Luxembourg in Transition
December 2021, stage 3

# Soil & People

2001
LOLA
51N4E
Systematica
Endeavour
TUK
ETHZ
Transsolar
Yellow Ball
OFC
Gregor Waltersdorfer

## *Fast Read (25 minutes)*

# *Deep Read (50 minutes)*

# Foreword

In response to redefining the role of spatial planning in decarbonisation of the Luxembourg's "bioregion", the team of Soil and People have investigated the potential of land management and lifestyle changes, i.e. soil & people.

The resulting strategy is structured in 3 steps.

## *Count it*

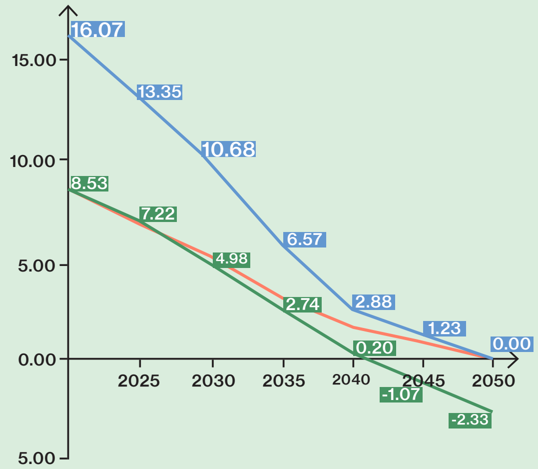
The development of an adaptive territorial land management tool which allows any public body of any scale, to map its land use change based on the defining demographic, diet and cultivation shifts, and to check its negative emissions in time. It can be tailored to local needs and criteria and applied to various scales from 1 to 1M hectares.

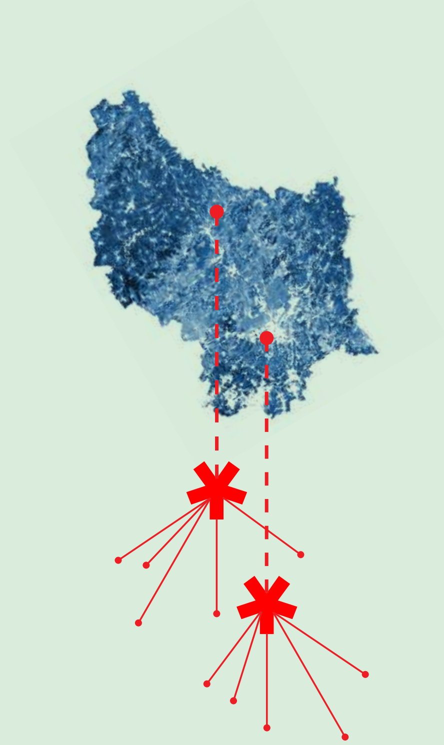
## *Change it*

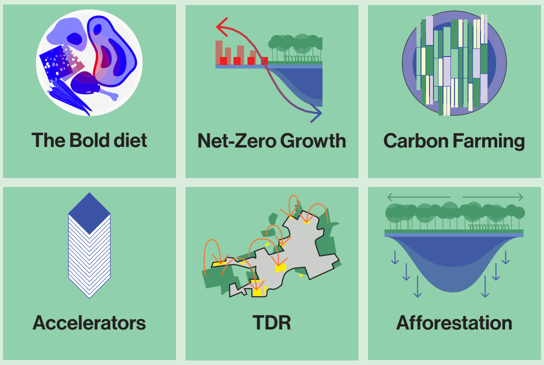
A series of pilot strategies applicable to rural and suburban localities across Luxembourg. The application of these strategies have been showcased and quantified in Bettendorf and Helfent, and they can be taken up from tomorrow.

## *Scale it*

A long list of key actors and decision-makers on the field whose advice has been integral to gaining insight on the practicalities of implementation. These conversations and insights form the basis of an academy of decarbonisation which can educate and upskill the first cohort of transition ambassadors. Their expertise spans from agriculture, to planning, construction, forestry, diet, communication, law and economics. This step embodies sharing and teaching which stands as a vector for exponential growth and upscaling the impact of the steps before.



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# Foreword

Throughout the past year the team of Soil & People concentrated on lifestyle changes and land use change as a spatial planning lever for decarbonisation of the territory of Luxembourg. As an outcome, a territorial project strategy was developed to maximise nature-based negative emissions, driven by a diet shift, a cultivation shift and a land management shift. The resulting vision is a quantifiable, holistic, evidence-based transition living up to Soil & People as its principal focus.

In parallel, rounds of conversation with experts, citizens, and authorities were carried out, operating as a reality check next to the scientific spatial investigation.

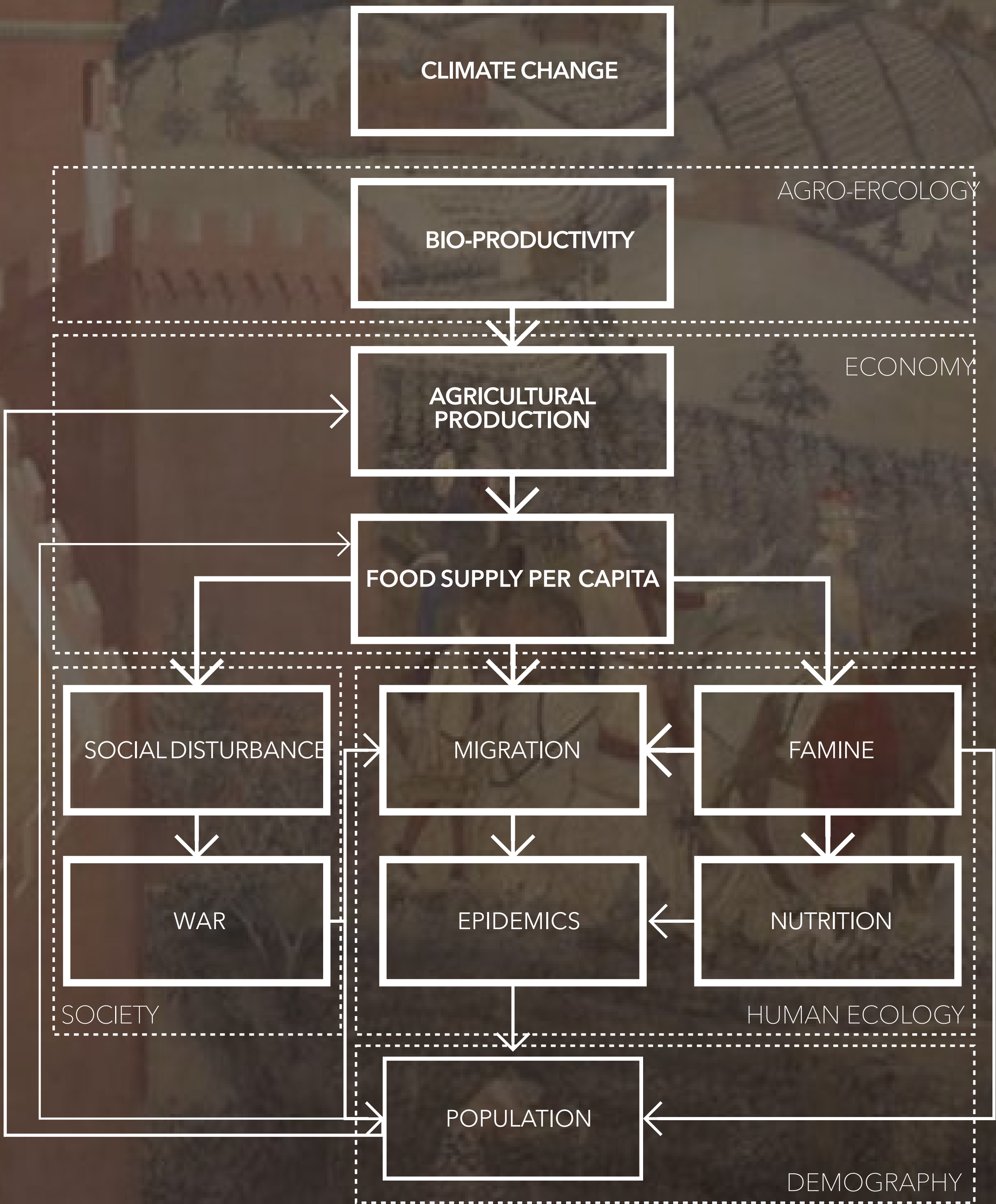
Inspired by already adopted actions and field conversations, problematic behavioural and legislative patterns of the territory have been carefully taken into consideration.
Examples of such observations include the battle a farmer had to fight to plant hedges on his leased farmland, due to inflexible preservation labels which put the interests of environmental protection and real estate economics in opposition with each other. Or the lack of hard data in the construction sector which disables the possibility to fully estimate the current emissions. Another example is the lack of consensus among farmers about definition of agriculture and among citizens about what needs to be preserved.

### *Climate change, countryside, crisis and causality.*

In the 14th century Lorenzetti painted the “allegories and effects of good and bad government” in order to remind Siena’s governing magistrates of their responsibilities. If half of the painting illustrates the city, the other half depicts the countryside, stressing its role and importance for society at large.
A 2011 study by David D Zhang et al. found that climate change was the ultimate cause, and climate-driven economic downturn the direct cause, of large-scale human crises in pre-industrial Europe and the Northern Hemisphere.

In the light of the challenges ahead, a dire warning to urgently reconsider and equip our landscapes.

Set of causal linkages from climate change to large-scale human crisis in preindustrial Europe (Zhang et al., 2011). The background features Lorenzetti's painting in Siena, depicting the relationship between cities and the countryside.



A carbon reading of landscapes, “paysagisme carbonique”.

# Report structure

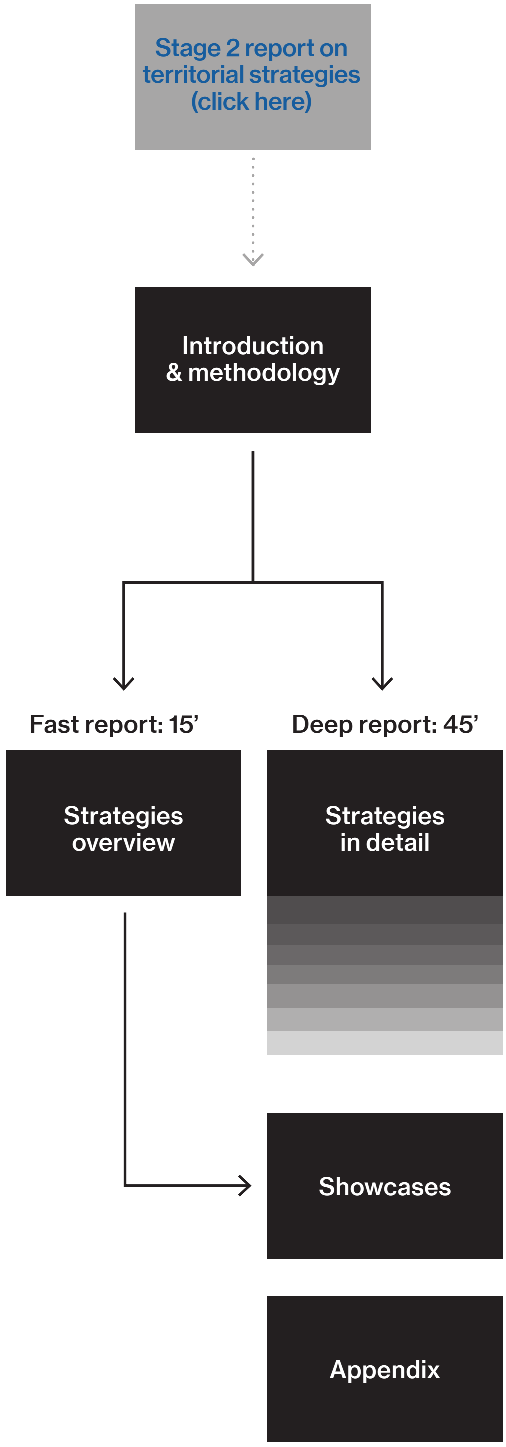
This report does not represent the exhaustive research and design that has been carried out through out the year long research on Luxembourg in Transition. Instead, its and attempt to illustrate a multi-faceted synthesis of territorial epitomes, and visionary responses for a diverse audience. It includes key extracts from interviews, results of scenario building and outputs of calculations. In an attempt to reach out to the broad spectrum of readers, the report also includes a variety of mediums to articulate its messages, ranging from text, diagrams, renderings, and comic-strips.
It is important to note, that the stage 3 report does not substitute the need for reading the stage 2 report, as many of the underlying definitions and research that has gone into building the territorial vision has been excluded from this final report in the benefit of ease of readability and guidelines provided by the project coordinators.

To further enhance accessibility of this report, we have designed it to function as a hybrid document. After reading the introductory chapter which introduces our position and methodology at large, you will have 3 choices to continue depending on your interests and time.

***The Deep report*** is an extensive dossier which elaborates the underlying dynamics of each strategy before landing on the showcases and present their applications.

***The Fast report*** is a highly digested copy of the deep report, where the strategies are only introduced as a concept and lands on the showcases in the least amount of spreads.

The transversal index is a cross-section through the report in response to key questions.



# The building blocks of negative emissions

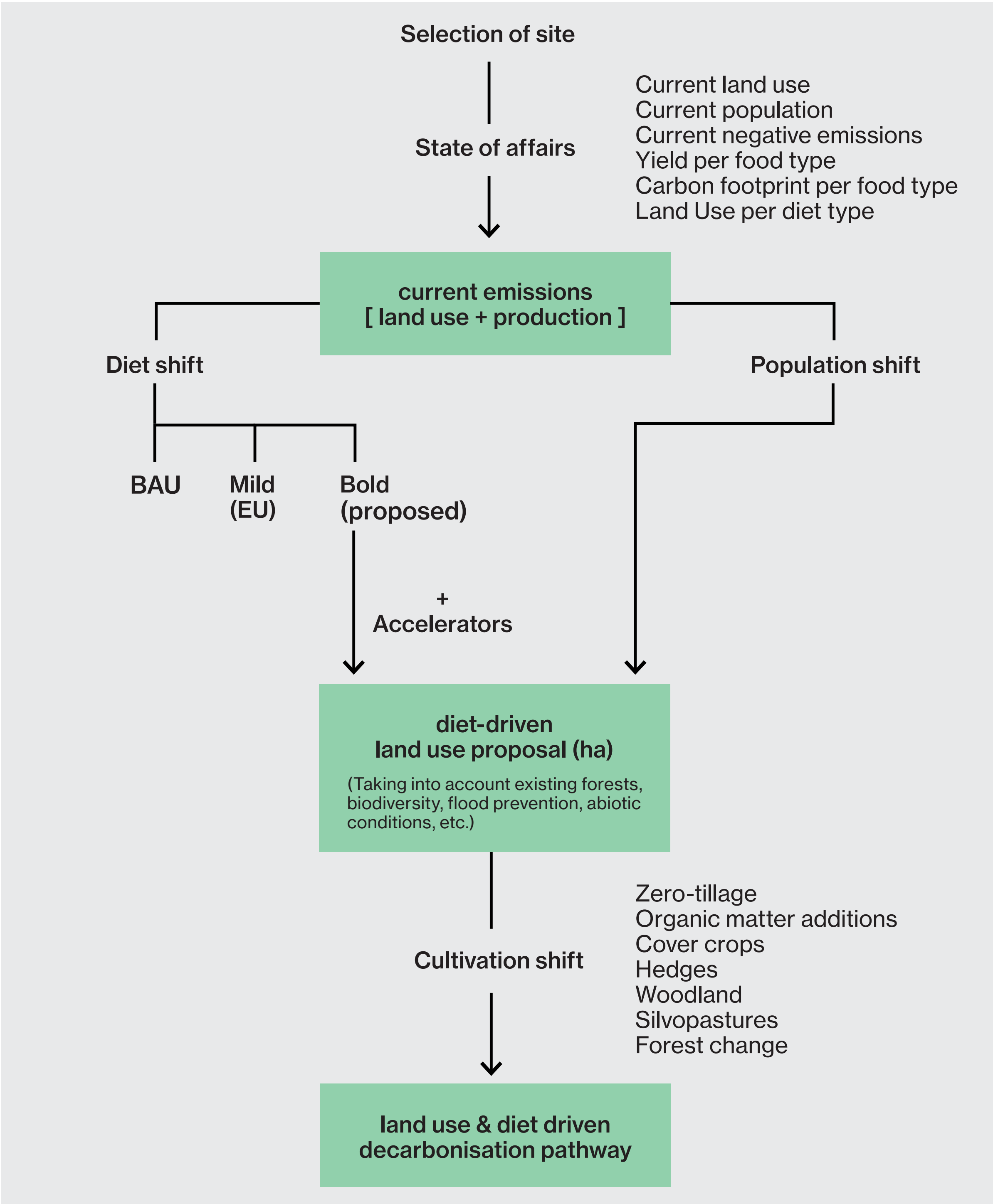



fig 1

# Methodology

Since the first stage of this study, nature-based solutions and lifestyle changes has been our theme of focus. We have adopted the European Commission's 1.5 LIFE scenario 1 and applied its anticipated trajectory for land Use and agricultural emissions to Luxembourg as our baseline (European Commission, 2018).

We broke down the building blocks of negative emissions into ***diet, demographic growth, efficiency of food production, planning and building culture, agricultural practices and forestry.*** For each of these factors, we have developed quantifiable strategies. These strategies can be applied in a variety of modes, resulting in local variants working towards a territorial ambition.

To manifest this possibility, we developed a land management tool which puts these drivers and accelerators into one algorithm integrating and interlinking different variables. These variables can be tuned and contextualised to local needs.

Taking into account the current and future abiotic conditions of Luxembourg bioregion, our vision for 2050 aims at ecological resilience in combination with food autarky and demographic growth. Beyond decarbonisation, our proposals have also taken into account climate adaptive measures and community wellbeing touching upon ***biodiversity, water, leisure and accessibility.*** In addition we have shared our ideas and insights with the citizens committee, local stakeholders, experts and decision-makers to get a better understanding of what lies ahead towards implementation of such strategies. These insights have informed the approach and proposals throughout the process.

The territorial strategies have been showcased over two sites to articulate how such a vision can be implemented with concrete actions. These showcased applications are not absolute, but offer a recommended possibility. They can be further developed and altered to match better the contextual needs and ambitions.

# Nature-based decarbonisation

The European Commission has laid out several scenarios for decarbonisation yet only 2 of them reach neutrality by 2050 (European Commission, 2018). As our focus has been on Soil and People, the EU 1.5 LIFE scenario was taken as a benchmark. This scenario is anchored on lifestyle changes and nature-based solutions. For this report this trajectory was reproduced for Luxembourg's functional region, but it is also possible to apply the same scenario to the scale of regions, cities and villages. While contextual parameters vary, the principles are constant. It is important to note that the efforts of this report focused on agriculture, and land use related emissions. For all other sectors, the adapted EU 1.5 Life trajectory stood as a principle.

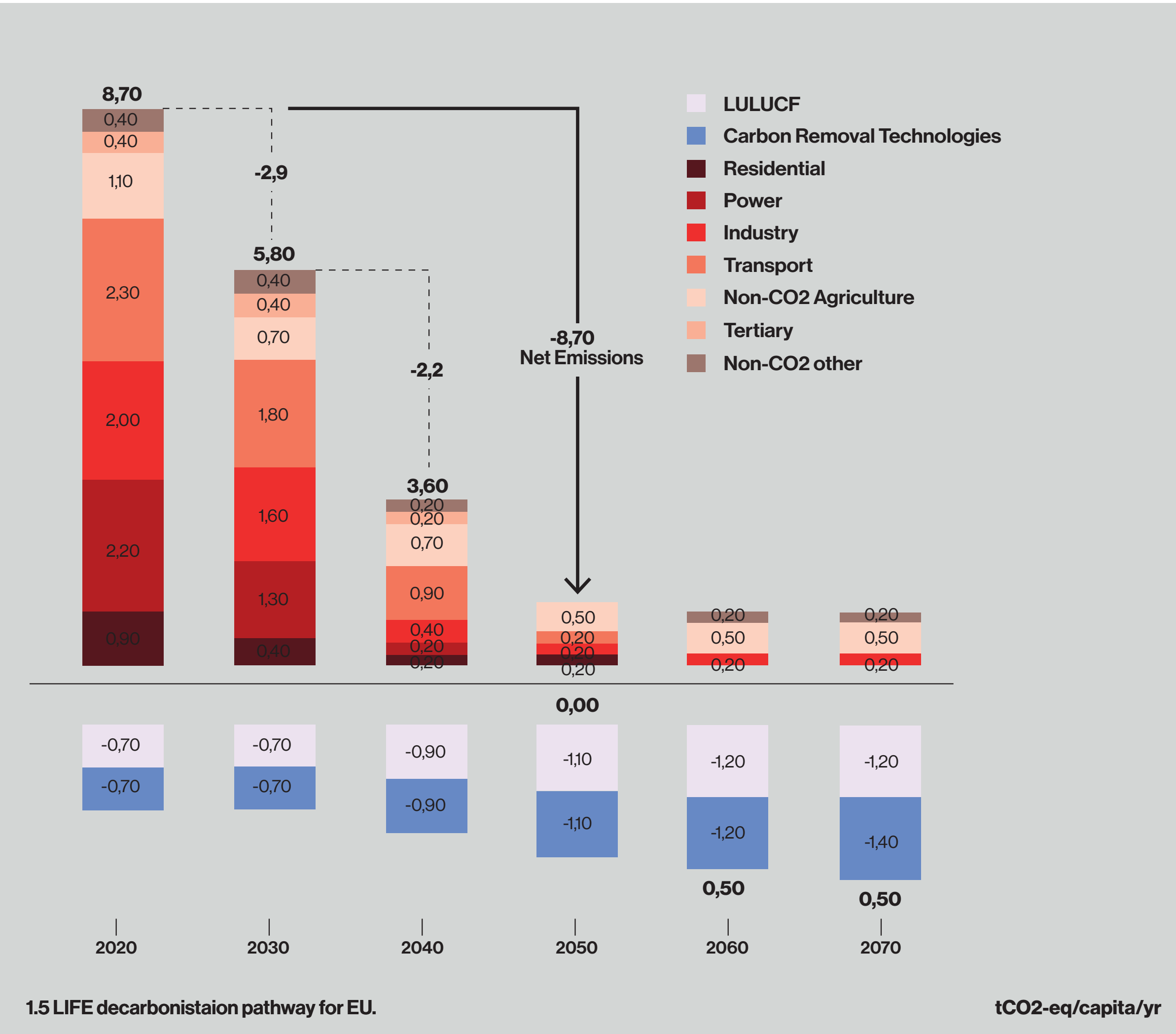



fig 2: EU 1.5 LIFE Scenario tCO2eq/capita/year.

What is clear in EU commission's report is that without enhancing carbon removal, or in other words negative emissions, reaching carbon neutrality by 2050 would not be possible. This is the reason we focused our efforts primarily to meet this ambition within the Luxembourg territory.

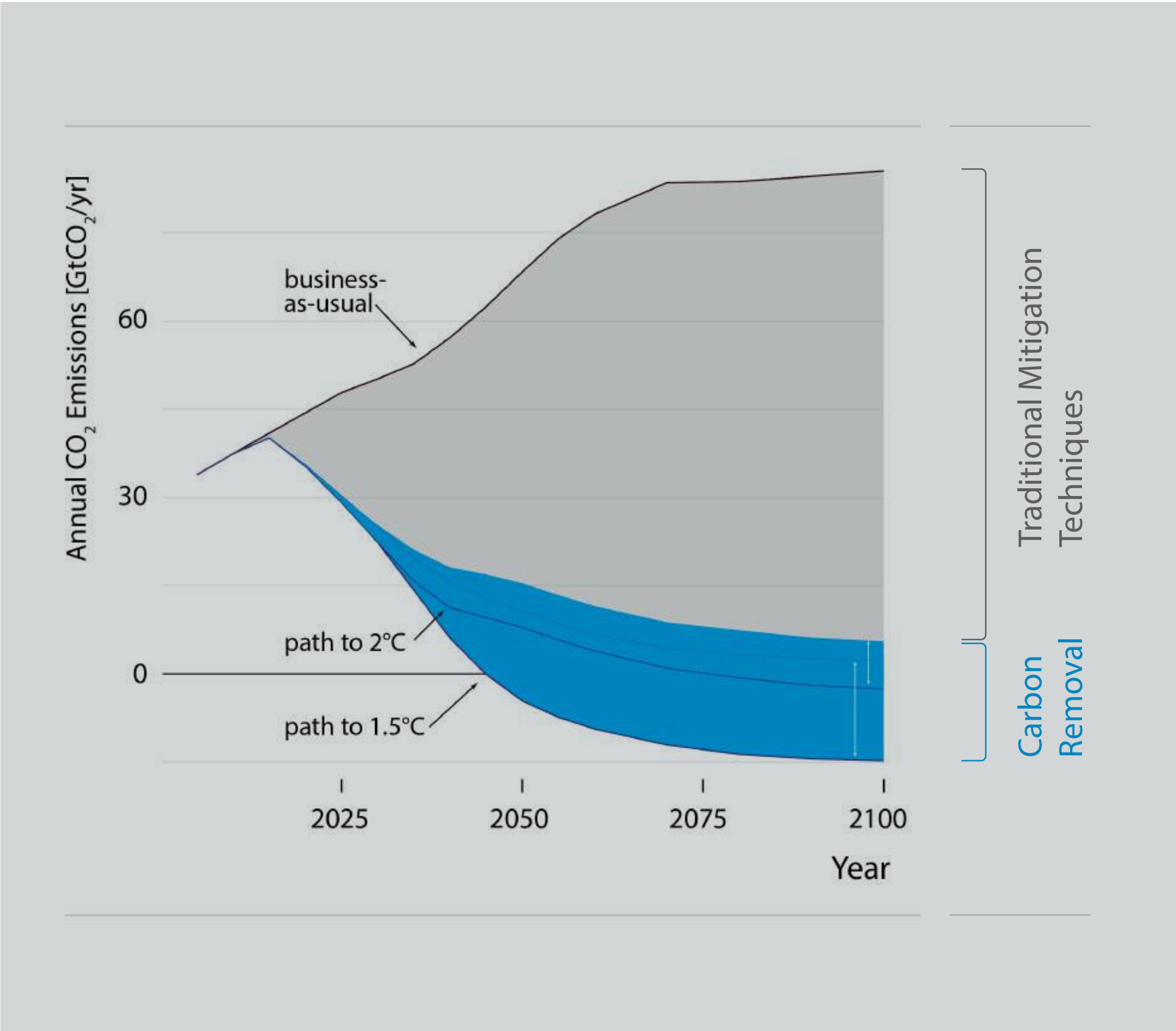



fig 3: Emission x paths.

# Negative emissions & Sequestration

Negative emissions, or carbon removal can be enhanced by technological solutions as well as nature-based solution. From an economic stand point, the cost of carbon removal by forests is maximum 27 dollars per $tCO_2$, while carbon capture technologies would at least cost 134 dollars and can go up to 342 dollars per $tCO_2$ (Woods, 2021).

We have chosen to consolidate our research and develop nature-based strategies with a goal of achieving maximum sequestration. In other words, by afforestation, decarbonising farming practices, and adapted land management, we aim to maximise and permanently fix C from atmospheric $CO_2$ in the soil of Luxembourg's bioregion (Deutsche Welle, 2021). However to enable enhancement of carbon absorption, preserving natural land cover is vital.
There is a direct correlation between the surface area of our carbon sinks and the amount of carbon the can remove. This emphasis on soil surface area is the underlying reason behind our other interventions which aim at reducing the land footprint of our problematic behavioural patterns as a society, especially in food consumption, planning and construction.

