60/EC). Evaluation of the [Urban Waste Water Treatment Directive](#) (UWWTD, 91/271/EEC), the European Commission adopted in February 2018 a [proposal for a revised Drinking Water Directive](#) to improve the quality of drinking water and provide greater access and information to citizens. The proposal for modernizing the 20-year-old Drinking Water Directive (98/83/EC) comes as a result of the REFIT evaluation, the implementation of the Commission's response to the European Citizens' Initiative 'Right2Water' and as a contribution to meeting the UN Sustainable Development Goals.

38 Pour la genèse de la loi voir chapitre "En guise d'introduction".

39 Article 20, § 1 et article 44.

40 Par masse d'eau, la loi comprend une partie distincte d'une eau de surface tel qu'un lac, un réservoir, un cours d'eau, un canal, ou une partie de cours d'eau ou de canal (article 2, point 32).

41 Directive habitats, article 6 § 3. Loi du 18 juillet 2018 concernant la protection de la nature et des ressources naturelles, article 32.

42 <https://gouvernement.lu/dam-assets/documents/actualites/2018/12-decembre/Accord-de-coalition-2018-2023.pdf - page 167>: Assurer des finances publiques en faveur d'un développement durable. Les moyens nécessaires au financement de projets en faveur du développement durable du Luxembourg seront mis à disposition. En prenant en compte le caractère transversal de l'Agenda 2030, il s'agira d'assurer la réalisation de projets innovants permettant de créer des synergies entre les dimensions du développement durable économique, social 168 et environnemental et de promouvoir la recherche en matière de développement durable, notamment la réflexion systémique et l'évaluation d'impact.

43 Directive habitats, article 6 § 3. Loi du 18 juillet 2018 concernant la protection de la nature et des ressources naturelles, article 32. Voir à ce sujet l'arrêt de la CJUE dans l'affaire C-98/03, Commission c. République fédérale d'Allemagne.

44 L'implantation projetée du Datacenter de Google et de la fabrique de yaourt de Fage a révélé des désaccords profonds entre différents membres du gouvernement au sujet de l'orientation économique du pays.

45 Revendiqué à maintes reprises par le Mouvement écologique, les trois partis ayant formé le gouvernement en 2018 ont annoncé dans leur accord de coalition l'introduction d'un outil

- d'évaluation interne des actes législatifs par rapport à leur impact sur le développement durable (Nachhaltigkeitscheck).
- 46 Loi du 10 juin 1999 relative aux établissements classés - Texte coordonné au 14 mai 2014, Mémorial A n° 81 du 14 mai 2014.
- 47 CHARTER OF FUNDAMENTAL RIGHTS OF THE EUROPEAN UNION (2007/C 303/01). OJ 14.12.2007. Article 17 Right to property 1. Everyone has the right to own, use, dispose of and bequeath his or her lawfully acquired possessions. No one may be deprived of his or her possessions, except in the public interest and in the cases and under the conditions provided for by law, subject to fair compensation being paid in good time for their loss. The use of property may be regulated by law in so far as is necessary for the general interest. 2. Intellectual property shall be protected.
- Article 37 Environmental protection A high level of environmental protection and the improvement of the quality of the environment must be integrated into the policies of the Union and ensured in accordance with the principle of sustainable development.
- 48 Nick, P. (2014.) Die Gesetzgebung über die neue FLurordnug. In 50 Joer Remembrement zu Lëtzebuerg. Pp34-41. Eine Veröffentlichung des Ministeriums für Landwirtschaft, Weinbau und Verbraucherschutz. Éditionsrevue
- 49 Wesche, T. 2019. Eigentum. Was ist das und wozu ist es gut? Die Zeit no. 16 11. April 2019, pp 46-47.
- 50 This section has been developed in large parts based on the NEXUS FUTURES Expert Working Paper D on the circular economy in the three scenarios by Paul Schosseler from +ImpaKT and by the Feuille de Route pour un approvisionnement durable en d'eau potable due Luxembourg Etude par P. Schosseler +IMPAKT pour l'Administration de Gestion de l'Eau, May 2019.
- 51 <https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/rethinking-the-water-cycle>
- 52 Companies such as Amamundu have developed technologies for an efficient reuse of the various valuable fractions of digestate, including water: <https://ama-mundu.com/en/welcome/>
- 53 Voir p.ex. le projet Interreg WOW (Wider business Opportunities for raw materials from Wastewater) <http://www.nweurope.eu/projects/project-search/wow-wider-business-opportunities-for-raw-materials-from-wastewater/>, avec la participation de l'Université du Luxembourg
- 54 This section has been developed in large parts based on the NEXUS FUTURES Expert Working Paper C on water demand and supply scenarios Alex Cornelissen from RTC4Water.
- 55 Les principaux systèmes de tarification sont la tarification proportionnelle au prorata des quantités d'eau consommées, la tarification binôme qui contient en plus un abonnement et la tarification progressive dans laquelle le prix unitaire de l'eau augmente avec le niveau de consommation (tarification à tranches croissantes). - Henri SMETS, La tarification progressive de l'eau potable in Académie de l'Eau, juin 2011.
- 56 Aussi LSAP et le Groupe parlementaire socialiste avaient saisi le ministre de l'Intérieur au sujet d'un système de tarification progressive (https://eau.public.lu/prix_eau/Avis/LSAP.pdf). Le système a d'ailleurs été appliqué dans plusieurs villes françaises ainsi qu'en Belgique en région bruxelloise et en Flandre. Le résultat a été plutôt positif, mais plusieurs paramètres ont dû revus, comme par exemple la situation de familles nombreuses indigentes.
- 57 Directive 2018/2001 du Parlement européen et du Conseil du 11 décembre 2018 relative à la promotion de l'utilisation de l'énergie produite à partir de sources renouvelables.
- 58
- 59 Abundant permaculture garden –resilience in cities:
<https://www.youtube.com/watch?v=Y9ZukMyeiLk>