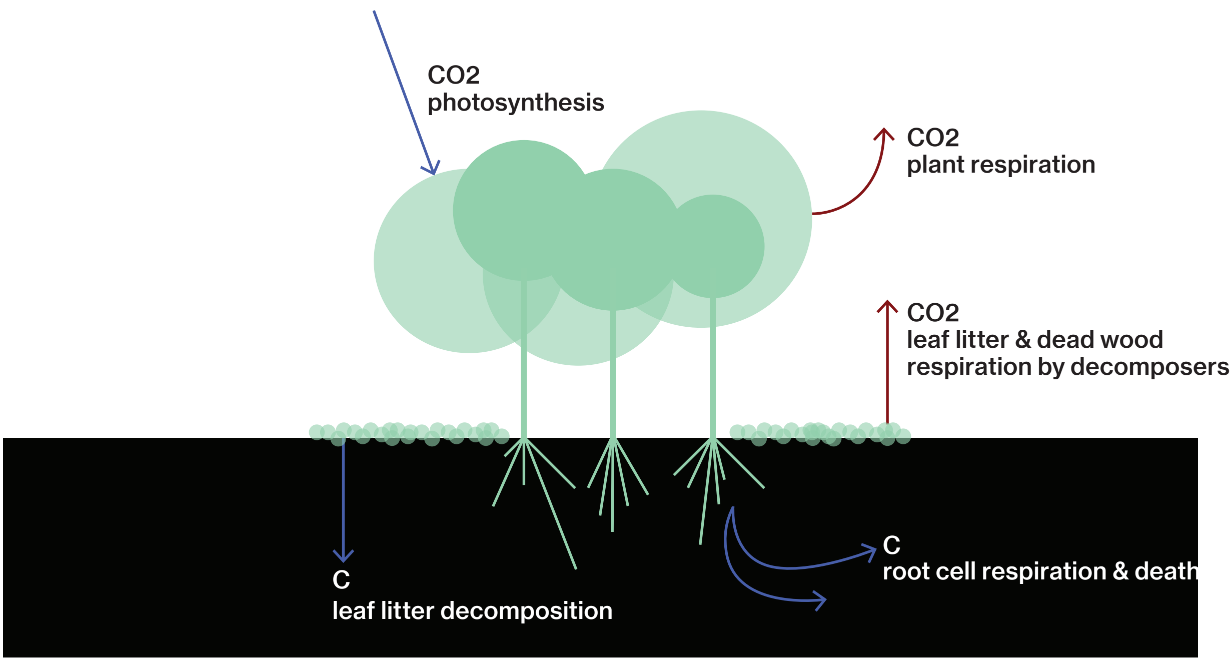
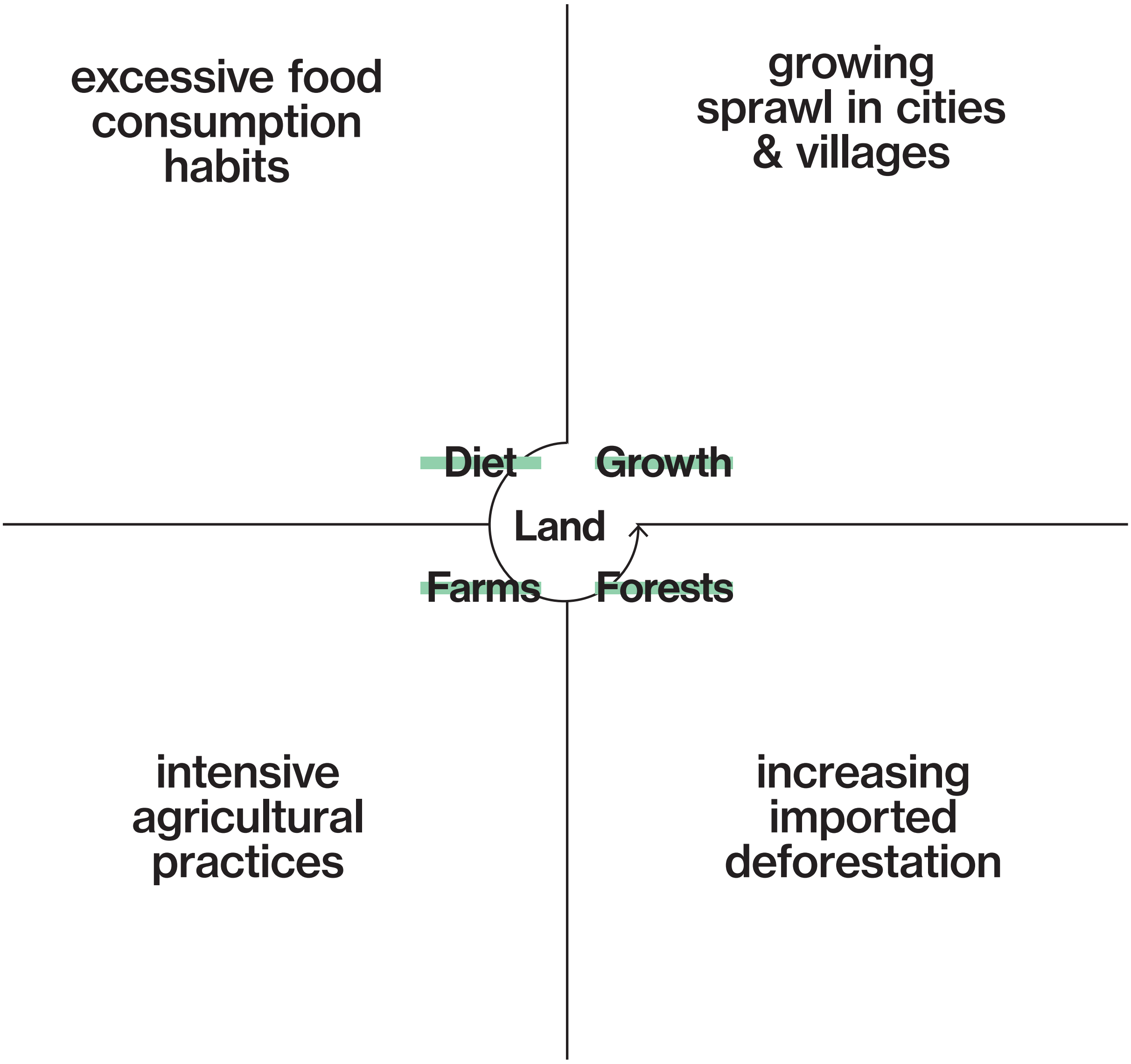



fig. 4: Carbon flows; illustrating the process of nature-based carbon removal, or sequestration

## Problematic patterns of the territory

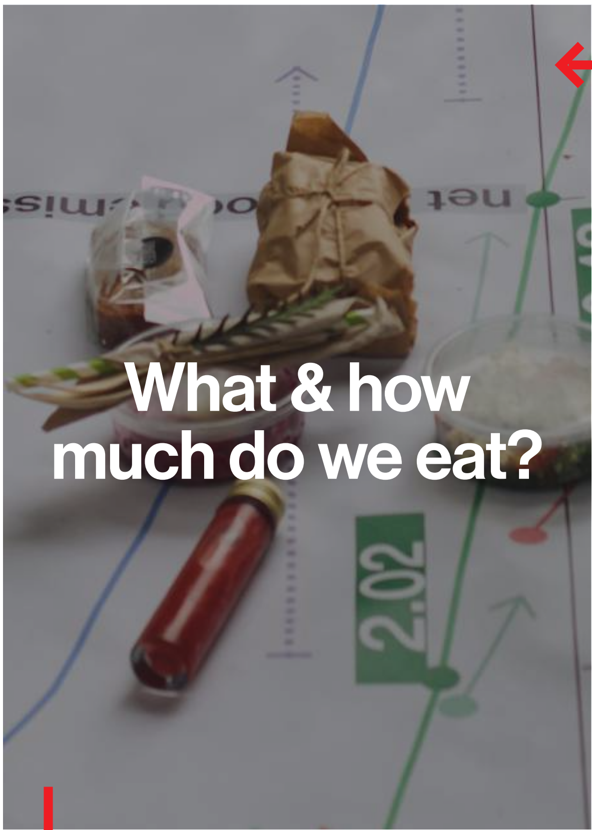


# The land deficit

Land is finite and a scarce resource. Today, the Bioregion of Luxembourg, the definition of which was explained extensively in phase 2, needs 2.5 Mha more land than it currently has under food production to feed itself. This pressure is hence externalised and it becomes a global issue. There is nearly a 600 million-hectare land gap between global agricultural land area in 2010 and expected agricultural expansion by 2050 (World Resources Institute, 2019).

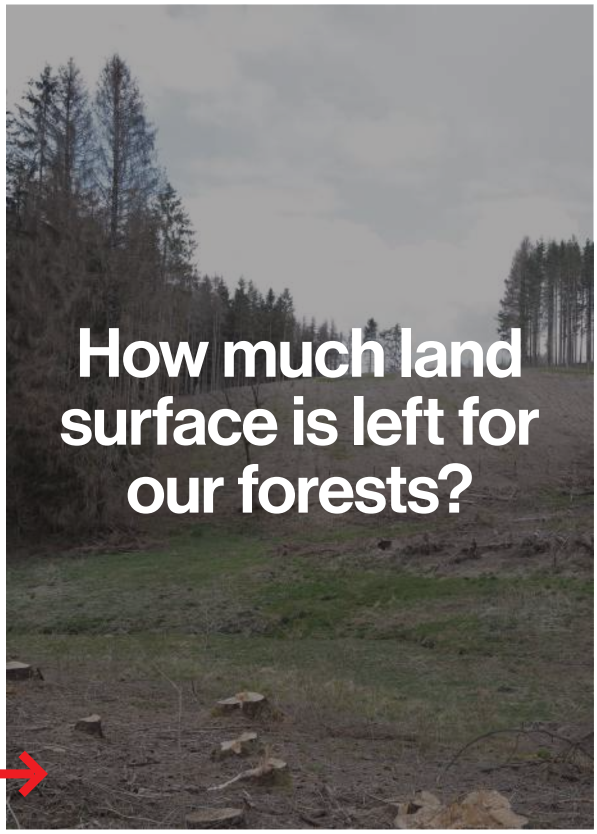
This pressure from food consumption and production in addition to an out of date planning culture, has resulted in an increasing land deficit that sits at the heart of the negative emissions question.

***Luxembourg bioregion needs x2.5 times its current productive land area to feed itself***


What & how much do we eat?
2.02

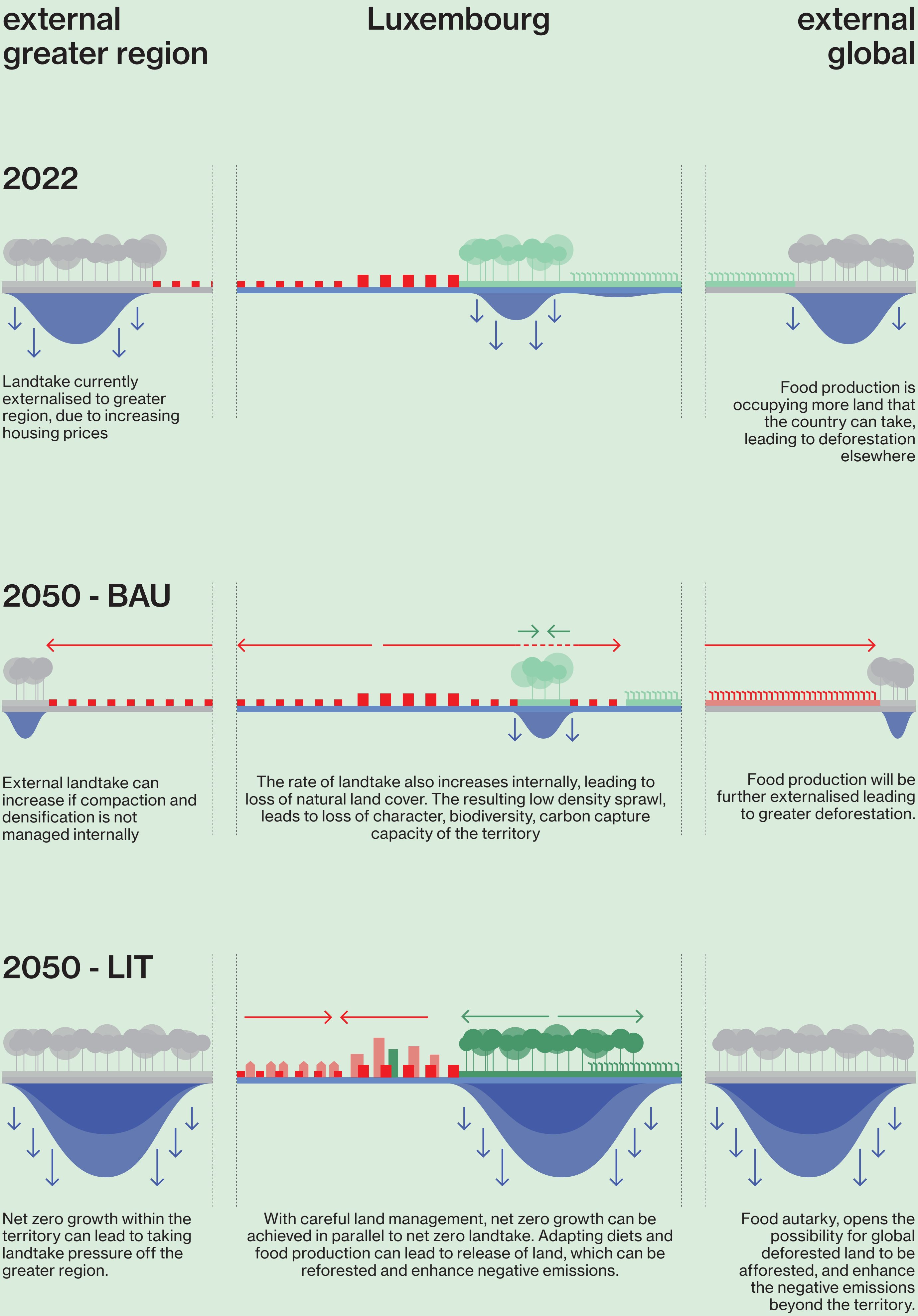

Can we sustain growth without landtake?


How do we grow our food?


How much land surface is left for our forests?

# Land flows

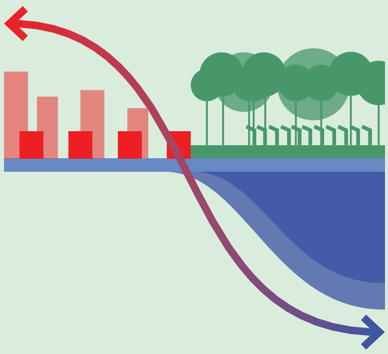
To be able to achieve negative emission goals with our forests and agriculture, we must reduce our food production land footprint, and to protect the natural landscapes we already have. Using a combination of diet shift and efficient food production methods, and compact growth of cities, we would be able to protect and increase the footprint of our forests. We can also reduce and eventually remove the pressure our behaviour as a society puts on land outside the boundaries of our region. The diagram on the opposite page illustrates these dynamics figuratively.



external greater region
Luxembourg
external global
2022
Landtake currently externalised to greater region, due to increasing housing prices
Food production is occupying more land that the country can take, leading to deforestation elsewhere
2050 - BAU
External landtake can increase if compaction and densification is not managed internally
The rate of landtake also increases internally, leading to loss of natural land cover. The resulting low density sprawl, leads to loss of character, biodiversity, carbon capture capacity of the territory
Food production will be further externalised leading to greater deforestation.
2050 - LIT
Net zero growth within the territory can lead to taking landtake pressure off the greater region.
With careful land management, net zero growth can be achieved in parallel to net zero landtake. Adapting diets and food production can lead to release of land, which can be reforested and enhance negative emissions.
Food autarky, opens the possibility for global deforested land to be afforested, and enhance the negative emissions beyond the territory.

# Menu of solutions

The solutions we have devised to address the problematic patterns of the territory, are organised in 6 categories. With the Bold diet and with assistance from the Land Use Accelerators, we have laid out a pathway to reduce the land footprint of our food. This will release an estimated 500,000 hectares of land in the Luxembourg bioregion. Net-zero growth and Transferable Development Rights (TDR), open up the possibility for net-zero landtake, in addition to addressing wider issues that exist within the planning and construction culture. These two strategies will protect the natural land cover. And finally, carbon farming and afforestation will enhance the capacity of the soil to remove carbon through natural processes to meet the ambition of maximum sequestration.



## Net-zero Growth

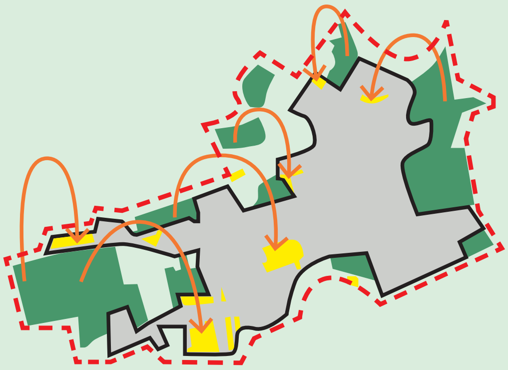
Which common values are shaping our cities today? Net-zero Growth investigates the societal and legal dynamics which could be revisited to enhance quality of life in neighbourhoods, and reduce emissions. It proposes a historically-rooted yet future-oriented approach to planning and construction.

## The Bold diet

The region today depends heavily on international pastures & cattle production to feed itself. This has a large impact on the carbon balance resulting in far greater indirect emissions than what is visible within the borders of the region. The Bold diet proposal is a behavioural pathway towards a sustainable future for the region.

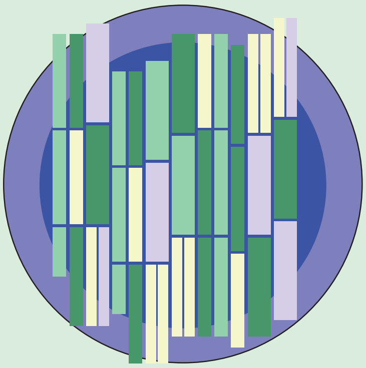
## Land use Accelerators

Non-soil based farming practices such as Controlled Environment Agriculture and Aquaculture, can produce much higher yields. They can also have stacked floors as they do not need soil. As a result, they can act as boosters in land reduction, and give us the time we need to shift our diet as a society.



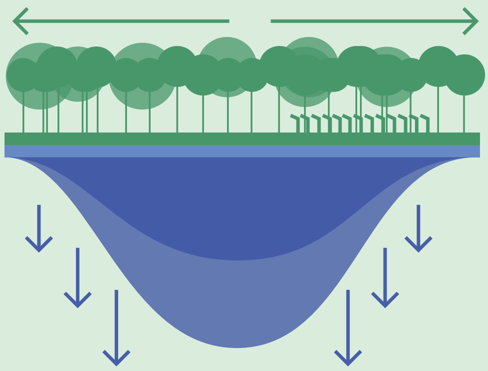
## TDR

Transferable Development Rights, provides a mechanism by which growth can be contained over existing sealed surfaces and built footprint. By revisiting property rights, it untangles the economic and environmental interests which are seemingly at conflict with each other, and suggests a new balance of interests.



## Carbon Farming

The land which remains under food production, can play a key role in reducing emissions and enhancing negative emissions. Following the recommended practices such as zero-tillage and planting hedges, the agricultural land can streamline the sequestration effort in parallel to afforestation.



## Afforestation

Afforestation is our primary sequestration vehicle. The land released from food production and protected by Net-zero growth, will be afforested. It also contributes to strengthening water infiltration, biodiversity, timber production, and leisure networks.

# A nature-based decarbonisation timeline

In the previous phase we laid out a step by step decarbonisation timeline with a focus on food emissions which took into account land use, land use change, forestry, and agricultural emissions, including emissions beyond the border of the region. This was done on the scale of the functional region and the biofunctional region. The methodology however, could be applied to any region, municipality or smaller area selection. We identified that following the Bold diet shift, the region can reach net-zero food emissions by 2040 and food autarky by 2045.

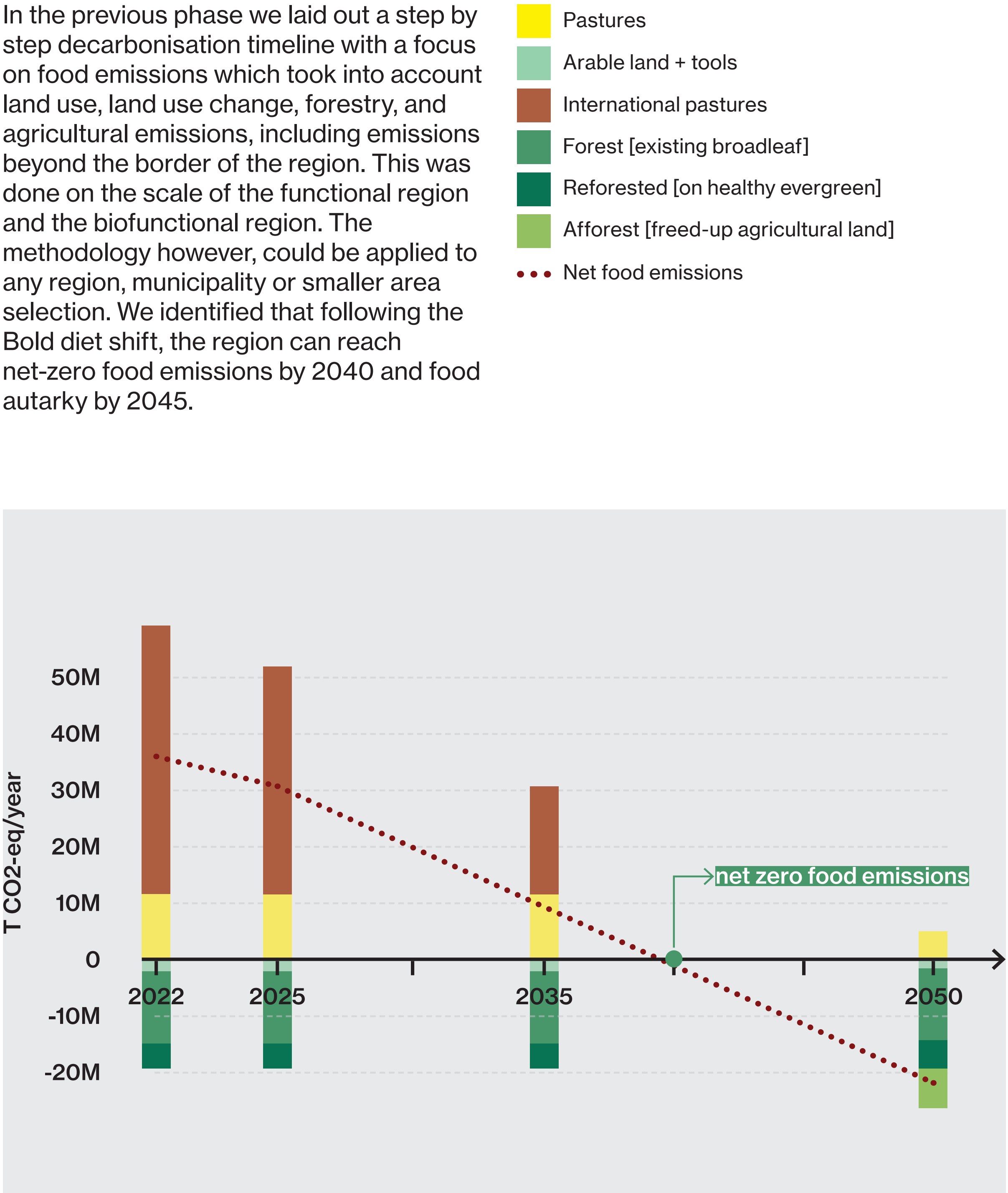
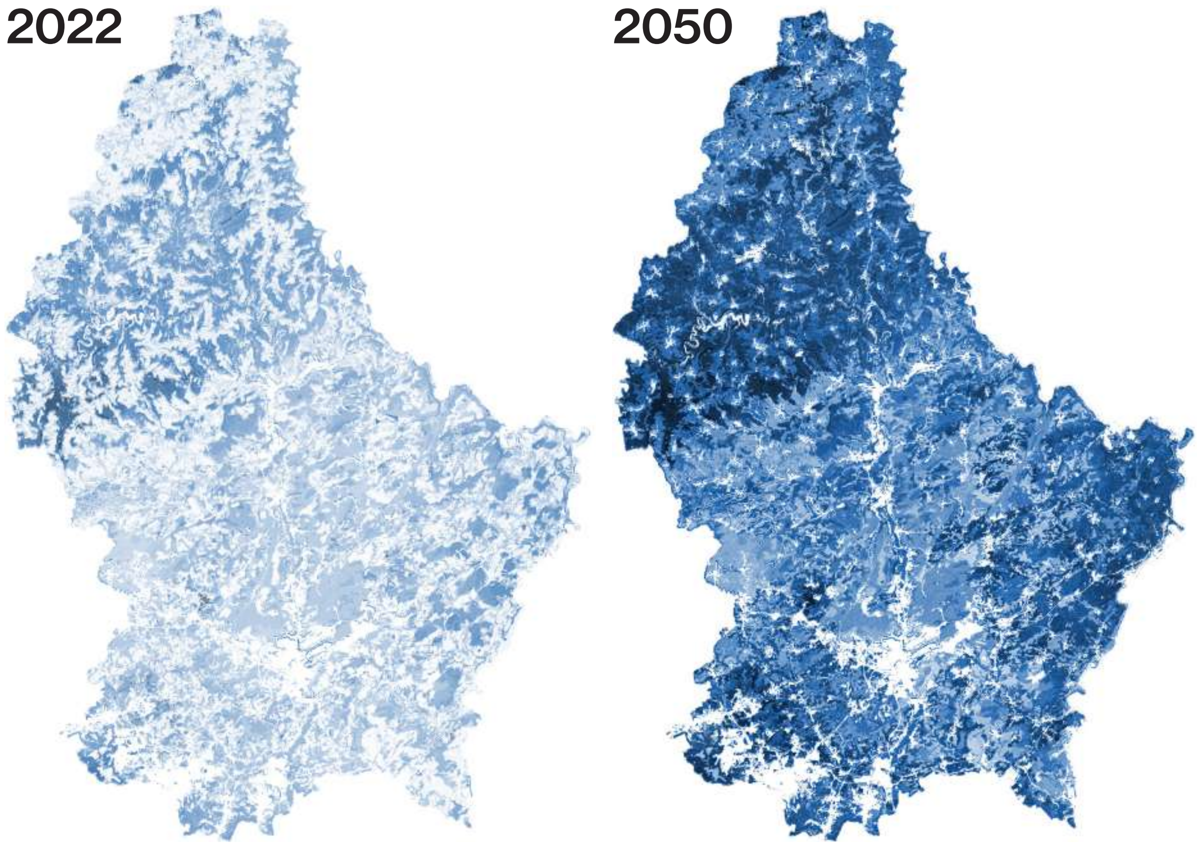



fig. 5: Annual sequestration/emission food provision and LULUCF BFUR.

# Luxembourg's potential SOC

The LU territory alone can sequester more than 18.9 MtCO2-eq by 2050.

- 50-70 t C/ha
- 100-120 t C/ha
- 120-140 t C/ha
- 180-200 t C/ha
- 200-220 t C/ha
- 220-240 t C/ha



# Academy of decarbonisation

In the first phase of this study we began by scouting the best practices across the region which are on the frontline of the transition towards a decarbonised territory, with the belief that by building coalitions among them we can disseminate their impact. As we narrowed down our scope of study, this exercise transformed into a series of online conversations, workshops, picnics, and interviews which together formed a curriculum for an academy of decarbonisation. These insights, at times in conflict with each other, provided us with the field knowledge which is necessary for translating the proposed strategies into actions.

We believe a clear gap that is felt is a lack of carbon literacy. There is an urgent need to raise awareness about how our individual decisions will have territorial impact. And the intent of such an academy would be to share the questions and possible answers that we have faced in this process with citizens, planners, builders, farmers, and politicians. Such a conversation, will form the foundation for reaching consensus around common values which is the underlying driver for all societal shifts.

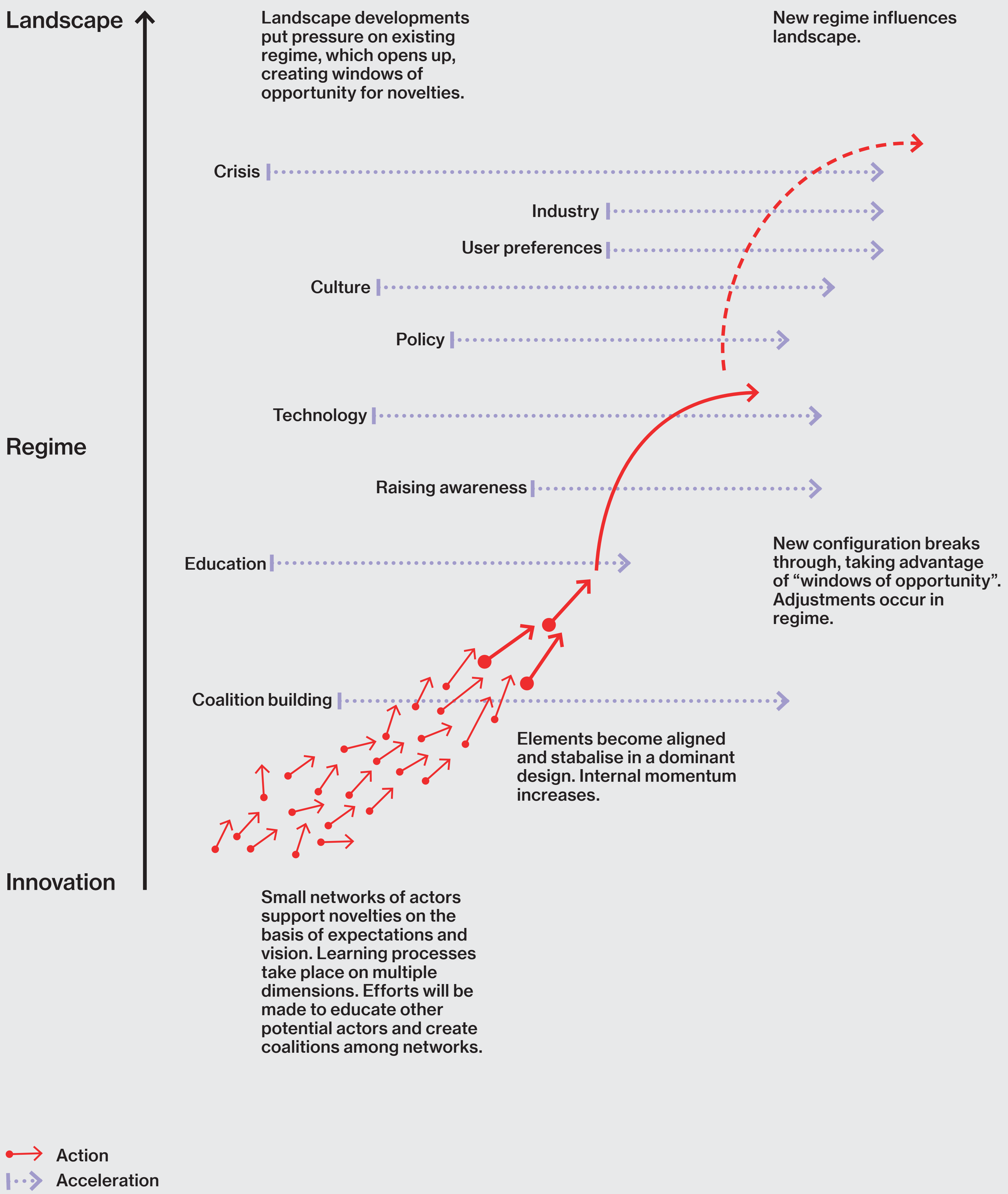



fig. 6: Multi-level perspective on transitions. (Geels 2002, 1263).