<https://permaculturenews.org/what-is-permaculture/>

<https://fermesdavenir.org/formation-longue-creer-fermes-territoire-devenir-payculteur> .

<https://www.permaculturedesign.fr/creation-jardin-foret-comestible-permaculture-gilde-projet-communaute-eco-village/> <https://fermesdavenir.org/fermes-davenir/pole-influence/plaidoyer>;
<http://www.inra.fr/home/index.php/Chercheurs-etudiants/Agroecologie/liste/dossiers/19120>

60 https://en.wikipedia.org/wiki/Peak_phosphorus, geological reserves estimated to 260 years based on current production, with 70% of the reserves in Morocco.

61 <https://www.phosphorusplatform.eu/espp-members/759-ministry-of-infrastructure-and-the-environment>,

https://ec.europa.eu/environment/natres/pdf/phosphorus/sustainable_use_phosphorus.pdf

62 This section has been developed in large parts based on the NEXUS FUTURES Expert Working Paper D on the circular economy in the three scenarios by Paul Schosseler from +ImpaKT

63 e.g. <https://www.citerneo.de/landwirtschaft>. These tanks have the advantage that they can also store more aggressive water, e.g. nutrient rich treated black water (see section on water).

64 <https://www.plasticrepair.es/en/>

65 Servoz, M. 2019. AI the future of Work ? Work of the future! Brussels, The European Commission. <https://ec.europa.eu/digital-single-market/en/news/future-work-work-future> last accessed 10 December 2019.

66 <https://gouvernement.lu/dam-assets/documents/actualites/2018/12-decembre/accord-de-coalition-2018-2023.pdf> - page 167:

Assurer des finances publiques en faveur d'un développement durable.

Les moyens nécessaires au financement de projets en faveur du développement durable du Luxembourg seront mis à disposition. En prenant en compte le caractère transversal de l'Agenda 2030, il s'agira d'assurer la réalisation de projets innovants permettant de créer des synergies entre les dimensions du développement durable économique, social 168 et environnemental et de promouvoir la recherche en matière de développement durable, notamment la réflexion systémique et l'évaluation d'impact.

67 Voir interview avec le ministre des Finances - Luxemburger Wort du 7/8 septembre 2019.

68 Actuellement, la loi modifiée du 5 avril 1993 relative au secteur financier fait autorité. Cette loi a été modifiée en dernier lieu par la loi du 22 juin en vue de l'introduction de lettres de gage portant sur les énergies renouvelables - Mémorial A n° 521 du 26 juin 2018. L'initiative législative est motivée ainsi: *Grâce à l'implication des secteurs public et privé, la place financière du Luxembourg a développé un écosystème apte à lever des capitaux internationaux dans le but de financer le développement durable. Le présent projet de loi vise à compléter la gamme de produits qui sont à la disposition des acteurs du marché et témoigne de l'esprit pionnier dont le Luxembourg a toujours fait preuve en la matière. Ainsi en 2007, la Bourse de Luxembourg (LuxSE) a coté la première obligation verte (« green bond ») au monde. Le Luxembourg est aujourd'hui devenu un centre d'excellence mondialement reconnu pour ces produits. Le « Luxembourg Green Exchange (LGX) » de la Bourse de Luxembourg est la première plate-forme mondiale exclusivement dédiée aux instruments financiers verts et cote actuellement plus de la moitié des obligations vertes du monde.* - Document parlementaire n° 7232.

69 (Dörry and Schultz, 2018)