## *From centimeters to hectares of consumption*

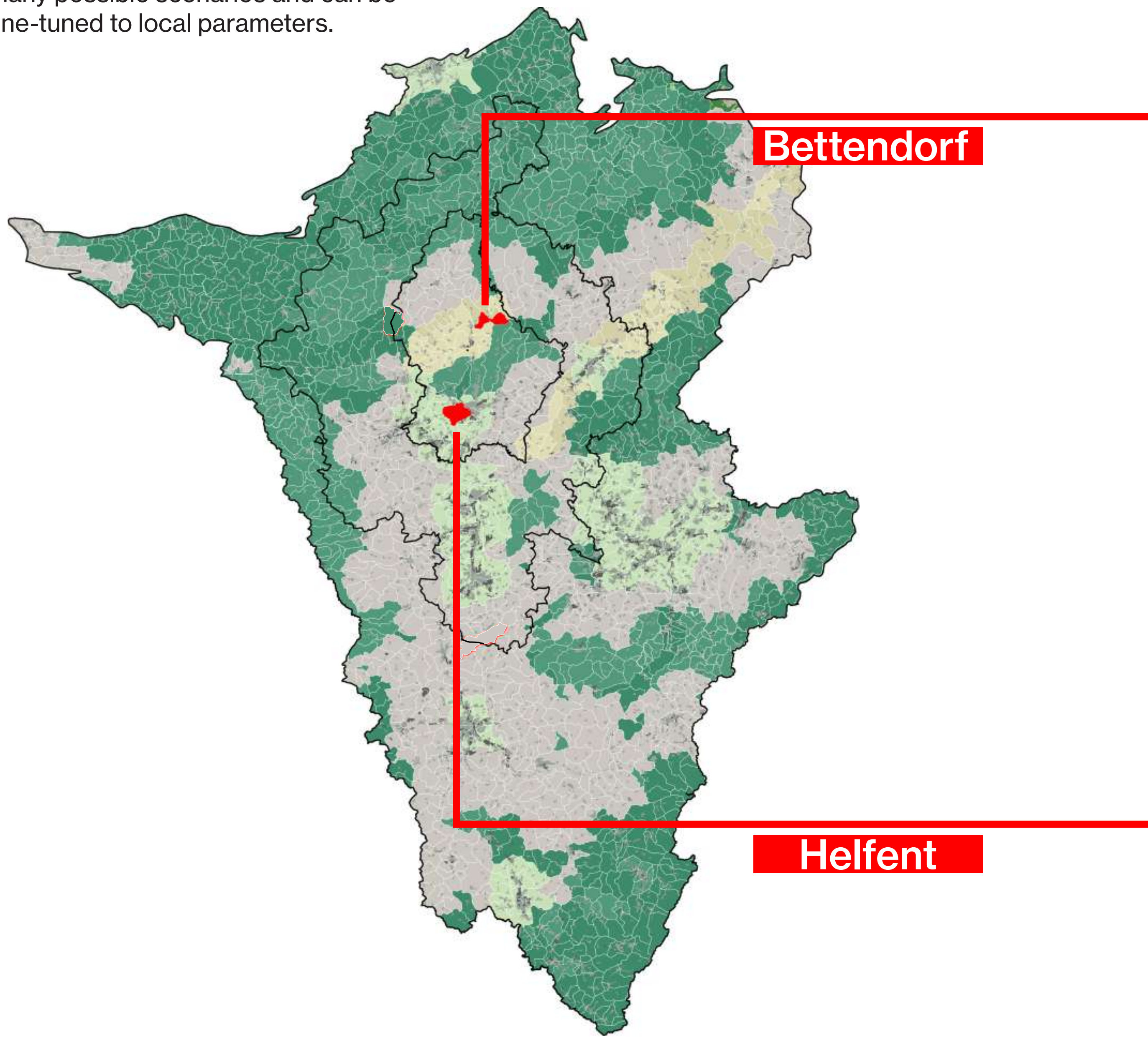
*“If I could run one pilot project, I would make our plates smaller. The size of our portions are a parameter which often falls out of sight. The perception we have by default of what portions is suitable for us is guided by the size of our plates and the standard for the dimensions of these plates have not taken into account the environmental footprint. With smaller plates, we allow ourselves to make more conscious choices on the amounts of food we consume, and that results in a more careful consumption of land for food production.”*

Jörg Nussbaum
Head of cultivation at CO-LABOR

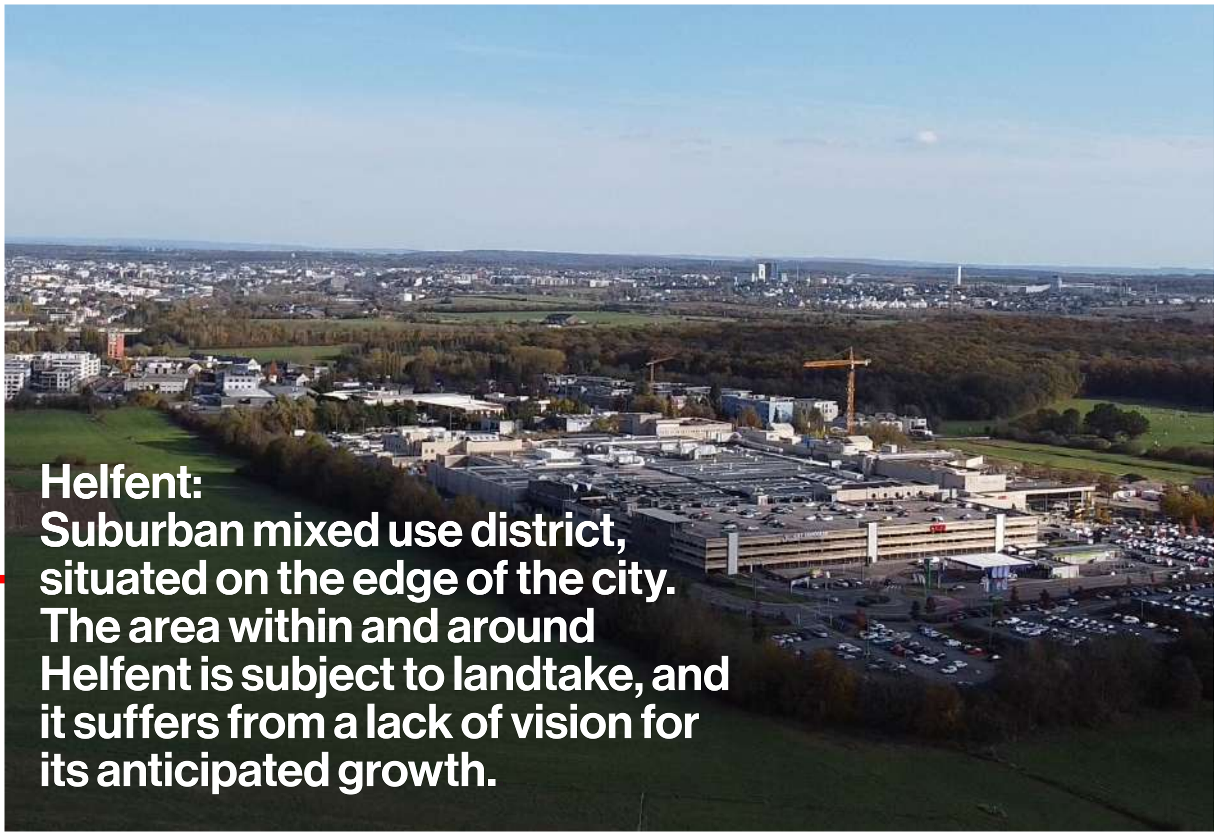

politicians/ governors
farmers/ cultivators
citizens/ consumers
milestone
2050
2045
2040
food autarky by 204
-1.73
net
-0.48
image 1

# Territorial showcases

To show how the proposed strategies could be applied, we have selected two sites with distinct yet familiar characteristics which could be seen as contextual blueprints for suburban and rural areas. These applications are one of many possible scenarios and can be fine-tuned to local parameters.



**Bettendorf:**
**Rural village in the north within the Nordstad perimeter, which suffers from lack of services and employment opportunities. Expanding sprawl is resulting in a gradual loss of character and natural land cover.**



**Helfent:**
**Suburban mixed use district, situated on the edge of the city. The area within and around Helfent is subject to landtake, and it suffers from a lack of vision for its anticipated growth.**

images 2,3

# References


**Text**

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Zhang, D. D., Lee, H. F., Wang, C., Li, B., Pei, Q., Zhang, J., & An, Y. (2011). The causality analysis of climate change and large-scale human crisis. Proceedings of the National Academy of Sciences, 108(42), 17296–17301. https://doi.org/10.1073/pnas.1104268108

**Images**

image 1: RAWDISH (2021). [Photograph]. https://www.rawdish.lu/

images 2, 3: Nathan, P. (photographer). (2015). Aerial views. Luxembourg [photograph]

**Figures**

fig 1: 51n4e, 2001, LOLA. (2021). LiT Report Phase 2. https://luxembourgintransition.lu/wp-content/uploads/2021/06/2phase_2001-komprimiert.pdf

fig.2: European Commission 2018

fig. 3: What are “negative emissions”? | myclimate. (2020). Myclimate.Org. https://www.myclimate.org/information/faq/faq-detail/what-are-negative-emissions/

fig. 4: Larson, S. L., Busby, R., Martin, A., Medina, V. A., Seman, P., Hiemstra, C. A., Mishra, U., & Larson, T. (2017, October). Sustainable Carbon Dioxide Sequestration as Soil Carbon to Achieve Carbon Neutral Status for DoD Lands. https://www.researchgate.net/publication/320808866_Sustainable_Carbon_Dioxide_Sequestration_as_Soil_Carbon_to_Achieve_Carbon_Neutral_Status_for_DoD_Lands

fig.5: 51n4e, 2001, LOLA. (2021). LiT Report Phase 2. https://luxembourgintransition.lu/wp-content/uploads/2021/06/2phase_2001-komprimiert.pdf

fig. 6: Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and case-study. Research Policy, 31 (8–9): 1257–1274.

# *Fast*
# report

# Index, *Fast report*

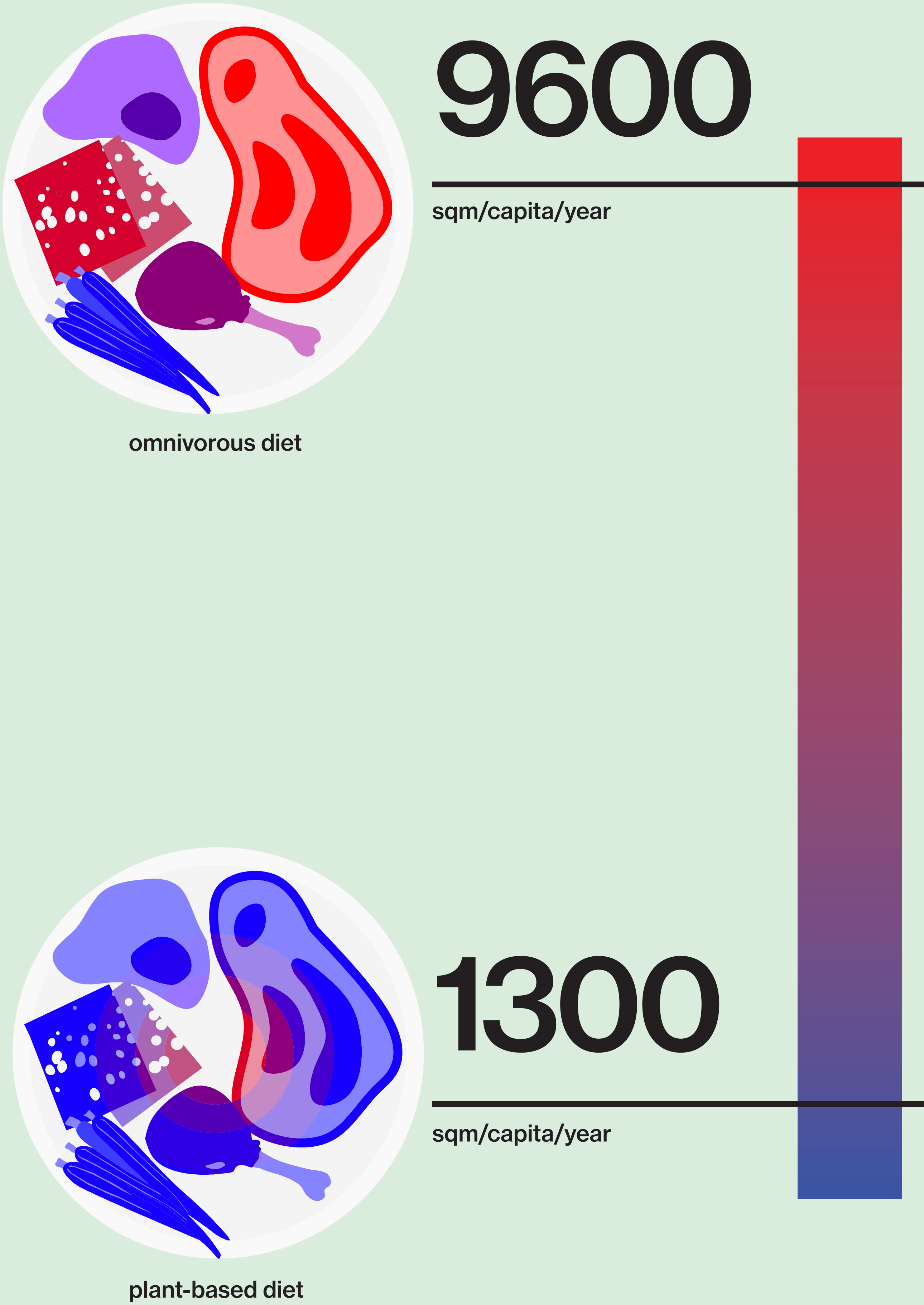



fig 1: Food emissions for food type and equivalent land use.

# Land release
# The dietary footprint

Food consumption is responsible for almost a third of total global emissions. This is not purely due to emissions from farming or packaging. It is an interconnected network of carbonising activities spanning from land use change, farms, animal feed, processing, transport, retail and packaging. That being said, land use change and agricultural practices are the activities which play the major role, and take up 71% of the emissions.

From a carbon footprint perspective; to put in comparison, the average diet in the US accounts for 2050 kgCO2-eq/capita/year, while a vegan diet is only 250 kgCO2-eq/capita/year.

From a land use perspective; the current global diet requires more than 7 times the land a plant-based diet would consume.

**Role of food in global emissions**

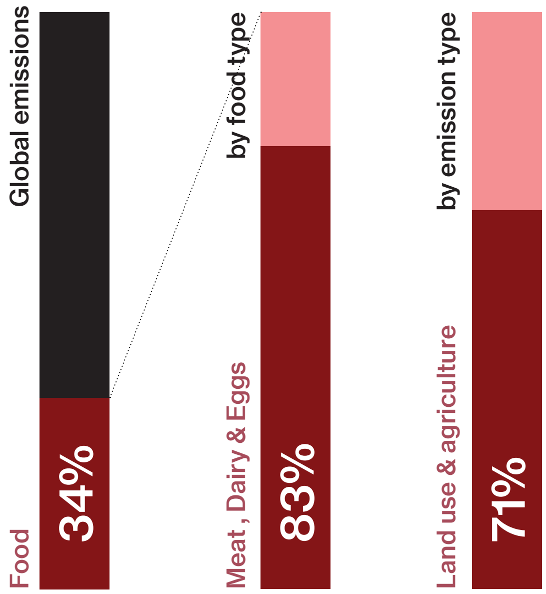



fig 2: Role of food in global emission

These two factors in combination, make a shift in our diets, the most effective measure to take for reaching carbon neutrality targets of 2050 by means of nature-based solutions.

The shift in diet is a highly sensitive topic and it is due to this reason that it is either not discussed, or even when discussed only mild shifts are seen as plausible. This assumption is reflected in the EU's proposal for a diet shift which only recommends a modest replacement of consumption of beef and mutton with meat of goat (European Commission, 2018).

What we have decided to explore, is what we have called the bold shift. We do not believe in a total vegan diet for everyone. However, we anticipate a gradual shift to diets that have a much lower carbon footprints. This shift will not need to occur over night, and does not mean never eating meat or dairy. It is a step by step balancing act towards a healthy future for our ecosystem and a resilient future for our food security. By exploring the bold diet shift, we prove that it is possible for the region the feed itself, reduce its food-related carbon footprint, and enhance negative emissions beyond any of the current projections.

***The Bold diet shift driven by citizens, has the power to parachute the total emissions of the region towards neutrality.***

# Land release; The Bold Diet

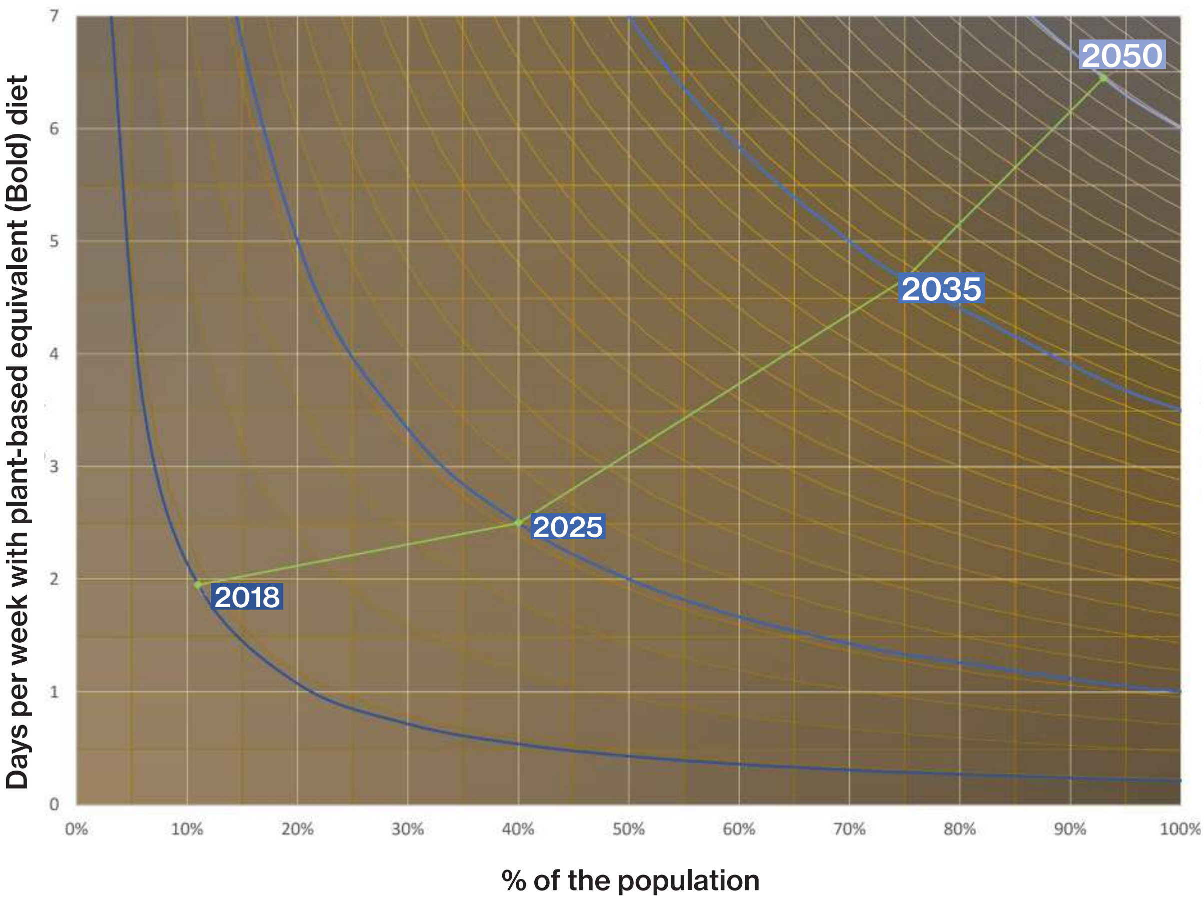
We envision a fundamental but plausible dietary change by 2050, which is illustrated in the following graph. It shows how many percent of the population practice a diet with a similar footprint to a plant-based diet on how many days per week, while the remaining percentage eat meat daily.
The blue lines stand for constant land use requirements, and the green line shows the evolution over time.
We recognized other diets, such as vegetarian and flexitarian, by converting them into plant-based.

Starting from the latest survey from 2018 (TNS Ilres, 2020), we picture the following scenario, which builds on projected market shares of meat and alternative products (Kearney,2020) and political support.

**The Bold diet shift if everyone had the same diet would be as follows;**
**100% of the population will practice a bold diet on 1 day/week in 2025,**

**100% of the population will practice a bold diet on 3.5 days/week in 2035,**

**100% of the population will practice a bold diet on 6 days/week in 2050.**



**“Howcome we have practically no local vegetable production?”**

Karin

citizens committee

**“Gardens produce so much harvest, but so much is thrown away, because the sharing or distribution network is not in place”**

Yolande

citizens committee

**“Could there be a community supported agriculture?”**

Sue

citizens committee

**“If everybody goes for soy milk, where is the soy coming from? ”**

Sandra

citizens committee

**“Could quality food be made less expensive?”**

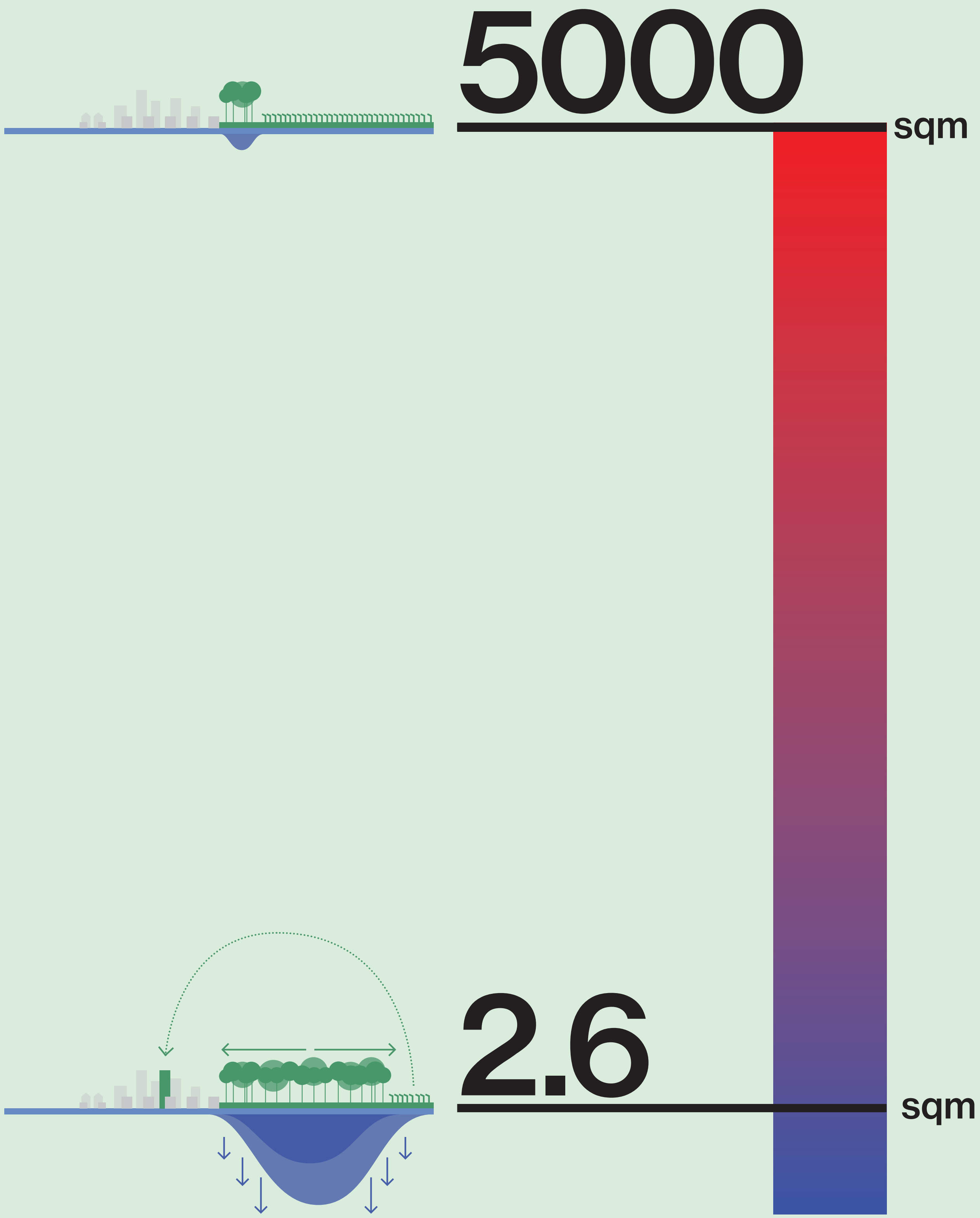
Julia

citizens committee

**“Most people will tend towards low-budget solutions”**

Claudine

citizens committee




Land footprint ratio; If compared to a 5000 sqm traditional farm, a 30 floor high vertical farm will need only 2.6 sqm of land to produce the same amount of produce. 2.6 sqm will contain 78 sqm of floor area over 30 floors.

# Land use accelerators; land efficient food and feed production

As a diet shift, is a society-wide undertaking which can only happen gradually, we have looked into alternatives to reduce the land footprint of food production. Non-soil based farming practices such as Controlled Environment Agriculture and Aquaculture, can produce much higher yields. They can also have stacked floors as they do not need soil. As a result, they can act as boosters in land reduction, and give us the time we need to shift our diet as a society in addition to producing with local and exotic products all year.

We have investigated the potential land impact of an algae farm, and a 30 floor vertical farm, in addition to the sequestration capacity they unleash. Algae have the highest potential for $CO_2$ sequestration per hectare of any plant. Since algae proliferate rather quickly, year-round, they can be grown in three-dimensional space and all of their parts can be used, so the amount of biomass to be harvested in one unit of a field (even up to 150–300 t ha–1) is many times that of field crops. In the future, algae could represent the most significant reserve for $CO_2$ sequestration both for the environment and for food.
When algae are consumed as food their carbon is emitted again so to lock sequestered carbon a percentage of algae production can be used as organic fertilizers to lock carbon in soils and improving soil fertility. Algae used for food production still have a positive impact on decarbonisation due to their land efficiency and carbon sequestration by afforested agricultural land. Algae have a mean of 188.5 (127–250) t biomass/ha/year with a sequestration value of 1.78 kg $CO_2$/kg biomass/year (Bai, 2017)

Controlled Environment Agriculture (CEA) is technology where all environmental factors are controlled. These facilities utilize artificial control of light, environmental control (humidity, temperature, gases...) and fertigation in isolated closed environments. The CEA typology ‘Green vertical farming’ is an important piece in the many efforts to establish urban food security in a world of changing climate (Gerecsey, 2018).

***The $CO_2$ abatement potential for green vertical farming compared to open field agriculture in is 70% reduction with additional benefits of 95% less land used, and 80 to 90% less water use, compared to traditional agricultural systems with equivalent production*** (Gerecsey, 2018).

Vertical farms reduce input costs, allow for production to be geographically close to the point of consumption, and create the opportunity to produce crops year-round. Vertical farming correlates more to creating different and controlled environments for growing produce than preventing or minimizing the damage caused by the climate in traditional farming locations. Vertical farms are deployed close to the point of consumption, their products reach their customers quickly, and therefore more nutrients of the crops are preserved (Gee, 2021). This reduces spoilage and food waste by growing exotic crops locally (Warzynski, 2021).

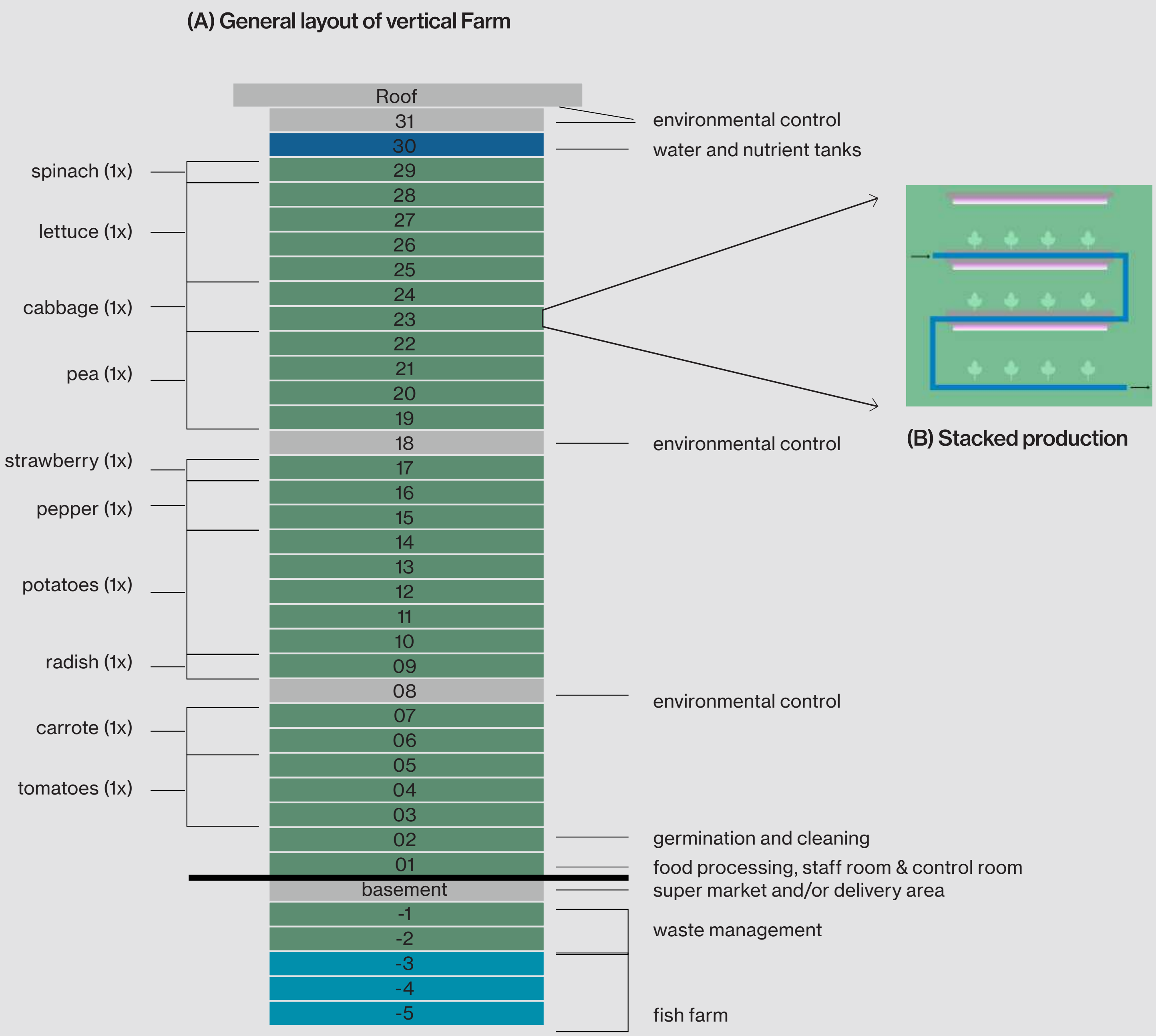



fig. 3

# Small land footprint due to multiple production floors (A) and stacked production (B)

# Benefits in reliable production and local crop diversification

Such a fully controlled environment with no losses from weather and pollution impacts with lowest food losses (linked to transportation, pest loss, reduction of unsold products) results in a reliable and year-round marketable production (Gerecsey, 2018).

Another group of foods that could be profitable are 'exotic foods', since these do not have to be imported (Geemente Rotterdam, 2018). An enticing example is Banana cultivation in greenhouses in Hveragerði. Where Icelanders operate the northernmost banana plantation in the world. The Icelanders have a dream of completely self-reliant. That goes for their tropical fruit consumption as well (Icelanders operate northernmost banana plantation in the world, 2019).

image 1: the northernmost banana plantation in the world

image 2: Stacked production

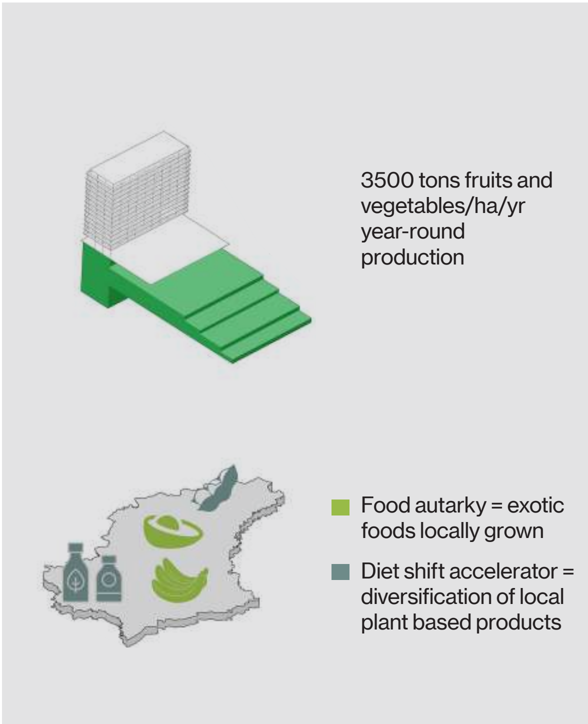
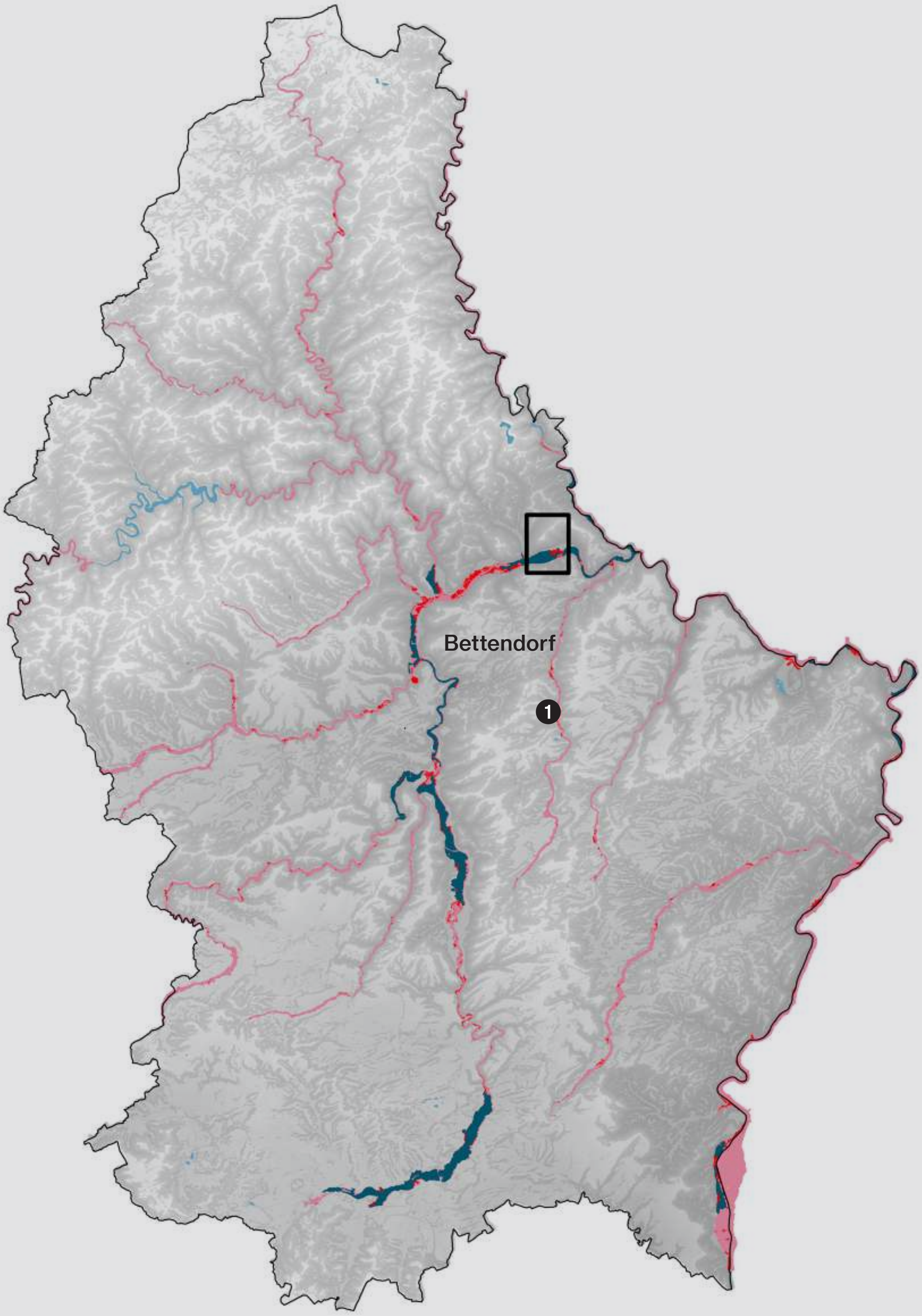



fig. 4: CEA accelerator: food autarky and diet shift

***Can decarbonisation of our productive landscape be used as leverage for ecological and climate resilience?***




Urbanisation in flood risk zone

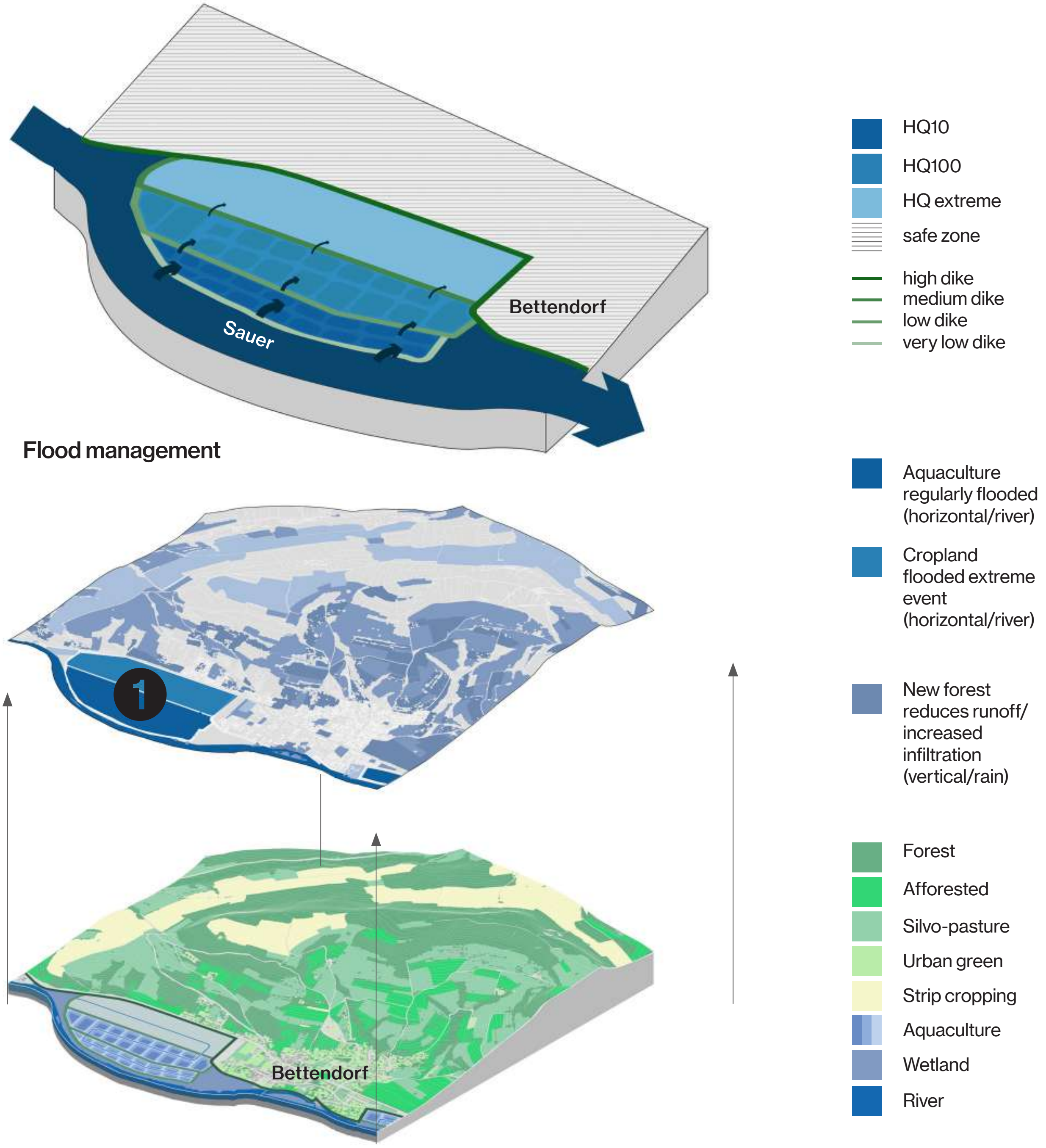
Search areas suitable for aquaculture

Flood risk zone HQ extreme

# Aquaculture’s yield efficiency enables reduction of food production’s land footprint in addition to providing flood water storage.

# Combining food production & flood water storage by aquaculture

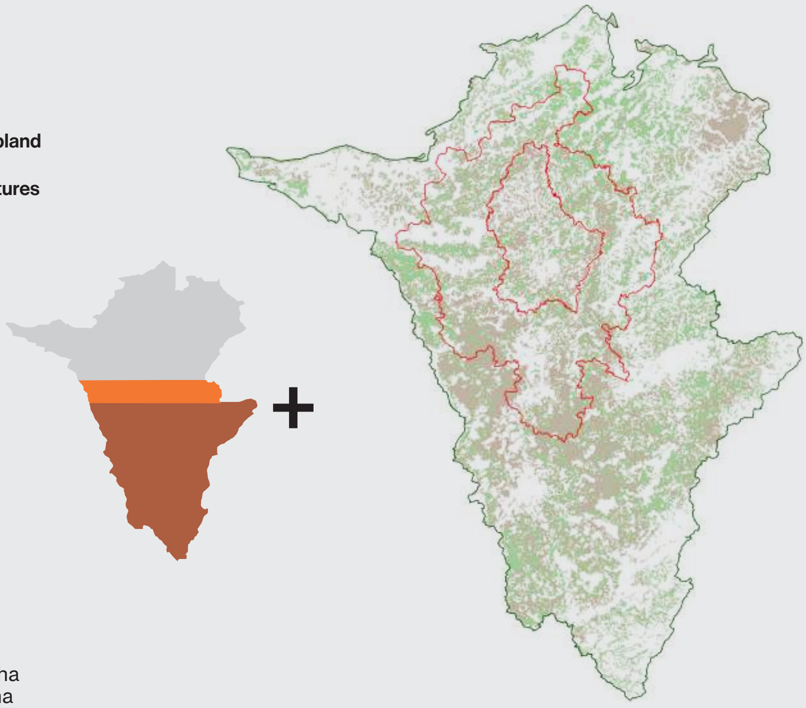
**Horizontal (river) flood relief**




**Land-use 2050**

## 2018

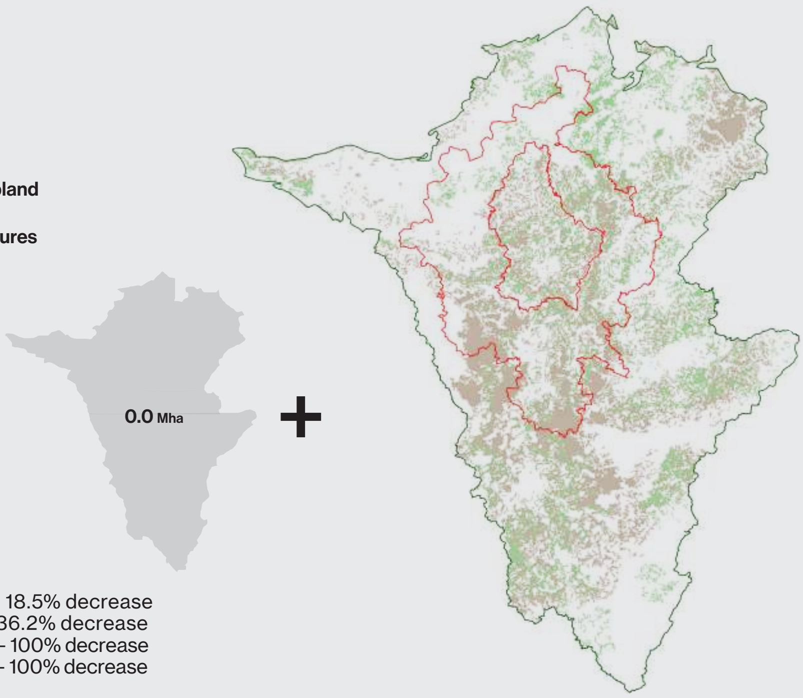
- Cropland
- Pastures
- International cropland
- International pastures




Cropland: 1.06 Mha
Pastures: 0.81 Mha
Int. cropland: 0.32 Mha
Int. pastures: 2.21 Mha

## 2050

- Cropland
- Pastures
- International cropland
- International pastures




Cropland: 0.86 Mha - 18.5% decrease
Pastures: 0.51 Mha - 36.2% decrease
Int. cropland: 0.0 Mha - 100% decrease
Int. pastures: 0.0 Mha - 100% decrease

# -3,3Mha

**decrease in land footprint of food consumption**

## The land surplus; drivers & quantified impact

The Bold diet shift with assistance of Land Use Accelerators, are able to release half a million hectares of land from food production in the bioregion. Other than protecting this valuable natural land cover which we will elaborate on in the next two strategies, we need a vision for what role this surface can play for the territory. Based on our maximum sequestration ambition and the increase of carbon sink surface area discussed in the introduction, we have developed a variety of afforestation scenarios in the second phase, which guide our territorial outlines.

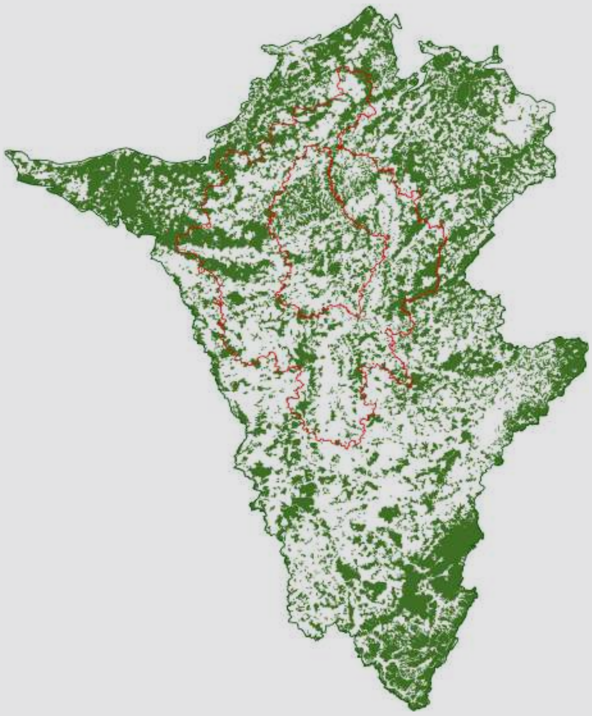
By afforestation, we have tried to connect the existing forests and biodiversity corridors, in addition to preserving the land parcels which have the suitable abiotic conditions in 2050 for food production.

# 500,000

**hectares of pastures & croplands of BFUR can be freed by 2050**

## 2018

Forest

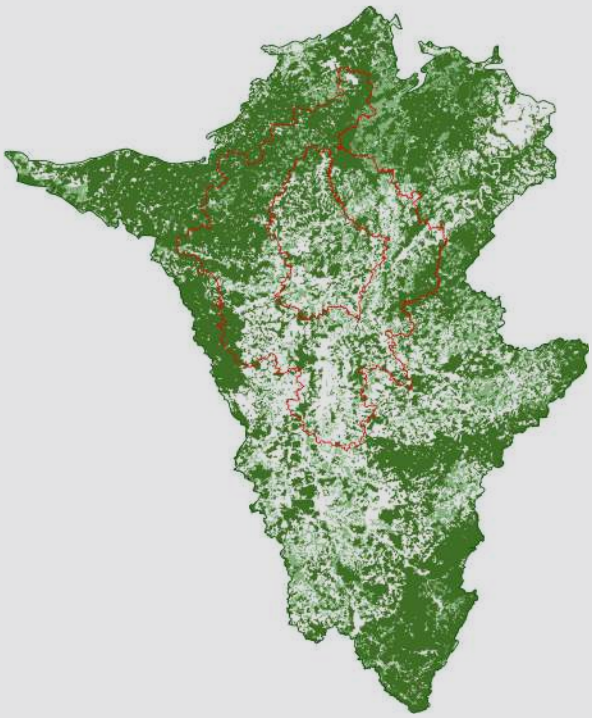


Evergreen production forest: 0.61 Mha
Deciduous Forest: 1.00 Mha

## 2050

Agroforestry

Forest



Reforested Deciduous Forest: 0.61 Mha
Regenerated Deciduous Forest: 1.00 Mha
Afforestated agricultural land: 0.49 Mha
Agroforestry/silvo-pastures: 0.51 Mha

# +1Mha

**increase in surface area of forestry and agroforestry**

# The land surplus: afforestation towards maximum SOC

Afforestation is our primary sequestration vehicle. As maximum sequestration and soil carbon stock is our ambition, we have envisioned the land released from food production and protected by Net-zero growth, to be afforested. These afforested lands also contribute to strengthening water infiltration, biodiversity, timber production, and leisure networks. The forests have been placed in positions which weave the network of existing forests to create continuity in biodiversity corridors. With close to nature forest management, ecological resilience could be married with timber production. With the help of transparent cross-border timber value chain platforms, smaller multi-species forests can also become an active member in the timber market, generating financial incentives for the many small forest owners to take part in the forestry sector more actively.

## Leisure

The belts and necklaces created by afforestation, provide the opportunity for accessible green passages around and between cities and villages. These treks can be complemented with other leisurely activities, and services. Together they form vibrant ecofunctional spines for communities who live around them.

## Timber

The wood cluster in Luxembourg has developed a platform where small forest owners and timber purchase enquiries will gain visibility. Trees will be registered in type and tagged, so that when a demand emerges, there is a clear understanding of where and what are the available trees. They will then be harvested with close to nature forest management.

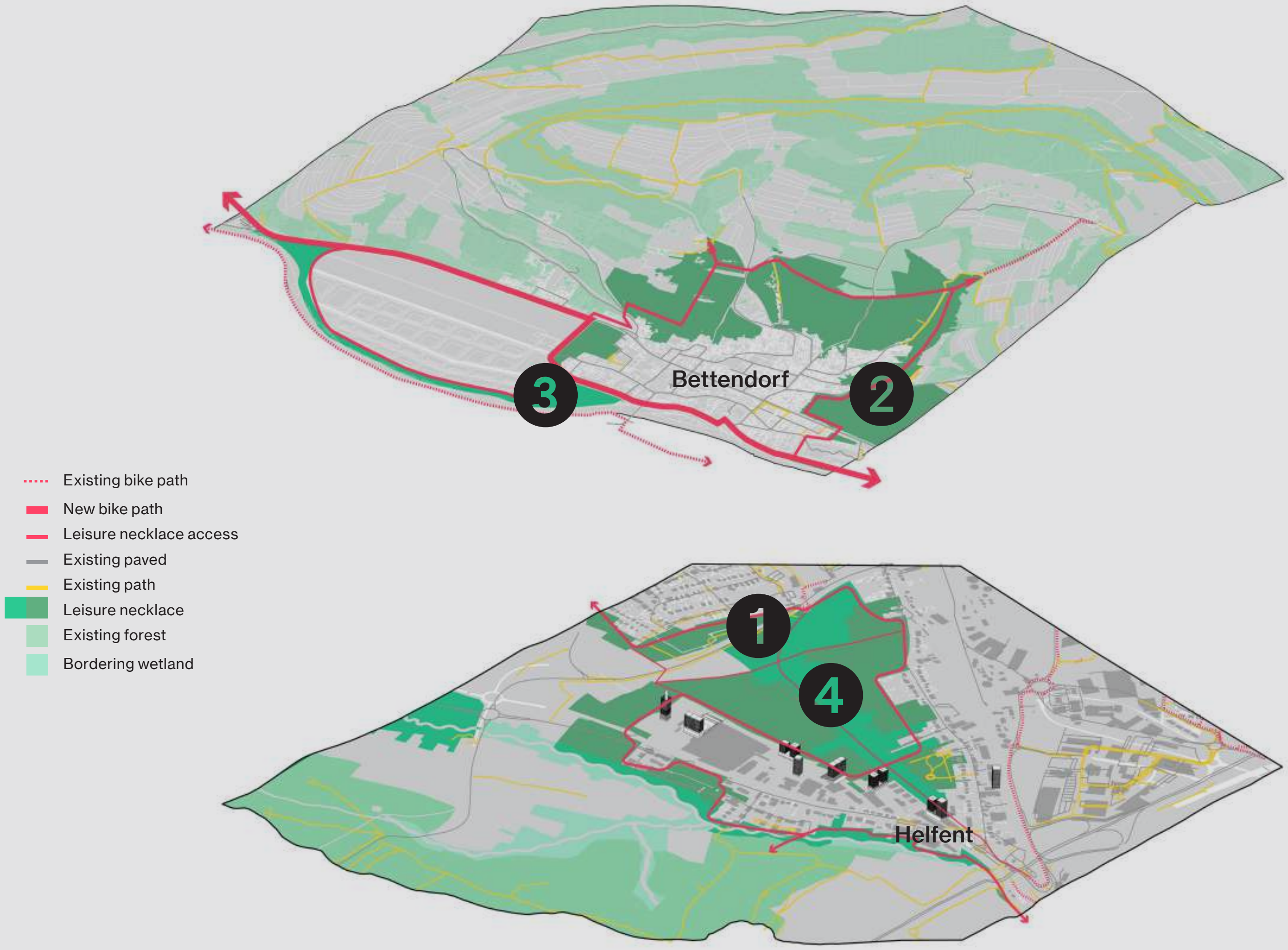
## Biodiversity

a productive forest is not in contrast to a healthy forest. With close to nature management we can enhance the health of our forests. In addition, by connecting the disconnected clusters of forests through afforestation, we can regenerate biocorridors which contribute to biodiversity, and bioeconomy.

## Water

A systematic approach towards forestry, agroforestry and silvopastures, will result in long-term benefits for the regional water footprint. By enhancing water infiltration and absorption of water run-offs before they reach the rivers, they can play an active role in flood mitigation.

# Leisure necklaces and public forests





Afforestation can increase to footprint of public forests which can act as new commons. These new forests can host a range of activities includings leisure, in addition to contributing to natural habitats for other species. These multilayered landscapes would be connected to each other and will improve the connetivity of areas they stand in between.

# Public forest as new commons

The urban fringe can be seen as 'planning's last frontier' arguing that areas abutting towns and cities have been largely neglected by land-use planning and by those agencies, public and private, with direct or indirect planning responsibilities (Gilhespy, 2020).

The rural-urban fringe is a diverse, dynamic, multifunctional region in terms of historical development, biodiversity, production, recreation, identity and landscape aesthetics It frequently consists of open and green spaces and alternative land uses, different from the densely built-up urban areas. Thus, it has the potential to be used for recreational and agricultural purposes of the citizens (Gündel and Kalonya, 2021).

The "common space" approach aims to repair the disconnection between natural, urban and rural zones, and it also aims for people to experience these areas with social activities. The term commons can be defined as the "tangible and intangible spaces of the public use and collective ownership that belong to society with free access"(Gündel and Kalonya, 2021).

image 3: Sportspark Genk by LOLA and LIST

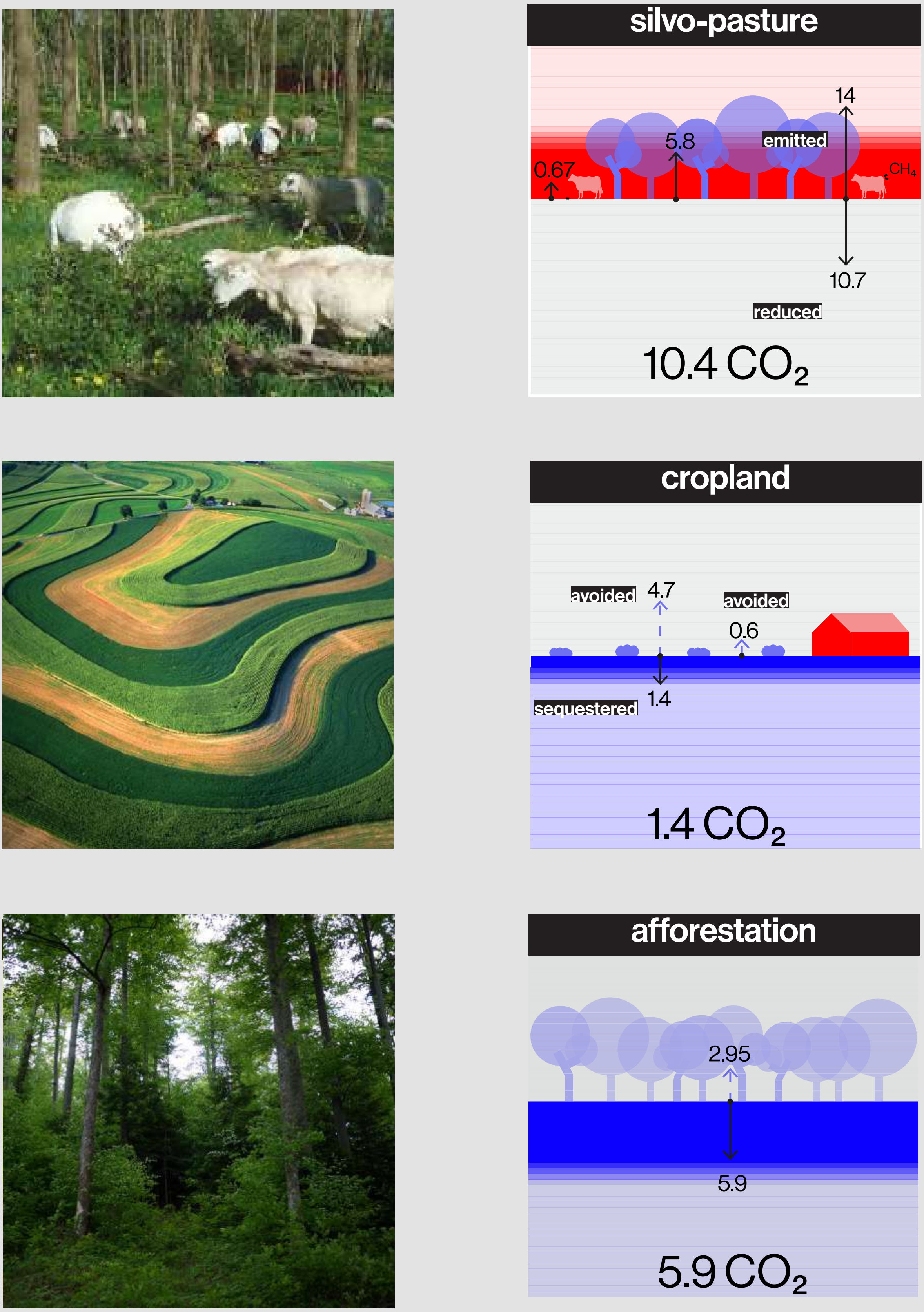



fig. 5: Total emissions/sequestration of 1 ha of land in cropland, silvo-pastures, pastures, reforestation, climax forest and afforestation.

# Carbon farming

For the remaining farmlands, it is vital to begin a transition to sequestering practices. Farming practices can play a crucial role in nature-based decarbonisation. As shown in the previous phases, practices such as silvo-pastures, afforestation and implementation of hedges on croplands and pastures are important sequestration tools able to mitigate carbon emissions. As an example, hedges reconstruction has two effects on SOC storage: local effect of SOC storage under the hedge itself and an anti-erosive effect locking SOC at the hillslope scale. Such practice has been implemented in Wallonia, who has declared to reconstruct 4000 km of hedges. Since the coalition agreement was concluded in 2019, 45 km of hedges, 1.7 km of undergrowth, 800 row trees and 1,900 fruit trees have already been planted (Region of Wallonia, 2019).

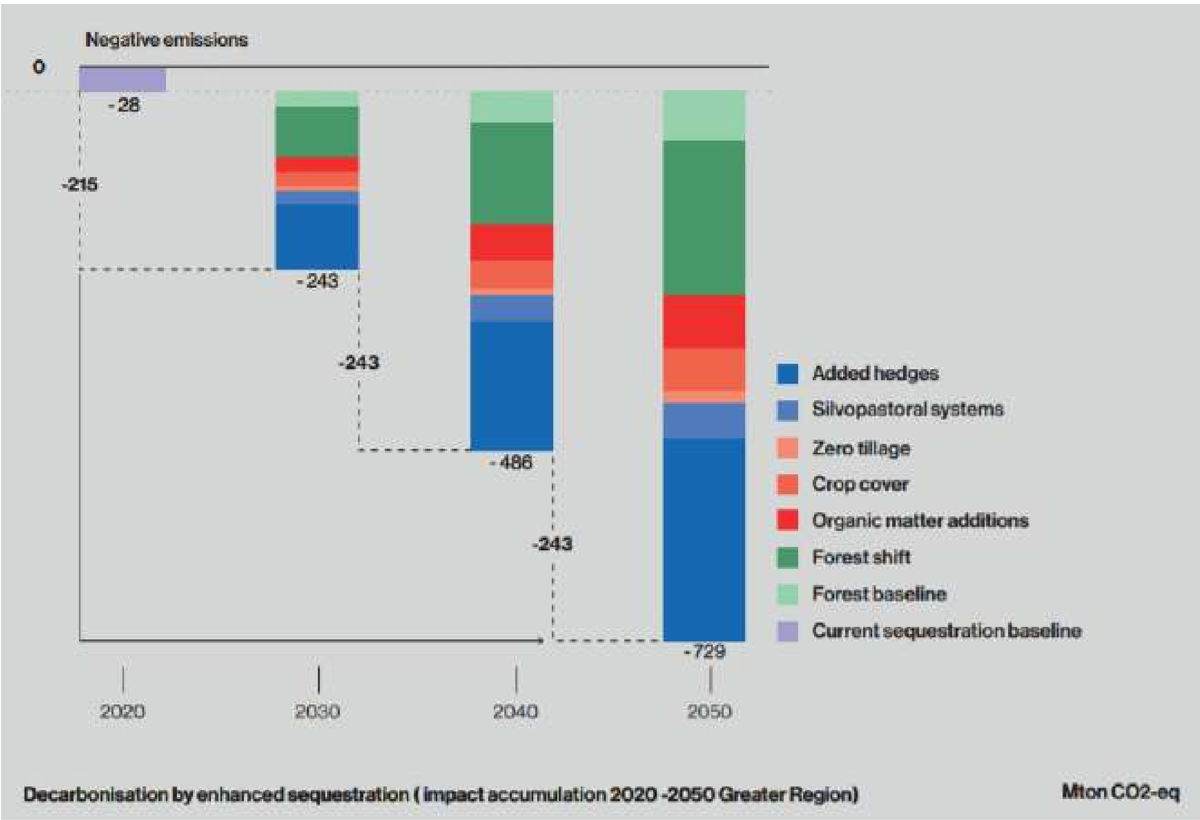



fig. 6: Decarbonisation by enhanced sequestration (impact accumulation 2020-2050 Greater Region). Mton CO2-eq.

# Net Zero Growth

**All you can eat territory**
Luxembourg has the 4th highest landtake rate in Europe (EEA,2019) which represents a land consumption of 0,5 ha per day (Fourmann and Tholl, 2019). If the built footprint grew from 1,63% to 1,74%, roads and parking spaces flourished at the same time from 5,73% to 6,24% of the territory (Liser, 2013), making Luxembourg the most fragmented landscape of the Greater-Region .
By 2020, built surface and infrastructure accounted for 15% of the national territory, up from 8% in 1990 (Fourmann and Tholl, 2019). At this rate, the country would be fully covered within the next 350 years.

**Perimeter Plague**
If over the last fifty years collective housing has steadily grown into becoming the dominant building typology, in 2018 single family houses still accounted for 28% of all buildings materializing landscape fragmentation and suburbanization (STATEC, 2018). If this housing typology still accounts for 1/3 of buildings, it is because zoning plans, building perimeters and communal politics still promote its dissemination.

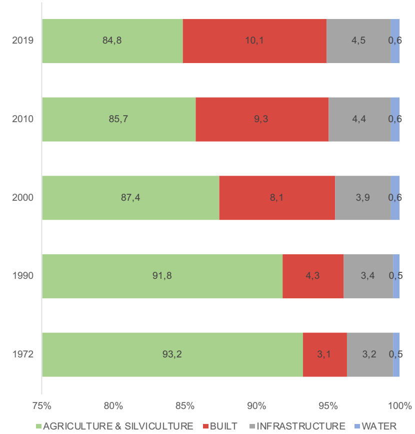


fig. 7

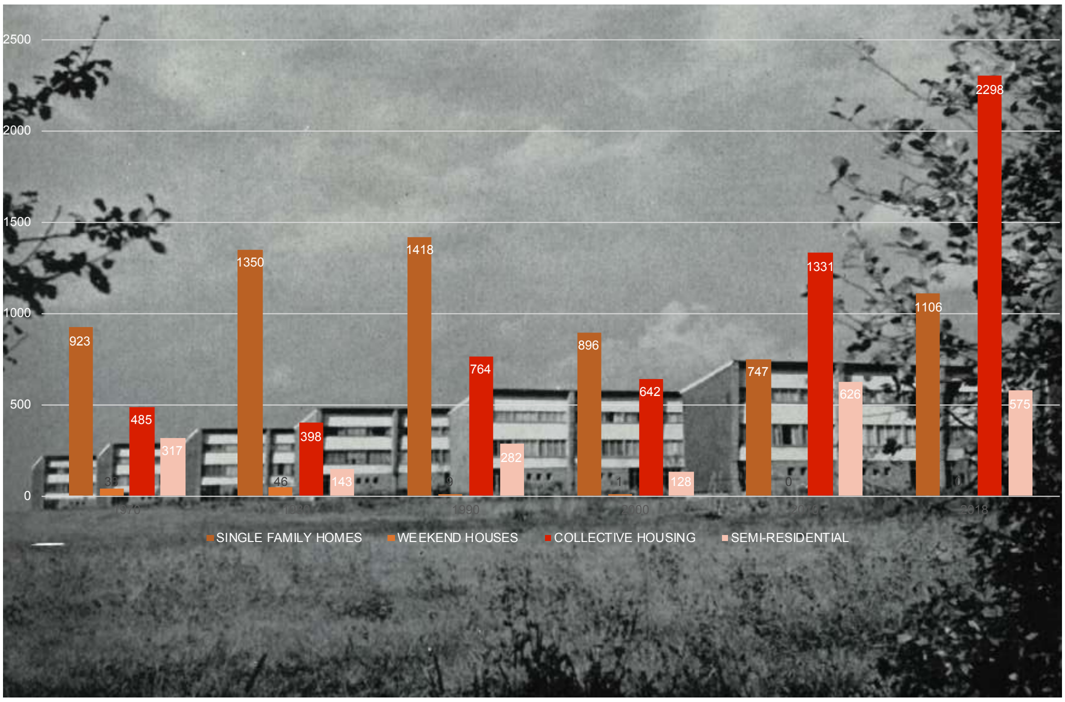


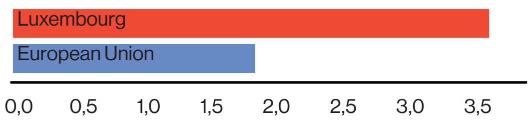

fig. 8: Housing Typologies. Habitations ouvrieres a Esch-sur-Alzette, Cite Eugene Reichling, Architectes Jemp Michels et Robert Lentz

## Collateral damage

Apart from losing the capacitiy of sequestering up to 7,5tCO2/year (Brown et al., 1996), landtake comes at a high collateral price both for private households as much as for the public realm:  the spreading of built tissue imposes the construction and maintenance of infrastructure, from roads to sewer systems. A built heritage which is becoming a structural burden for generations ahead.

In 2016, Luxembourg topped EU government expenditure on transport with 3.7 % of GDP (Eurostat, 2016) , while private household expenditure on personal mobility went up from 16,7% in 1999 to 19,2% in 2008 of total spending (EEA, 2011) .

The latter indicates an additional phenomenon: suburbanization and the loss of centrality is followed by the exodus of amenities from rural villages into specialized clusters or more urban areas.




a fragmented territory demands mobility:
expenditure on transport % GDP

The single-family home thus makes its inhabitants more dependant from mobility and turns village communities into dormitories.
It is therefore paramount to revise our communal building codes and zoning plans.

Where villages could once cope with 20 meter high silos or flour mills and the related tractor activity, 4 to 5 floors buildings with activated groundfloors on sealed land could reanimate town centres, both economically and socially.

image 4: a tale of 2 scales. Zettinger Mill, Bettendorf.

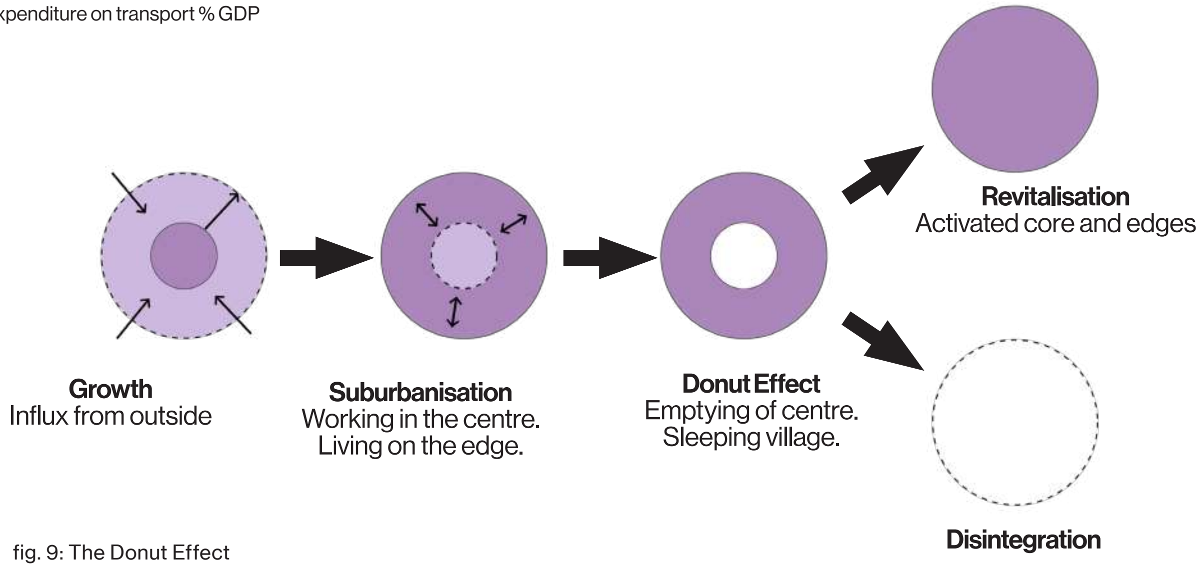


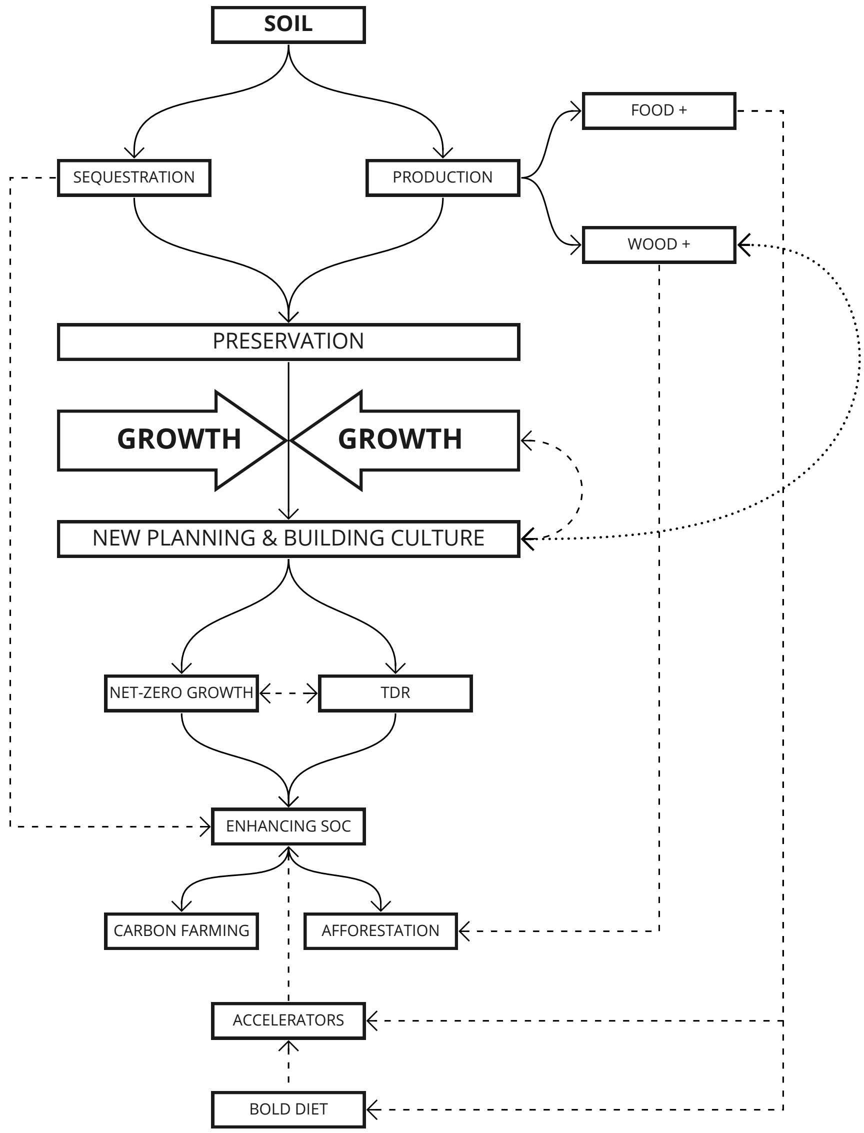

fig. 9: The Donut Effect

# Where and how, now!
# On transforming cultures of planning & construction.

***In order to allow the development of the region and promote smart demographic and economic growth while activating the soil's capacity for carbon sequestration and optimized production, current cultures of planning and construction will need to be transformed*** (US EPA, 2021) (GGDL, 2020).

If the question of where we build is paramount, how we build will have major implications on the carbon footprint of our buildings and our construction industry, on (r)urban resiliencies (Mariani, 2018) and might potentially lead to the advent of new regional economic value-chains.

The current planning culture, as an operational expression of the political silo system, still promotes the fragmentation of the territory into zones of specialized i.e. sectoral activities, leading to the sprawling of our towns and cities at a high investment

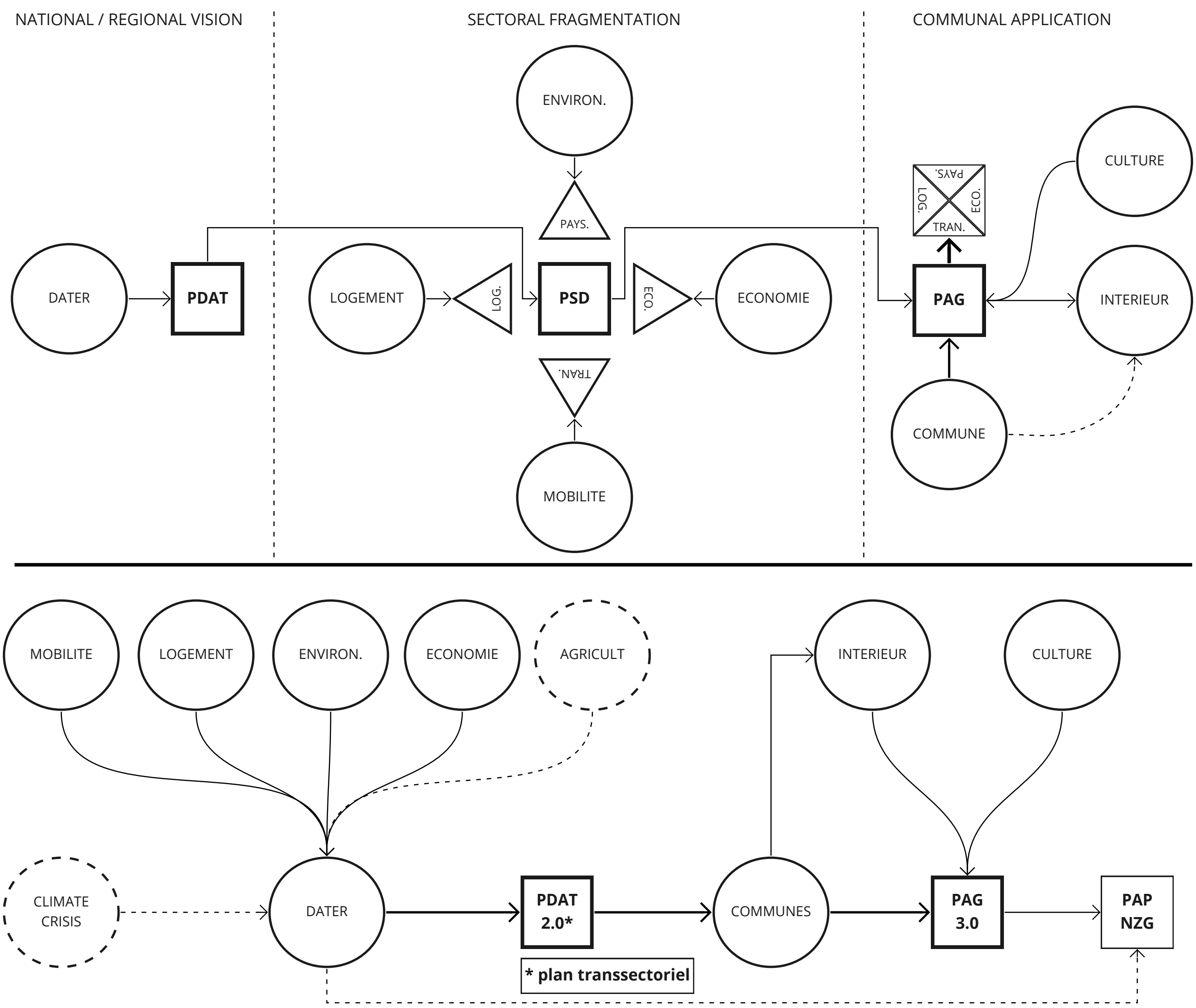


and maintenance cost of public infrastructure (Coubray, 2021).

The dissemination of the single-family home, of the activity zone hangar, of the business park building (...), collaterally provoke the weakening of social coherences and communities within villages and/or neighbourhoods and ultimately lead to the loss of (r)urban and landscape identities.

image 5: Ingeldorf, fragmented landtake with reminiscences of agriculture.

**Territory: disassembled through sectoral thinking**



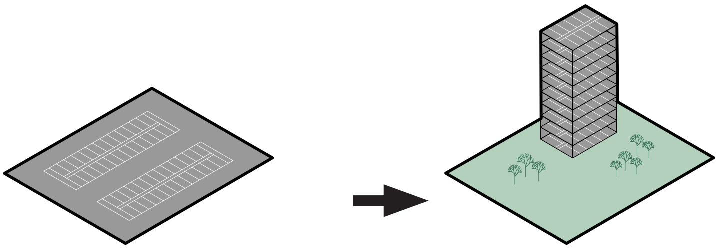
Protecting unsealed land in order to exploit its full sequestration and/or production potential can help to overcome the current status-quo of average planning and building reflexes which are in fine dissolving urban structures at the cost of communities.

***The objective of zero landtake imposes the development of daring yet appropriate planning approaches resulting in specific built applications.***

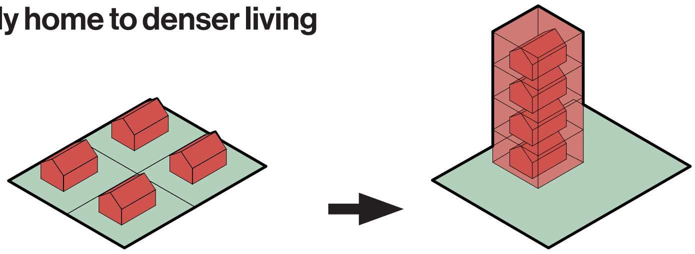
Three studies (LISER, 2021) recently revealed that “there is enough potential land for accommodation in Luxembourg”(Heindrichs, 2021). To solve the equation, underused capacities of already sealed land need to be identified, mobilized and activated, in a transitory time by tools like Transferable Development Rights, TDR.

These neglected potentials sit either within urban tissues, where they are already

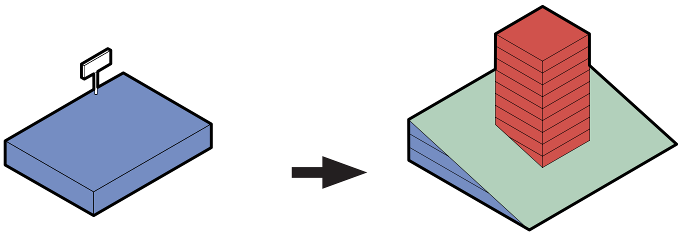
**1. Reclaiming sealed surfaces**



**2. From the single-family home to denser living**



**3. From a monofunctional archipelago to a cross-sectoral neighborhood**

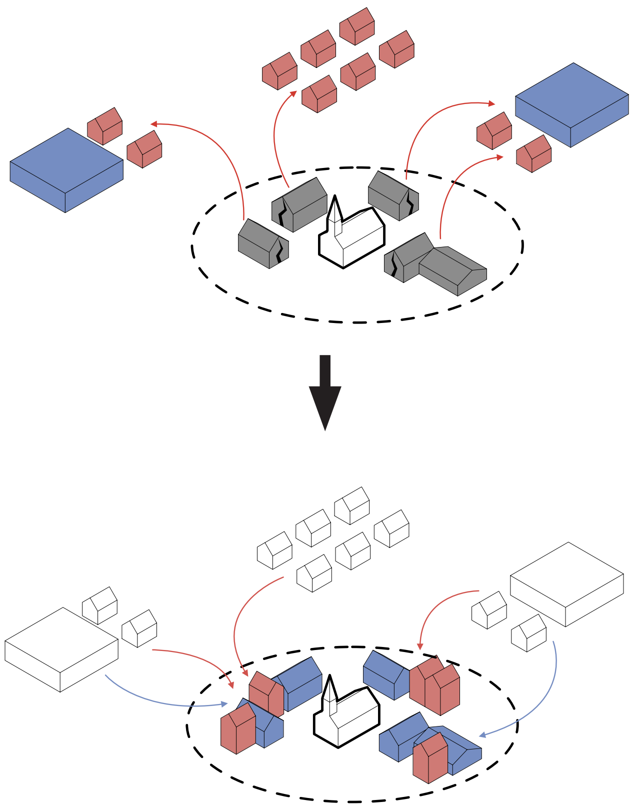


being monitored by Baulücken programmes (GGDL, 2016), or also and foremost in suburban / peripheral and rural contexts (LISER, 2021).

In the latter two, by overcoming sectoral specialization and fragmentation, underused spatial potential can become a key asset in strengthening and/or fostering (r)urban identities.

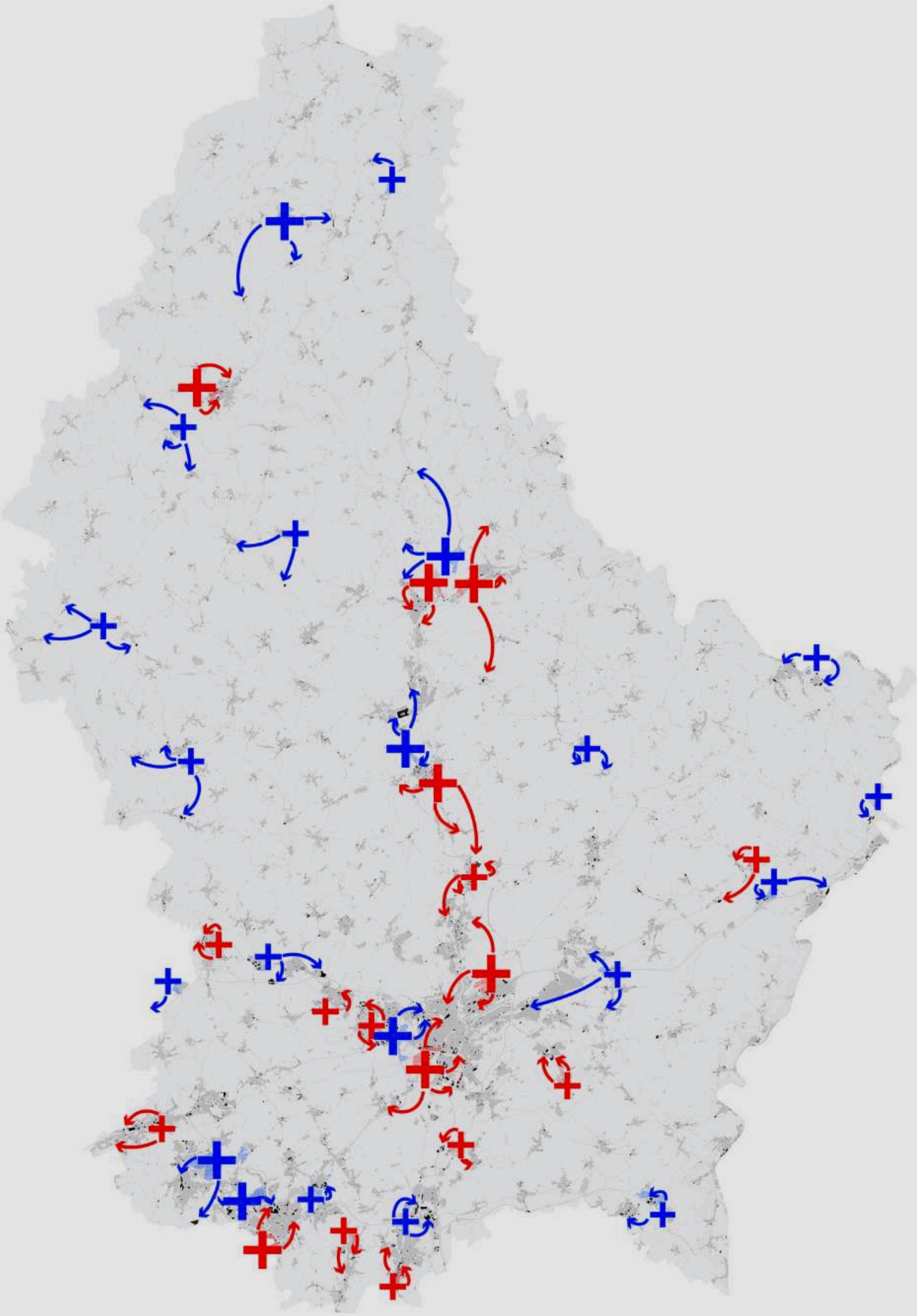
2 case studies serve as epitomes symptomatic for the region beyond its small-city urban conditions:
***Subarbia, & Ruralia***

### 1. From diffuse suburban developments to a concentric village structure



Fast report

**Land protection by TDR**



# Battle of Luxembourg

“Battle of Luxembourg” showcases the territorial spread of landtake. Housing expansion zones are presented in red crosses, and economic expansion zones in blue crosses, as foreseen in the sectoral plans. The arrows suggest a redistribution of expansion zones by prioritising underutilised land, such as brownfields and large open-air parking lots. To meet the net zero landtake ambition of the territory, property rights and land management needs to be rethought.

***Of the sealed surfaces in Luxembourg, 43,8 % are due to residential buildings.***

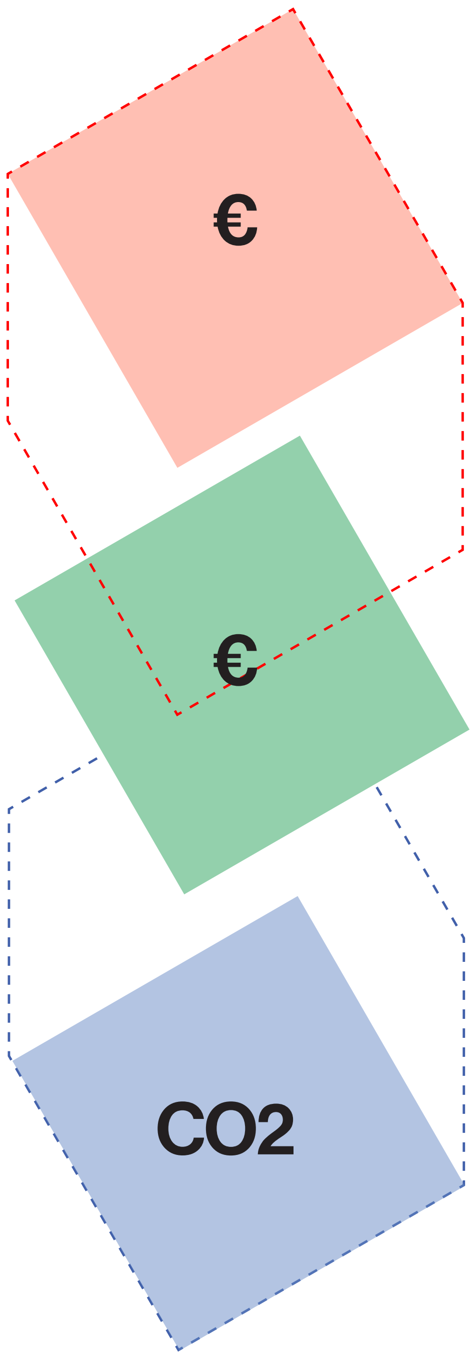
**(Fourmann and Tholl, 2019)**


image 6


image 7

# *Can we sustain growth without landtake?*

# Property as a bundle of rights




## Development right

Developer's interest;
profit from end product (as anticipated in the PAP table) minus land value and building cost.

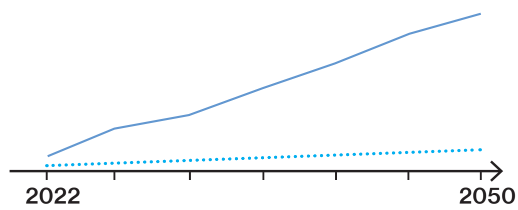
| | | | |
|---|---|---|---|
| COS | 0.24 | CUS | 0.84 |
| CSS | 0.5 | DL | 66 |

## Ownership right

Landowner's interest;
increased value of land due to development rights

## Subsurface right

Public interest;
capacity of soil for natural decarbonisation (as anticipated in the negative emission timeline of the parcel)



# TDR principles

In the law of the medieval Roman empire, whoever owned soil, the ownership extended up to the heavens and down to hell. In this way land ownership was attached to what sat below and above it. In the 20th century, TDR was born to protect values of public interest against increasing land values while still allowing for private interest to benefit from speculative development. With this tool, development rights and speculation could be detached from the land, designated for preservation, by purchasing the right of building from the owner. That right could then be transferred to another site, assigned as a receiving zone.
For such transactions to happen, reaching a consensus over the selection criteria of sending and receiving zones is paramount. To do so we need to understand what our common values are for preservation of land. As maximising negative emissions and net zero landtake has been our goal, we have identified sending zones as current expansion zones identified in PAG documents. And as for receiving zones we see all sealed surfaces and underutilised structures as destinations for such transfers.

For natural landscapes under threat from landtake, which we categorised as our sending zones, we need to consider three categories of rights; Ownership and use rights which are assigned to the landowner. Development rights above ground which are of economic interest to the land owner and developer. And finally the subsurface rights beneath the soil, which are of environmental interest to the society and the planet. The TDR mechanism allows for the land owner and developer to retain their speculated financial gain while allowing for natural landscapes to be preserved and play their essential role in decarbon-isation of the territory (Commonweath of Massachusetts, 2020).

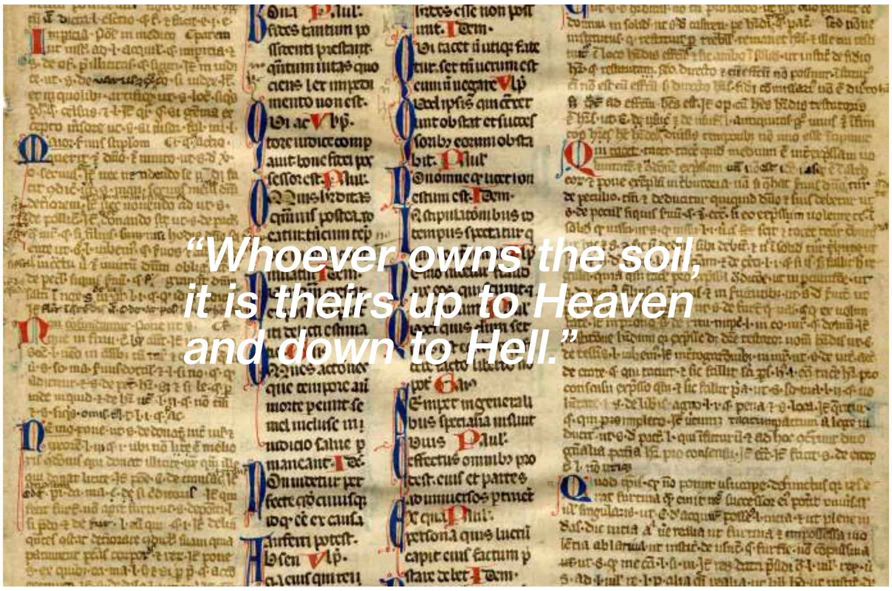
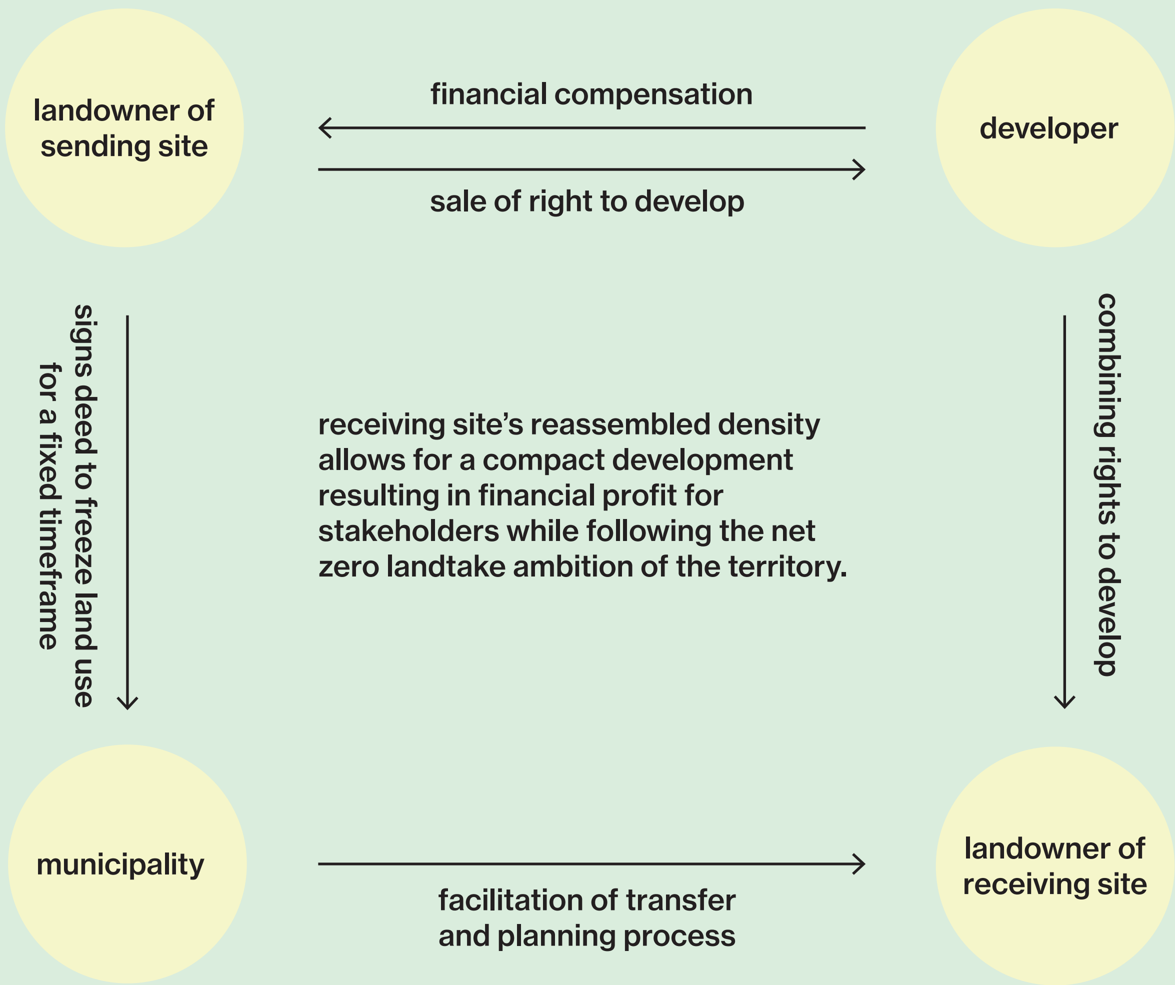
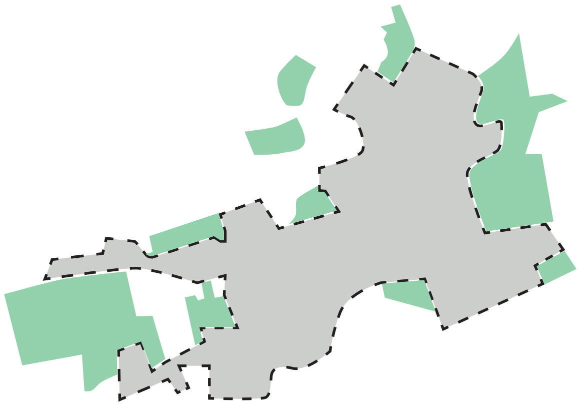



image 8: Justinian, Corpus iuris civilis. (1275).

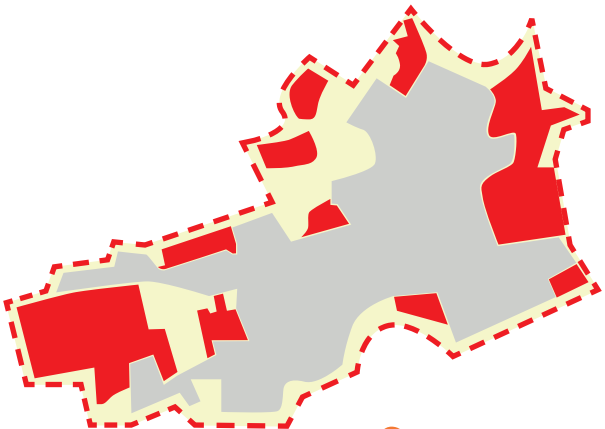

landowner of sending site
financial compensation
sale of right to develop
developer
signs deed to freeze land use for a fixed timeframe
receiving site's reassembled density allows for a compact development resulting in financial profit for stakeholders while following the net zero landtake ambition of the territory.
combining rights to develop
municipality
facilitation of transfer and planning process
landowner of receiving site

## Overview of transaction

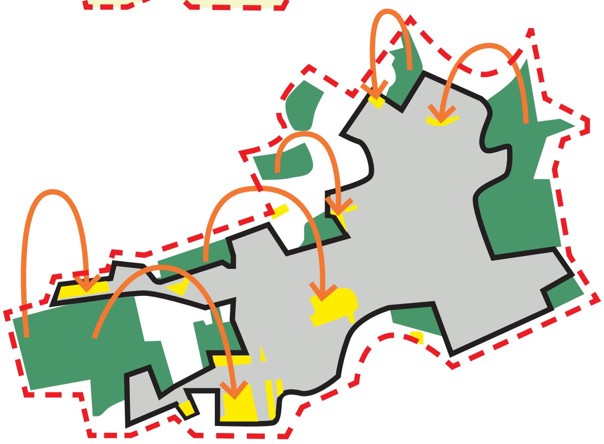
### 1 Peripheral arable lands under pressure from landtake



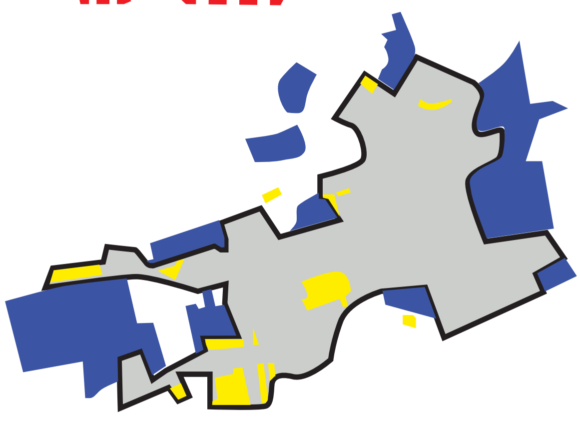
### 2 Expansion of building perimeter in PAG to release pressure. Introduction of development rights to arable lands resulting in landtake



### 3 Transfer of development rights from arable sending sites to sealed receiving sites



### 4 Achieving economic return from receiving sites, and natural decarbonisation on sending sites.



# 2022

the decision for new zoning of the two exemplary sites below, is driven today by conventional planning regulations and economic interest. We foresee a pathway were without compensating the economic interest we can meet the environmental ambitions of Luxembourg in Transition.

# 2050

conventional planning
result in economic pr
involved, and it come
environmental health
community.

| | |
|---|---|
| 0.3 | 0.7 |
| 0.5 | 40 |

**Sending site; arable land**

**Transferrable De**

| | |
|---|---|
| 0.5 | 1.1 |
| 0.8 | 45 |

**Receiving site; parking**

**current PAP**

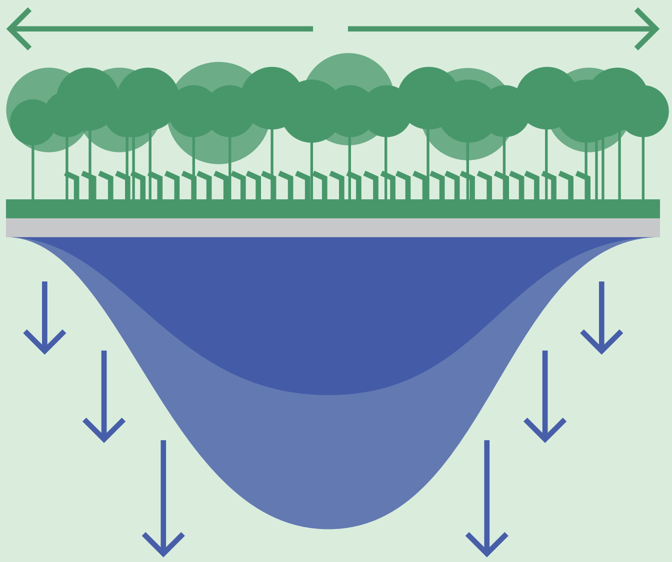
## 0 BAU

g of these 2 sites will
ofit for the parties
s at the cost of
and interest of the

## 2050 LIT

with TDR, the economic profit of the parties involved will remain intact, while the environmental score of the interventions will be preserved and enhanced.

| | |
|---|---|
| 0.0 | 0.0 |
| 0.0 | 0.0 |



velopment Rights

| | |
|---|---|
| 0.1 | 1.3 |
| 0.1 | 91 |

new PAP

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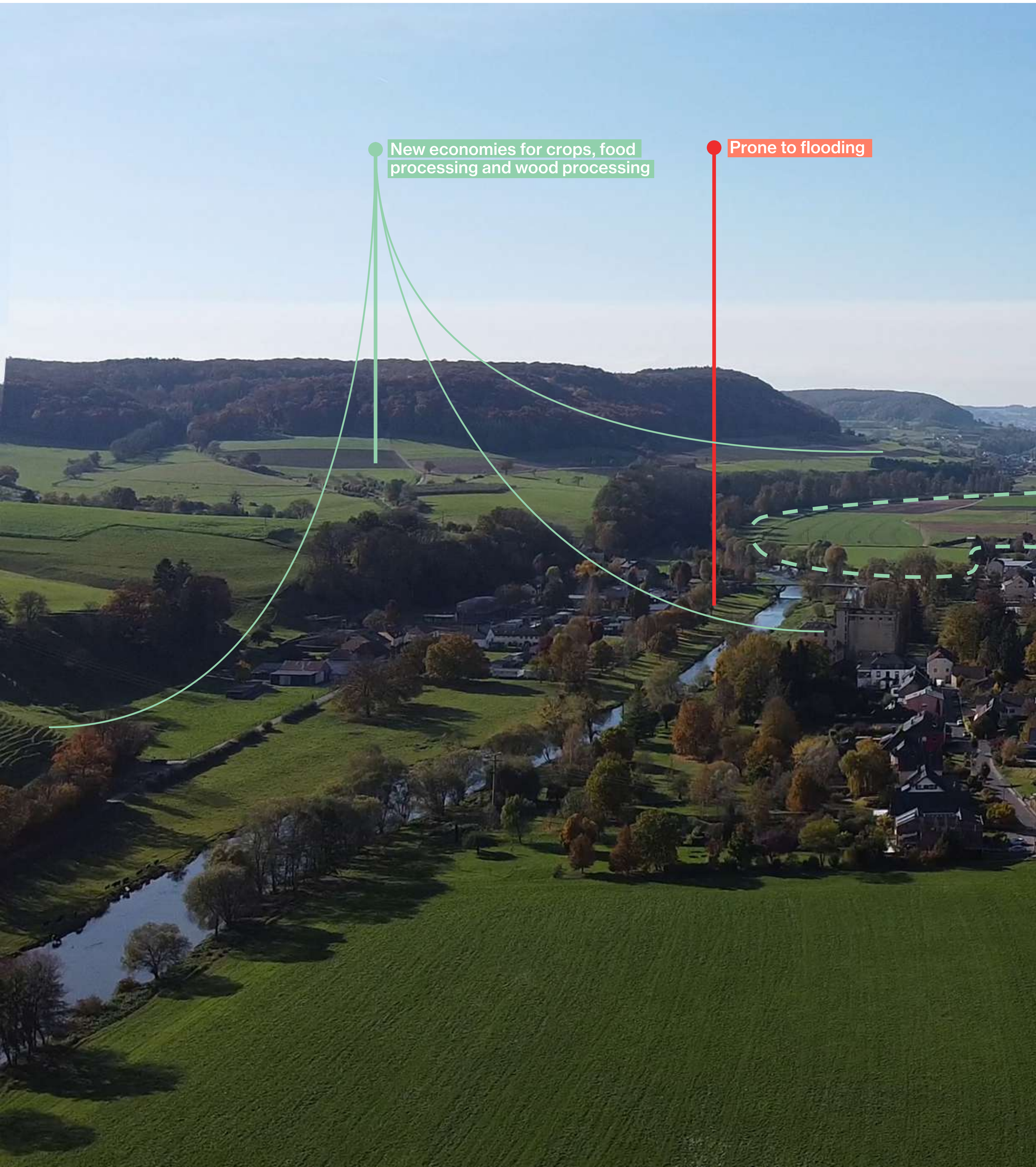
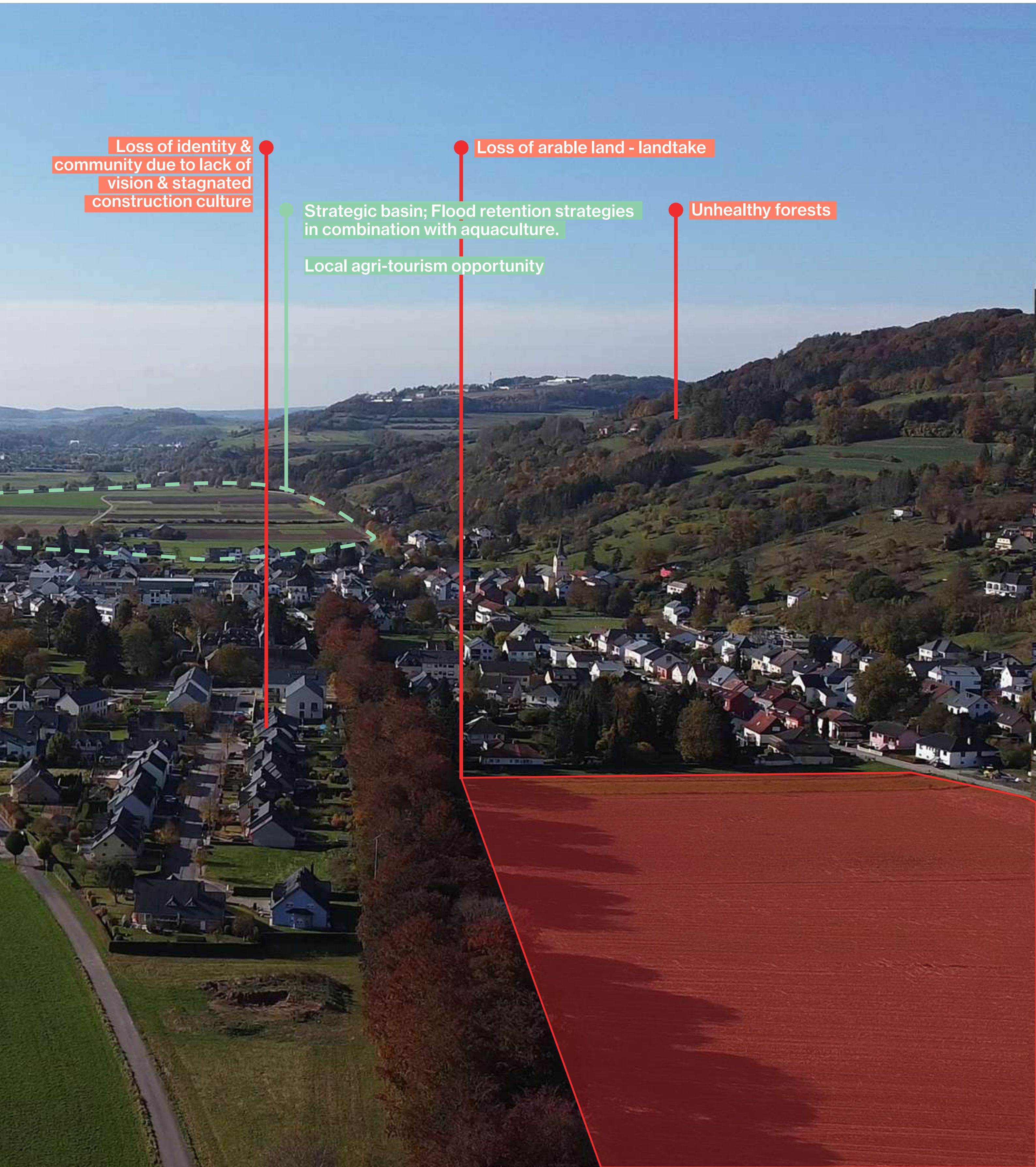
# Territorial Showcases

# Showcase 1



New economies for crops, food processing and wood processing
Prone to flooding

# Bettendorf



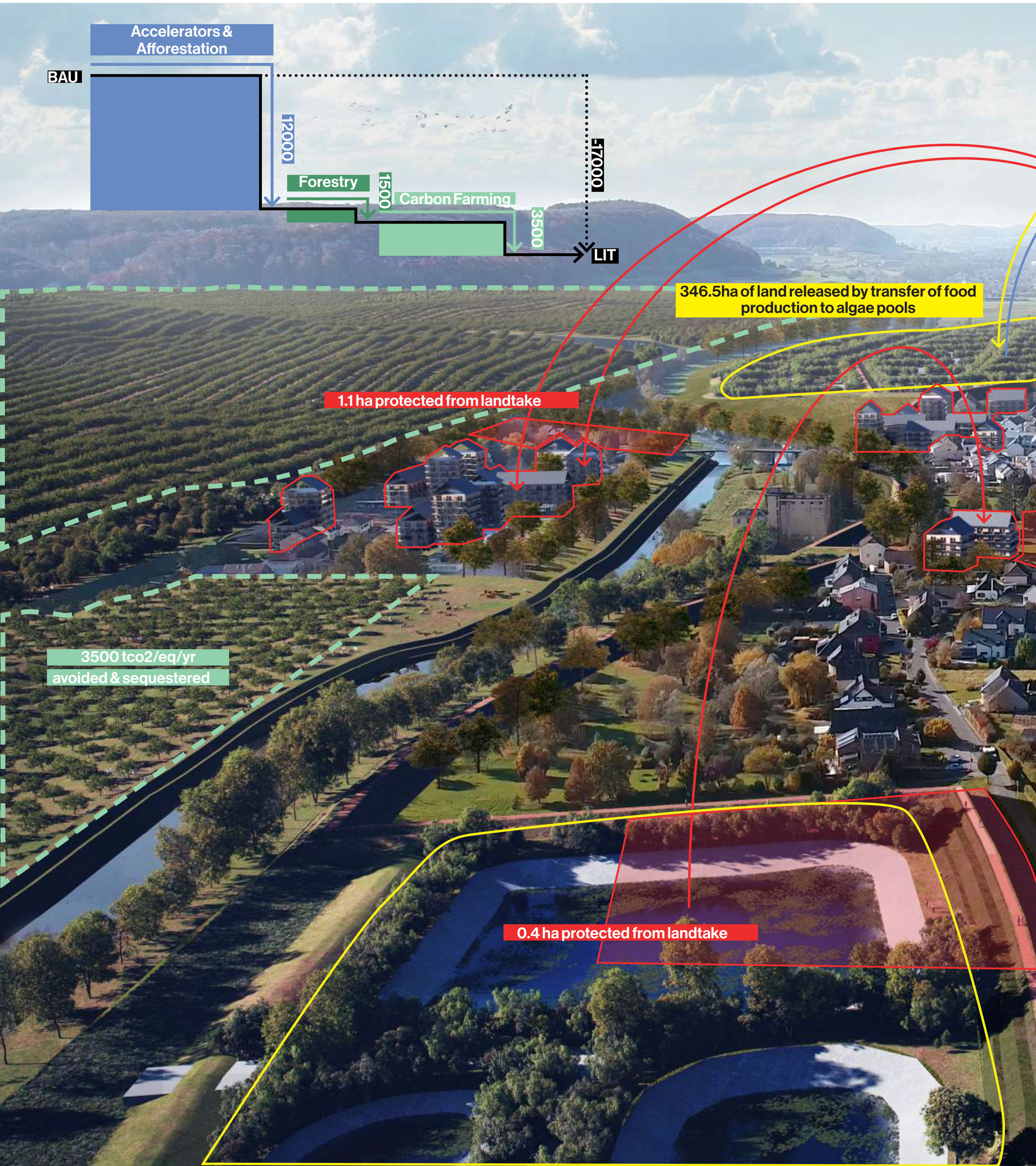
Loss of identity & community due to lack of vision & stagnated construction culture
Loss of arable land - landtake
Strategic basin; Flood retention strategies in combination with aquaculture.
Local agri-tourism opportunity
Unhealthy forests

# Bettendorf 2050 Business as usual

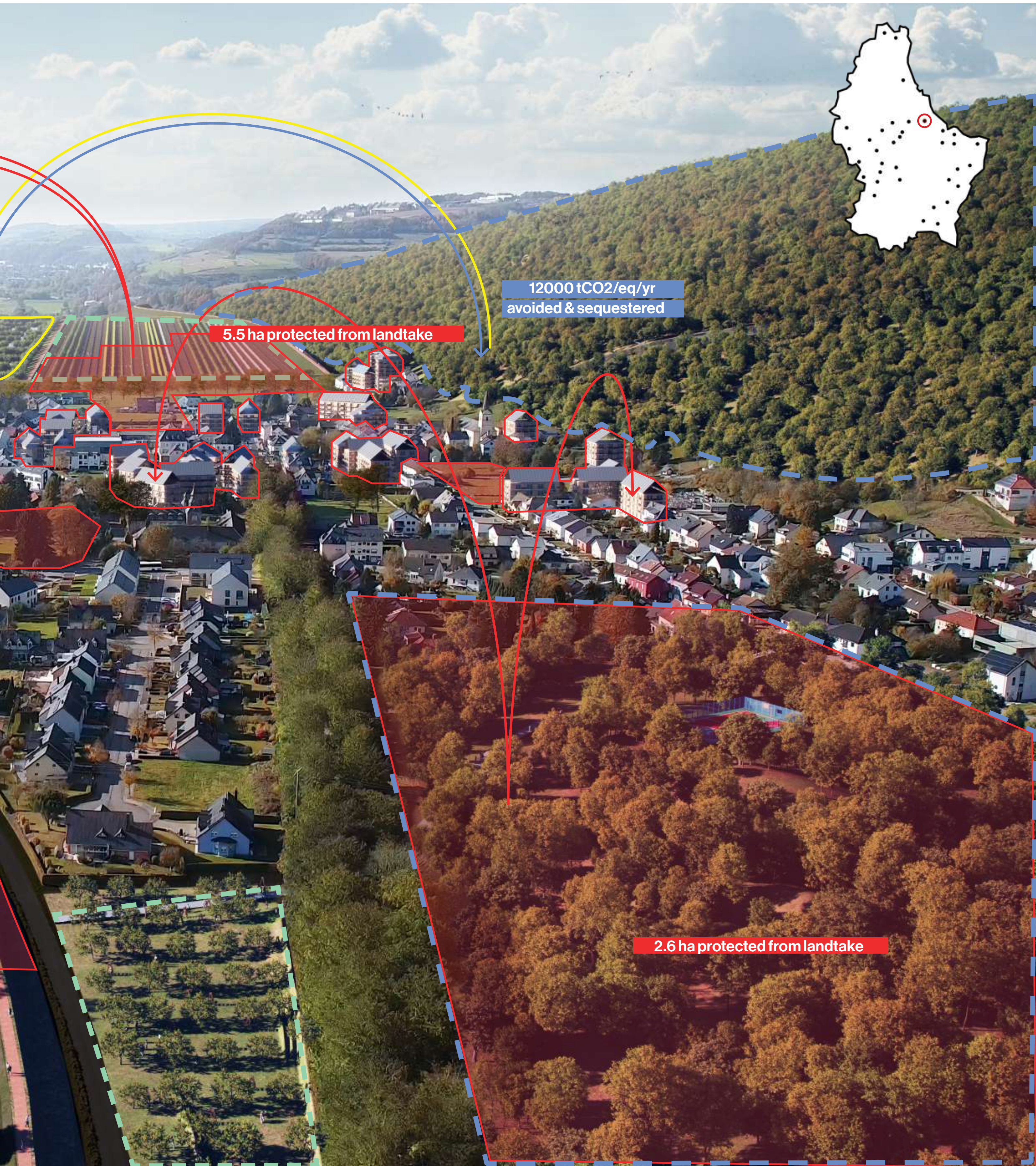
Landtake in combination with speculative low density development will lead to an evergrowing sprawl condition resulting in a gradual loss of character for the village. Sealed soil will put a burden on climate mitigation activities. Without addressing the food & wood value chain, the opportunity for new economies will be lost, and when the Sauer floods again, the village will be subject to costly damages.

# Bettendorf 2050 Proposal
# Resilient Ruralities

Bettendorf in 2050 is a dense and compact village with a strong rural character. The new apartments allow for the natural land cover to be preserved and enhanced. New public forests connect the existing forests together and form accessible treks to walk and cycle through. The algae pools have provided the village with new economies and have made the region much more resilient in face of floods. In addition they have accelerated the land release from feed production



which can now be afforested. The timber from afforested lands and new crops have also contributed to a more vibrant economy in the village attracting new demographies to its social fabric. With the village having a higher population and a more vibrant community, services such as groceries, bakeries, schools, medical facilities and leisure activities are more present. The arrows over the image below show the land management interventions in action which result in enhancing negative emissions of Bettendorf, as shown in the timeline.



# Bettendorf
# Decarbonsation menu

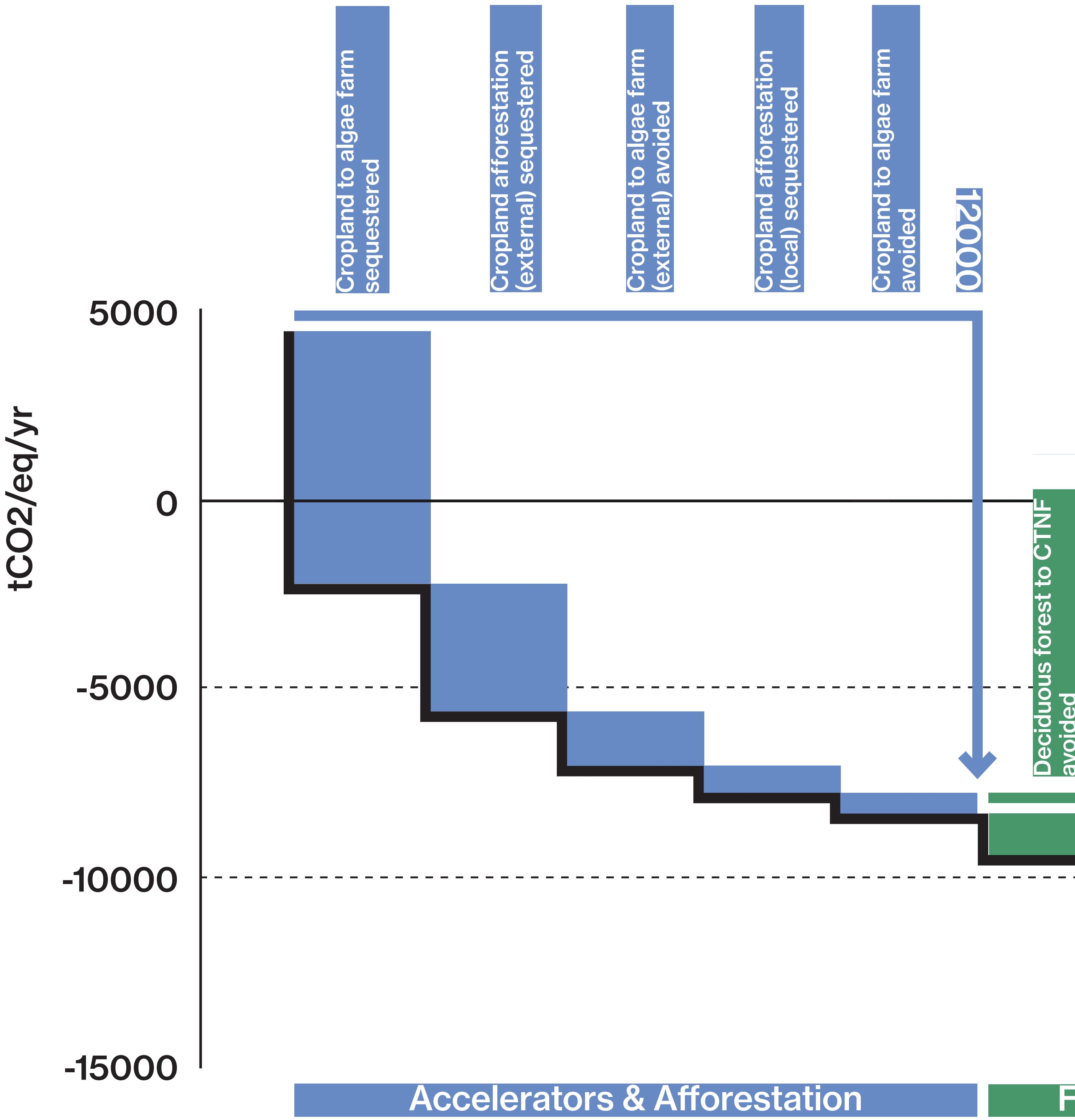
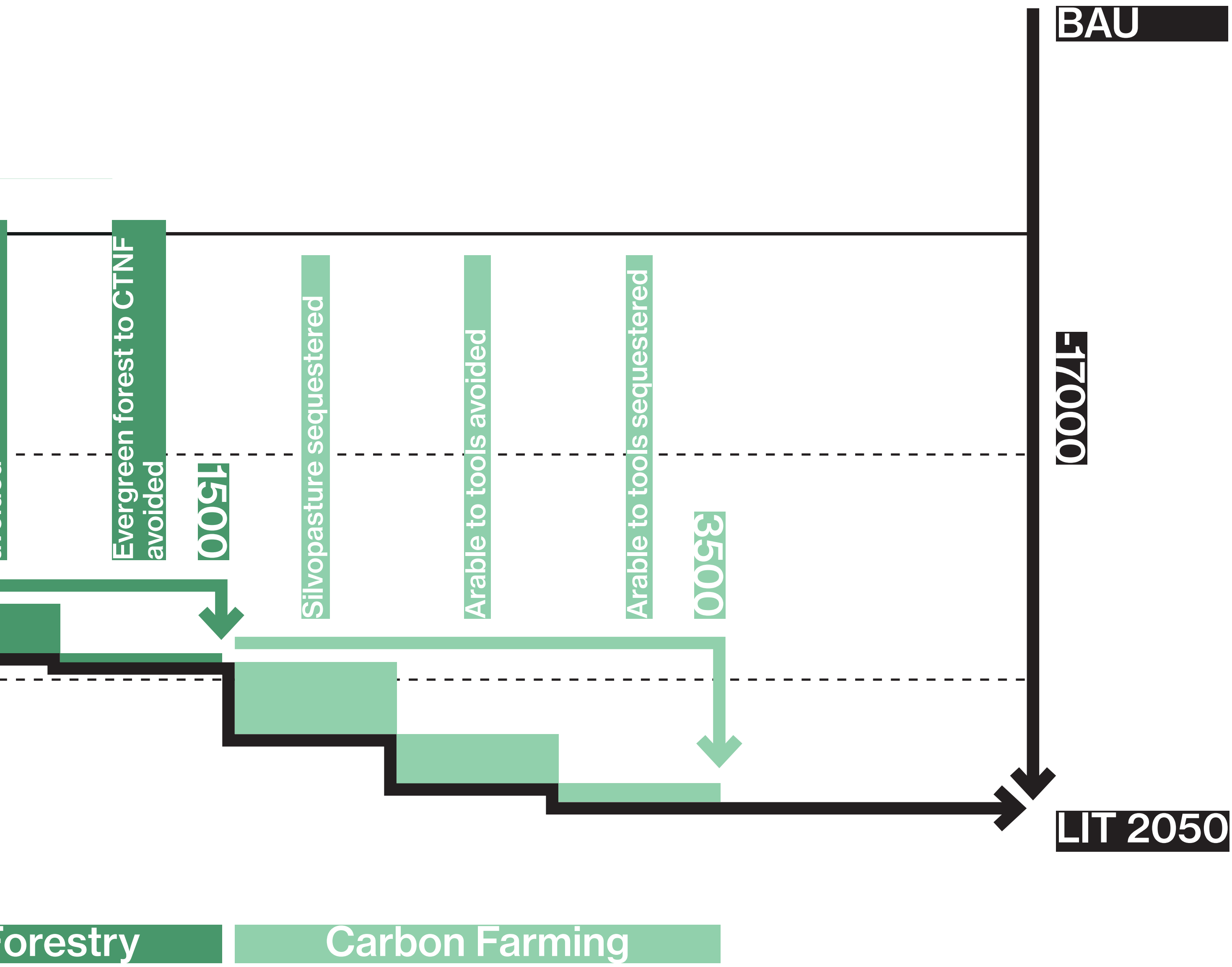



fig 3: Decarbonization menu showcase 1.


BAU
Evergreen forest to CTNF avoided
1500
Silvopasture sequestered
Arable to tools avoided
Arable to tools sequestered
3500
-17000
LIT 2050
Forestry
Carbon Farming

# Bettendorf 2050; Resilient Ruralities

The sealed surfaces of abandoned farm barns become new housing experiences with activated ground floors. Heritage serves as prospective base for socio-economic revitalization of rural villages.

In central locations, inhabitants of 4 to 5 level collective housing villas will benefit from services and small retail that shoulder light agroforestry processing.

1. Old farmhouses are preserved and refurbished. Their architecture allows them to become either collective housing or services such as medical practices.
2. Single floor barns are replaced by active ground floors hosting services like small-scale shops or cafés.
3. These ground floors can also integrate processing and craft, linked to working with local resources.
4. Ground floors boast intensely vegetised roofs on which smaller housing units sit
5. In less central areas, 4-5 floor villas of collective housing are articulated around shared park areas

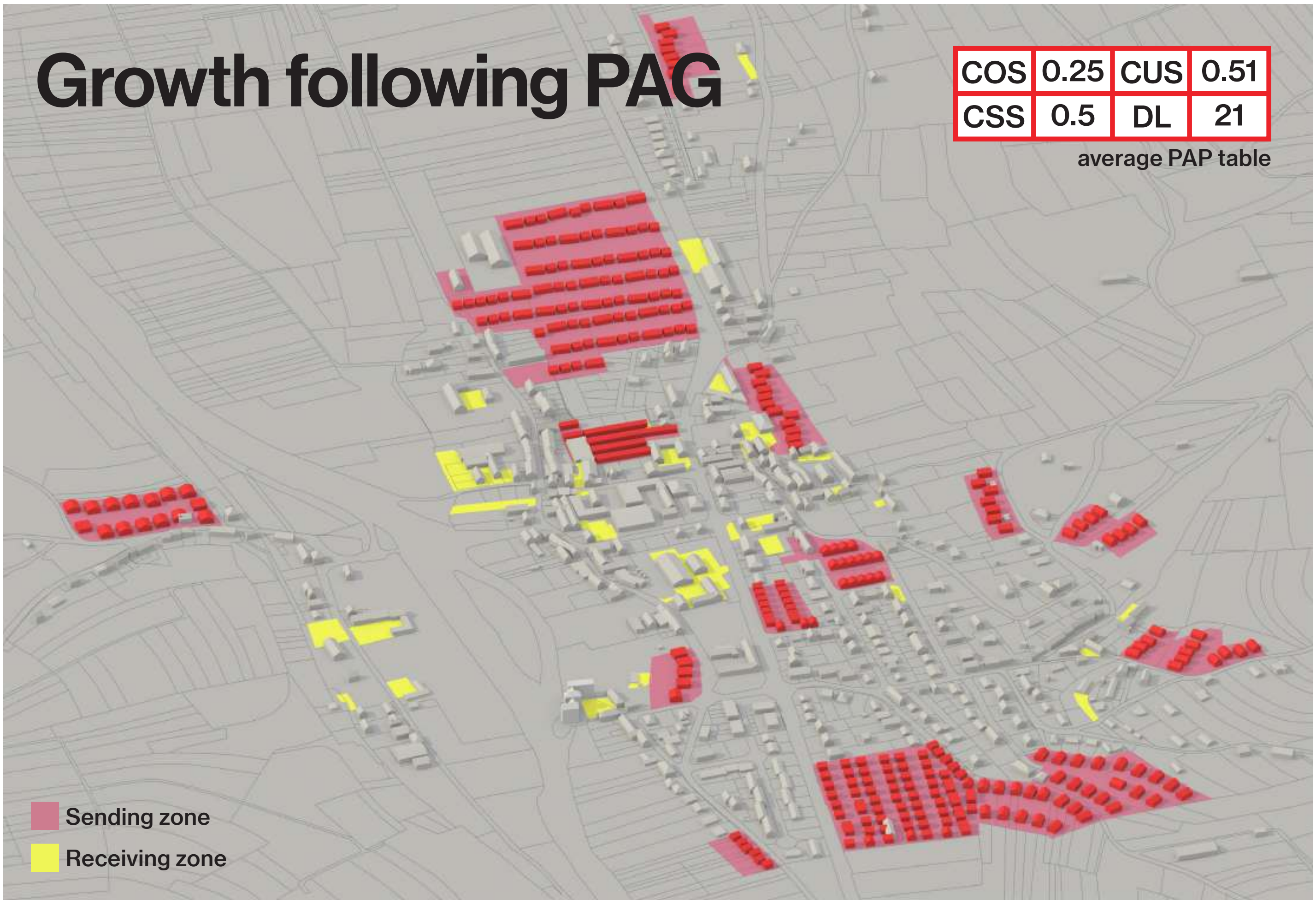
# Bettendorf
# Transfer of Development Rights

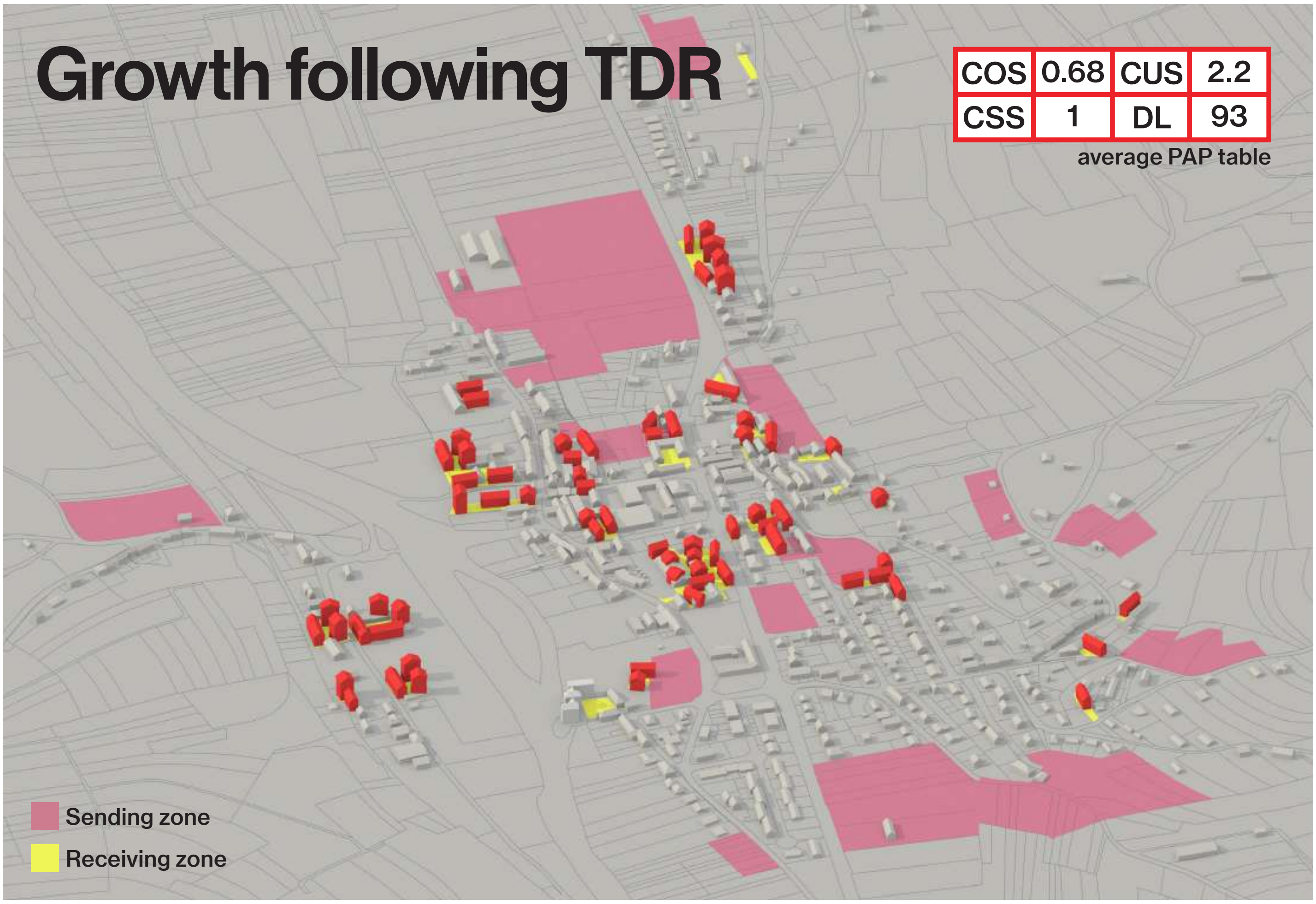
With the TDR instrument in place, and following our proposed sending and receiving zones, we carried out a scenario where growth is projected over the receiving site as much as possible, while considering the identity of the village. Two factors were taken into consideration while planning the receiving sites. First was to not build more than 4 floors along the streets which form the historical core of the village built before 1900s. For all other areas, Moulin de Bettendorf stood as a reference for maximum height. Using this guidelines, 64,900 sqm of floor area was projected over the receiving sites.

With a more compact village, there is a higher incentive for services such as grocery stores and leisure amenities to serve the community. Village centres will become more lively especially if spaces for economic activities are also considered while planning growth.

The growth of the village over its existing sealed surfaces also has a limit. When and if the village reaches this cap and exhausts its sealed surface capacity, the deeds which have matured in the sending zones can be revisited. The use and rights of those sites can be reimagined in alignment with the future vision of the village and the ambitions of its community.

image 1: Mill of Bettendorf seen from the river Sûre (2014).


Growth following PAG
COS 0.25 CUS 0.51
CSS 0.5 DL 21
average PAP table
Sending zone
Receiving zone


Growth following TDR
COS 0.68 CUS 2.2
CSS 1 DL 93
average PAP table
Sending zone
Receiving zone

# Bettendorf
# Land use change 2021 to 2050

- Industrial cropland
- Pasture
- Space for river
- Urban green
- Space for river
- Forest
- Afforested (5 yr)
- Afforested (15 yr)
- Afforested (30 yr)
- Silvo-pasture (5 yr)
- Silvo-pasture (15 yr)
- Silvo-pasture (30 yr)
- Strip cropping
- Aquaculture
- Wetland
- River

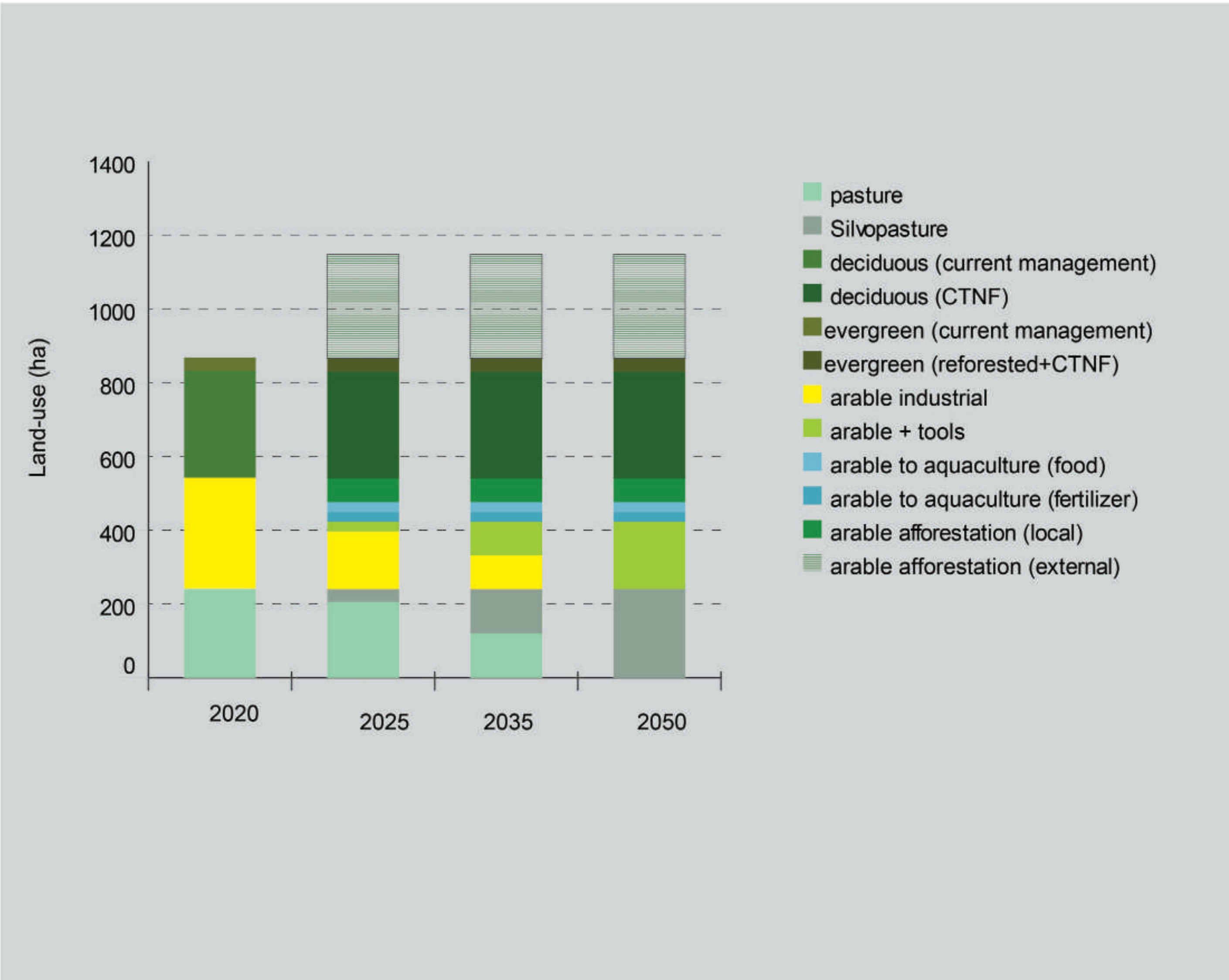



fig 1: Landuse change showcase 1.

2021

2025

2035

2050

# Bettendorf
# Agriculture and LULUCF emissions
# 2021 to 2050

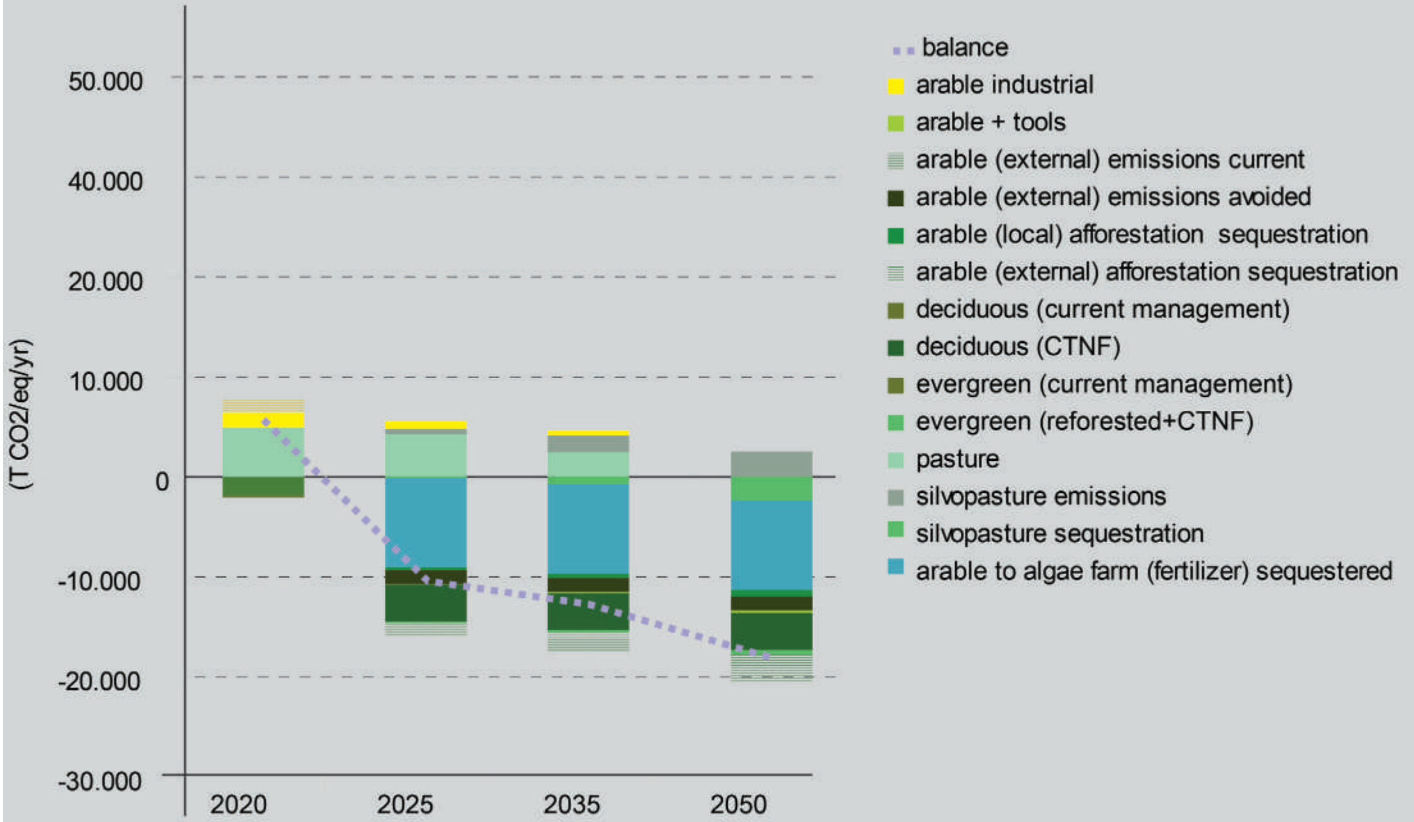



fig 2: Negative showcase 1.

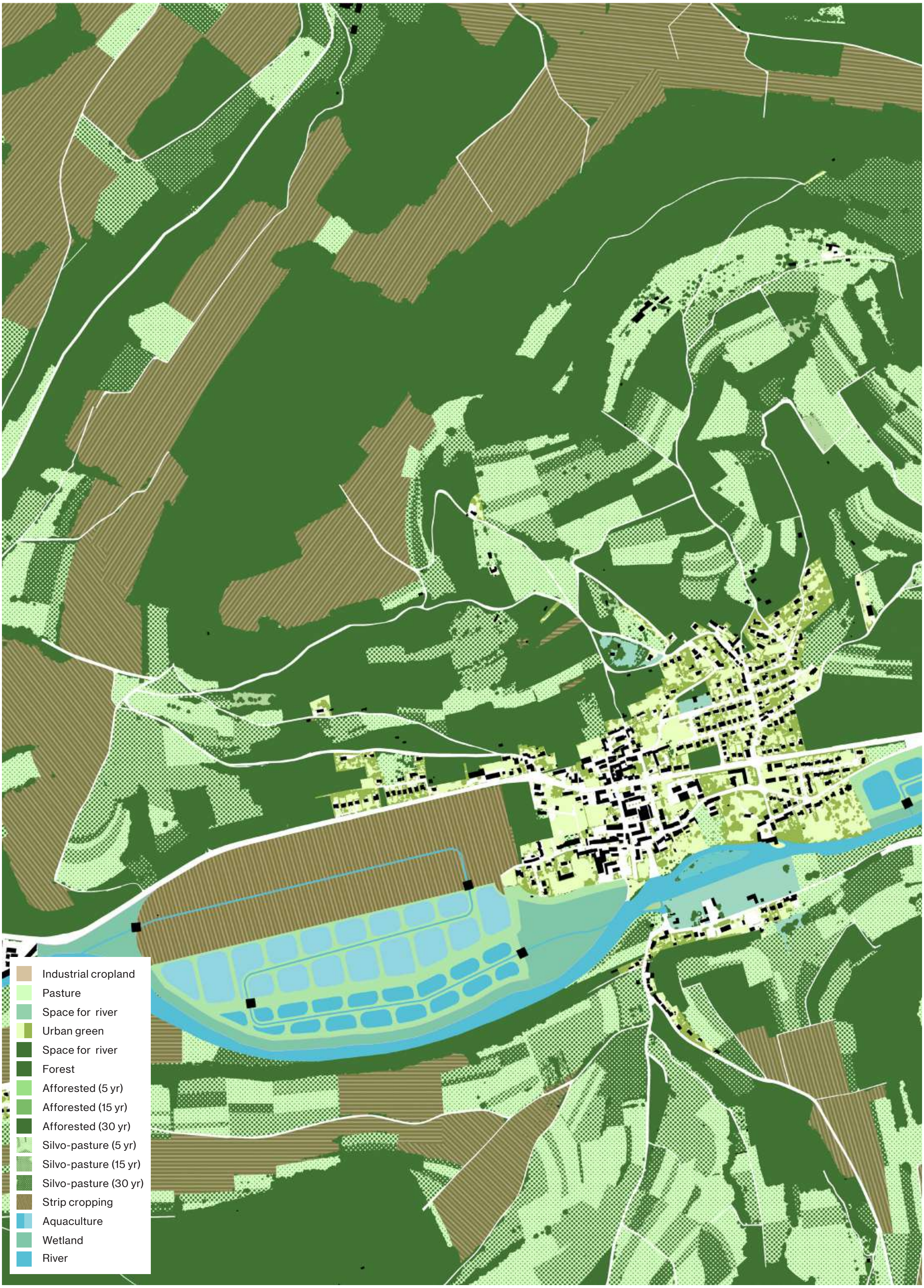
2021

2025

2035

2050

- 12,7 t CO2 eq./ha/yr  + 20,47104 & -  10,0771 t CO2 eq./ha/yr  - 1.4 t CO2 eq./ha/yr  - 335 t CO2 eq./ha/yr

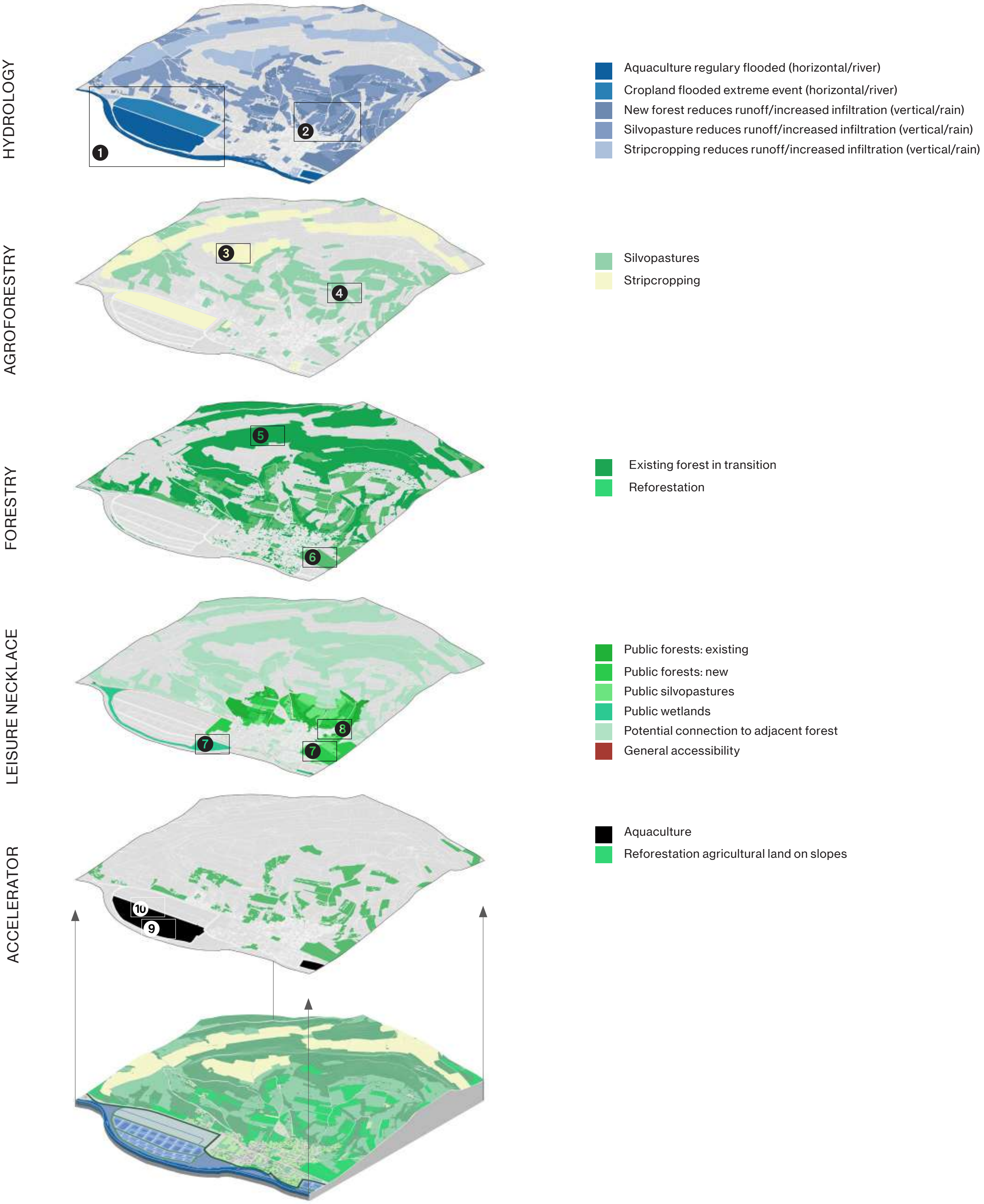



Land use change 2021 to 2050


Agriculture and LULUCF emissions 2021 to 2050

# Bettendorf
# Overview of tactile interventions

## Multifaceted landscape development

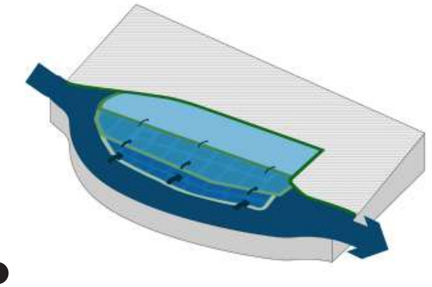



Land-use 2050

# Measures & principles

HYDROLOGY

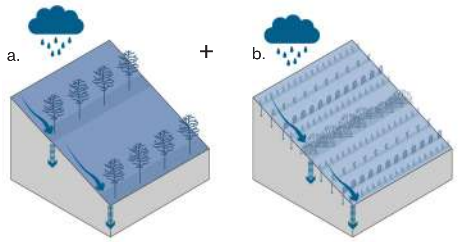
## Horizontal (river) flood relief



- HQ10
- HQ100
- HQ extreme
- safe zone
- high dike
- medium dike
- low dike
- very low dike

1

## Vertical (rain) flood relief

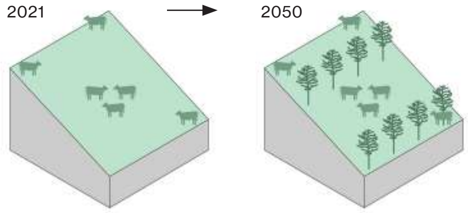



- a. silvopasture
- b. stripcropping
- runoff catchment
- infiltration/ groundwater recharge

2

AGROFORESTRY

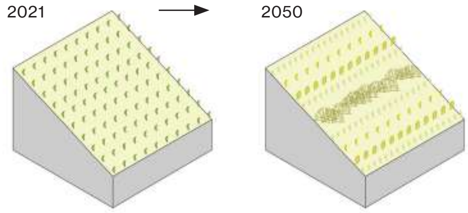
## Silvopastures




- Cattle
- Fruit/nuts

3

## Stripcropping

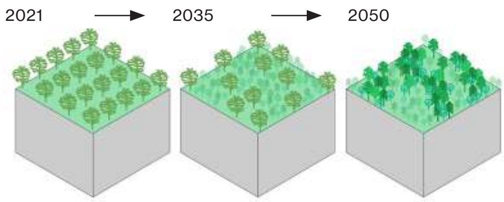



- monoculture
- polyculture
- ecological strip

4

FORESTRY

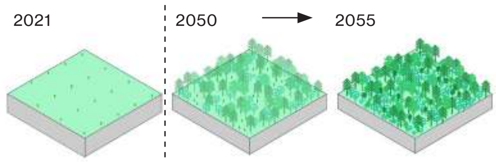
## Existing forest in transition




- Trees unadapted shifting climatic ranges
- Adaptive species diversification approach
- Resilient forests

5

## Close to nature forest management

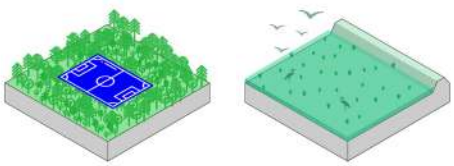



- clearfelling management
- selective harvest management
- mixed and uneven-aged, structurally diverse forest stands

6

LEISURE NECKLACE

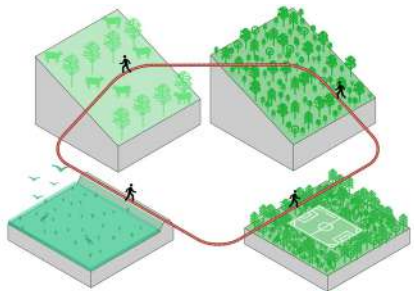
## Public functions



- urban program
- natural program

7

## Connectivity

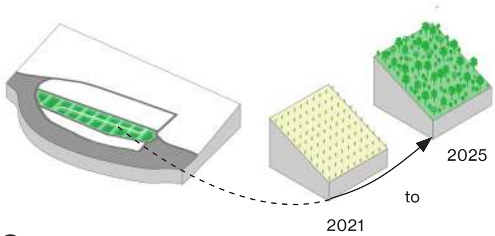


- General accesibility

8

ACCELERATOR

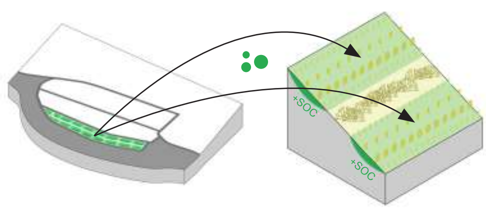
## Aquaculture accelerator: food footprint reduction and afforestation




- 13 x more yield/plant protein/ha
- freed-up cropland
- afforested cropland

9

## Aquaculture accelerator: algae as organic fertilizer and SOC source




- Algae production 335 t CO2 eq./ ha/yr sequestration
- Organic fertilizer
- SOC increase

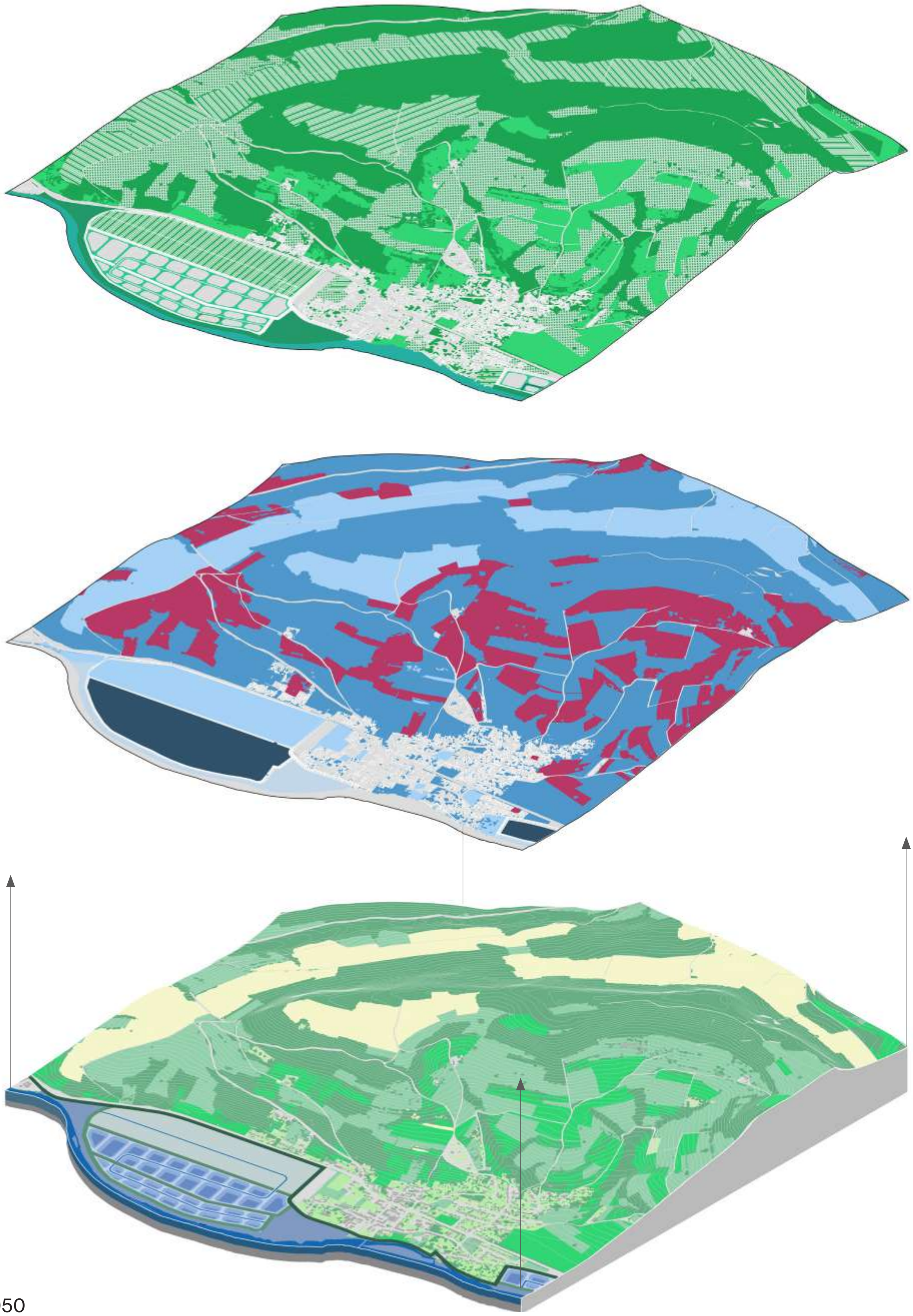
10

# Bettendorf
# Overview of tactile interventions

Decarbonisation as leverage for Integrated landscape development

ECOLOGY

CARBON



Land-use 2050

Increased matrix connectivity by ecological intensification agriculture (sharing)

Increased matrix connectivity by sustainable intensification to set agricultural land aside for afforestation (sparing)

Heterogeneous patch types: novel and remnant natural and semi-natural habitats

- 12,7 t CO2 eq./ha/yr

+ 20,47104 and - 10,0771 t CO2 eq./ha/yr

- 1.4 t CO2 eq./ha/yr

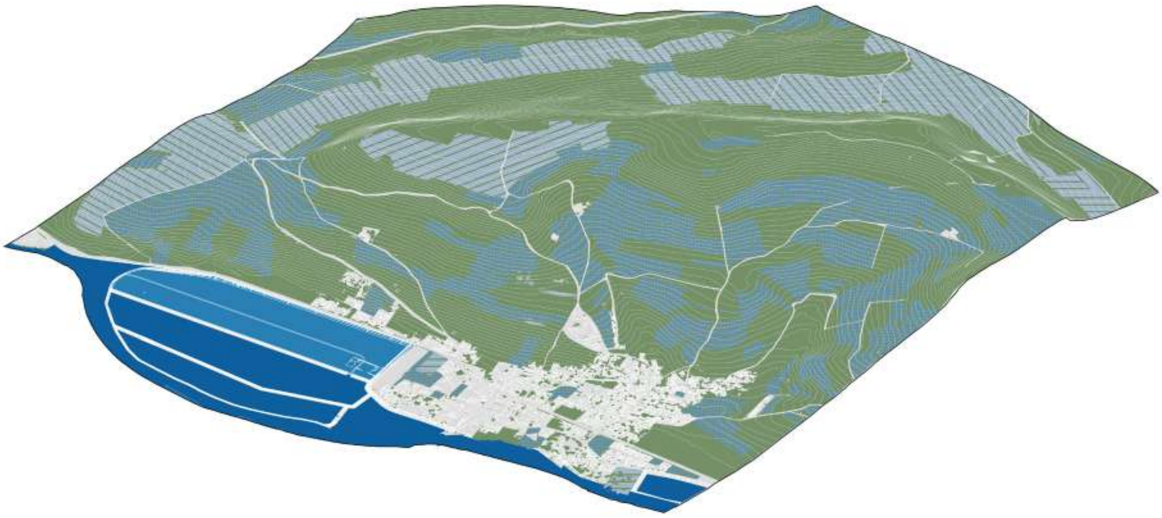
- 335 t CO2 eq./ha/yr

Forest
Afforested
Silvo-pasture
Urban green
Strip cropping
Aquaculture
Wetland
River

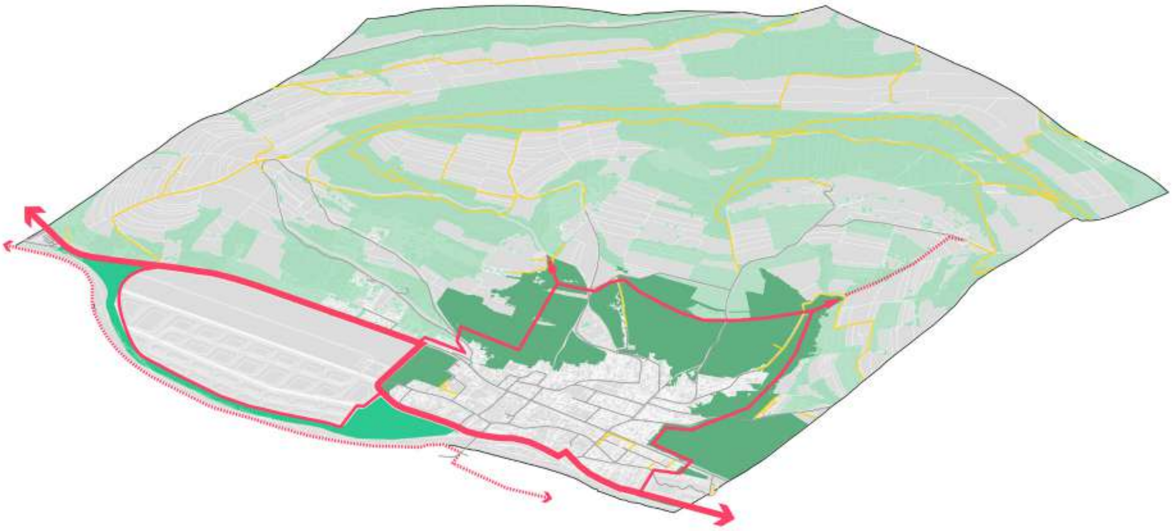
# Bettendorf
# Overview of tactile interventions

Decarbonisation as leverage for Integrated landscape development

RESILIENCE/ADAPTATION



LEISURE



PRODUCTIVE

reduced run-off, increased infiltration

reduced high river levels and reduced (flash) floodrisk low located villages

more space for the river to reduce the waterlevel of excess flows and avoid economical damage downstream due to large scale flooding

HQ 10 & 100: high to medium flood probability

HQ extreme: floods only during extreme event

climate/drought & future disturbance resilient forests

crop disease control, soil fertility increase, reduced erosion soil loss, increase soil water retention and availability

climate/drought & future disturbance resilience trees, increase soil water retention and availability

Existing bike path

New bike path

Leisure necklace access

Existing paved

Existing path

Leisure necklace

Existing forest

Mean annual merchantable
= 8 m3/ha/yr with close to nature forestry management

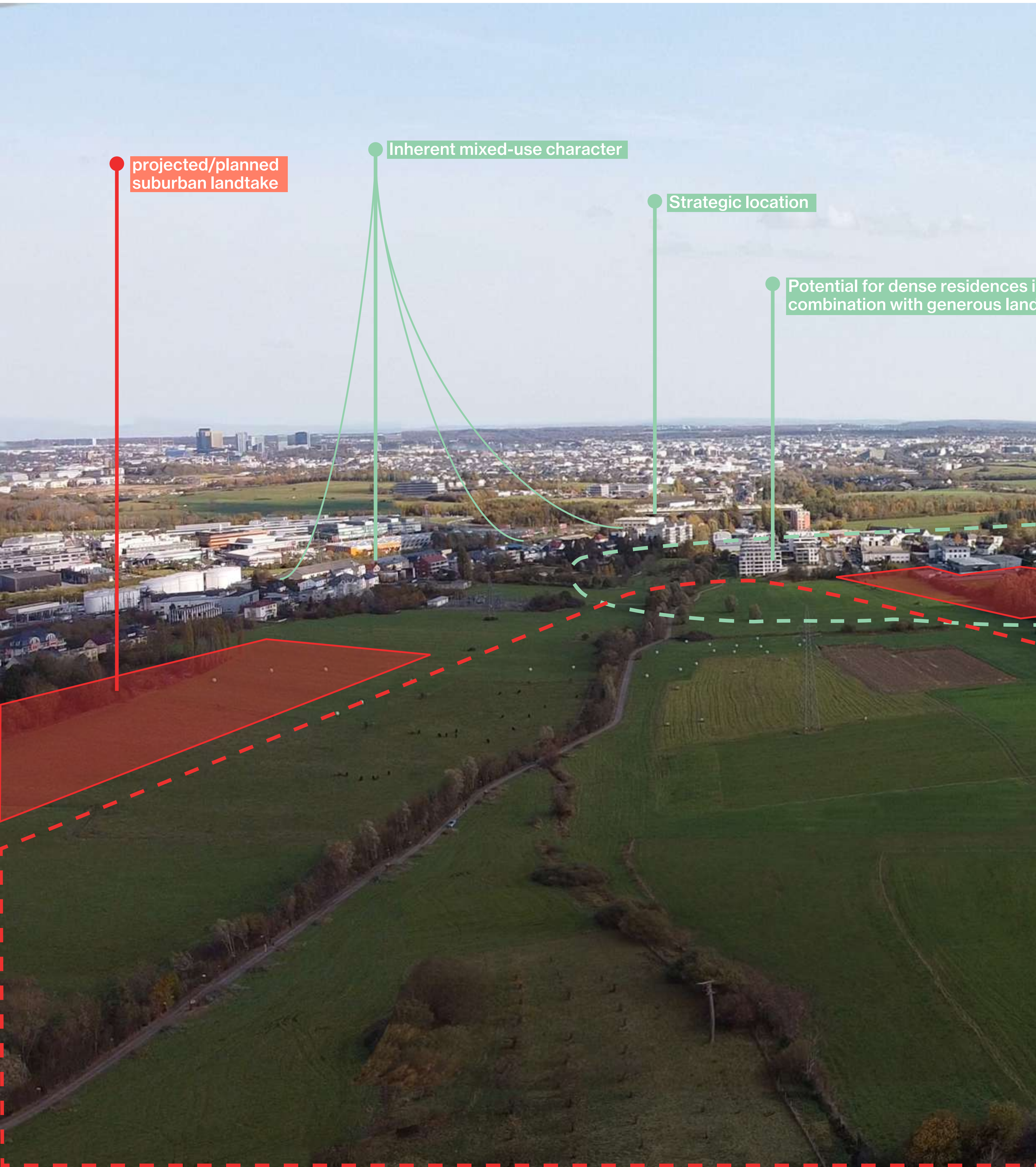
Silvopasture: 0.01 to 0.23 tons/ merchantable/protein/ha/yr

Protein crops: 1.8 tons/ merchantable/protein/ha/yr

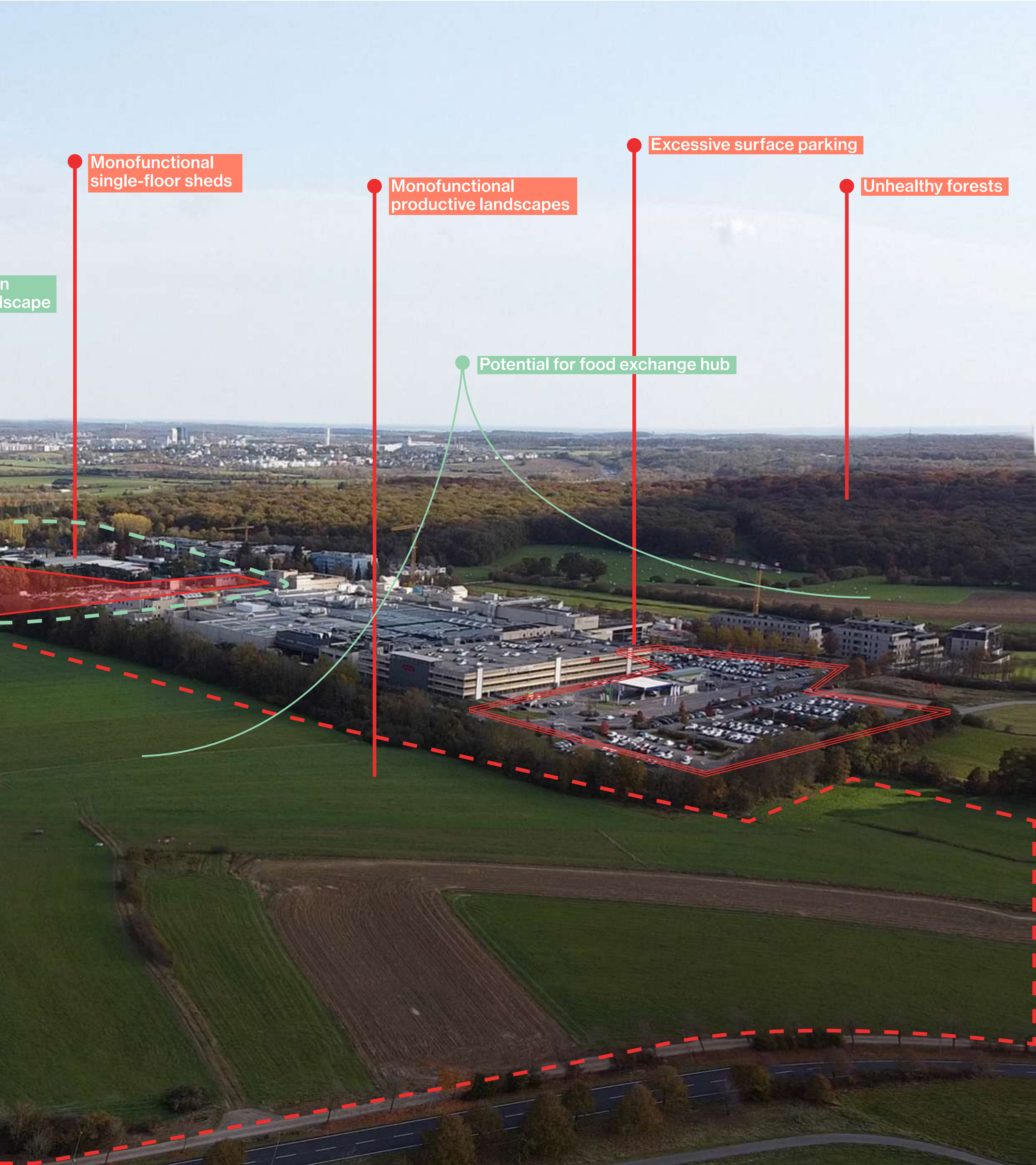
Aquaculture algae for food: 13 tons/ merchantable/protein/ha/yr

Aquaculture algae for fertilizer: 150 to 300 tons/ merchantable/biomass/ha/yr

# Showcase 2


projected/planned
suburban landtake
Inherent mixed-use character
Strategic location
Potential for dense residences i
combination with generous lanc

# Helfent


Monofunctional
single-floor sheds
Monofunctional
productive landscapes
Excessive surface parking
Unhealthy forests
n
lscape
Potential for food exchange hub

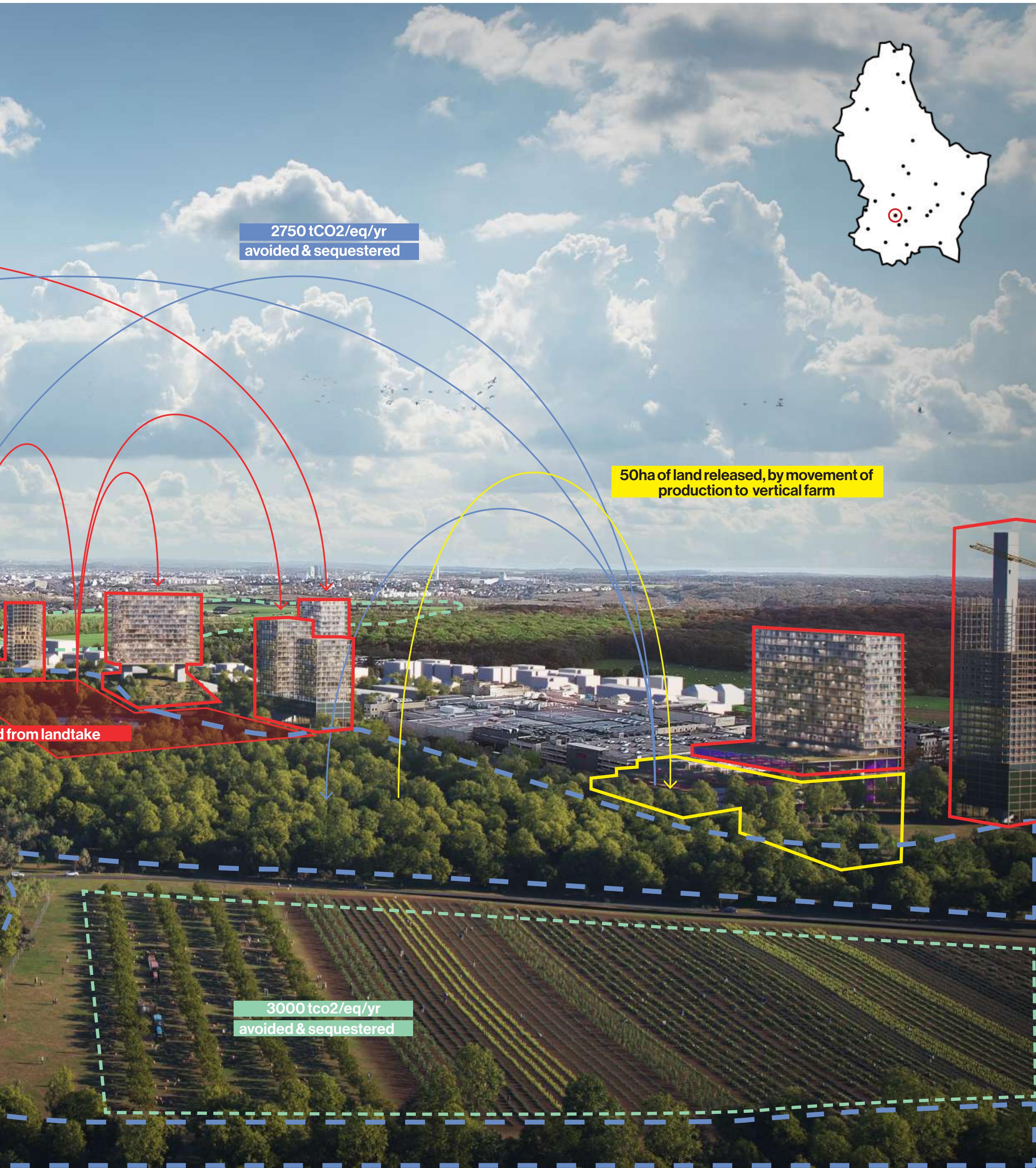
# Helfent 2050 business as usual

Suburban sprawl and excessive soil sealing around the Petrusse river will diminish the potential that Helfent has to turn into a compact, resilient and lively neighbourhood.  The agricultural activities within Helfent will be pushed away to the margins and heat island effect will contribute to loss of biodiversity and lowering quality of life. The sealed surface expansion will not allow the soil underneath to play its role in natural carbon capture.

# Helfent 2050 proposal
# Sublime Suburbia

Helfent in 2050 has become as much a generous renaturalised valley and afforested land, as a lively neighbourhood made of new typologies of living and working in mixed-use highrises. These highrises play a key role in preserving arable land and forests. The plinths of these towers are accommodating economic, civic and leisure facilities and services. The City Concorde is now a hub for food production and distribution. Produce from the surrounding silvopastures and the

vertical farm is processed and sold there directly to consumers, in the market which stretches over the terraces of the old parking towards the landscape. The afforested pastures now connect the previously fragmented forests into a necklace of leisure destinations around Luxembourg city. The arrows over the image below show the land management interventions in action which result in enhancing negative emissions of Helfent, as shown in the timeline.



# Helfent
# Decarbonsation menu

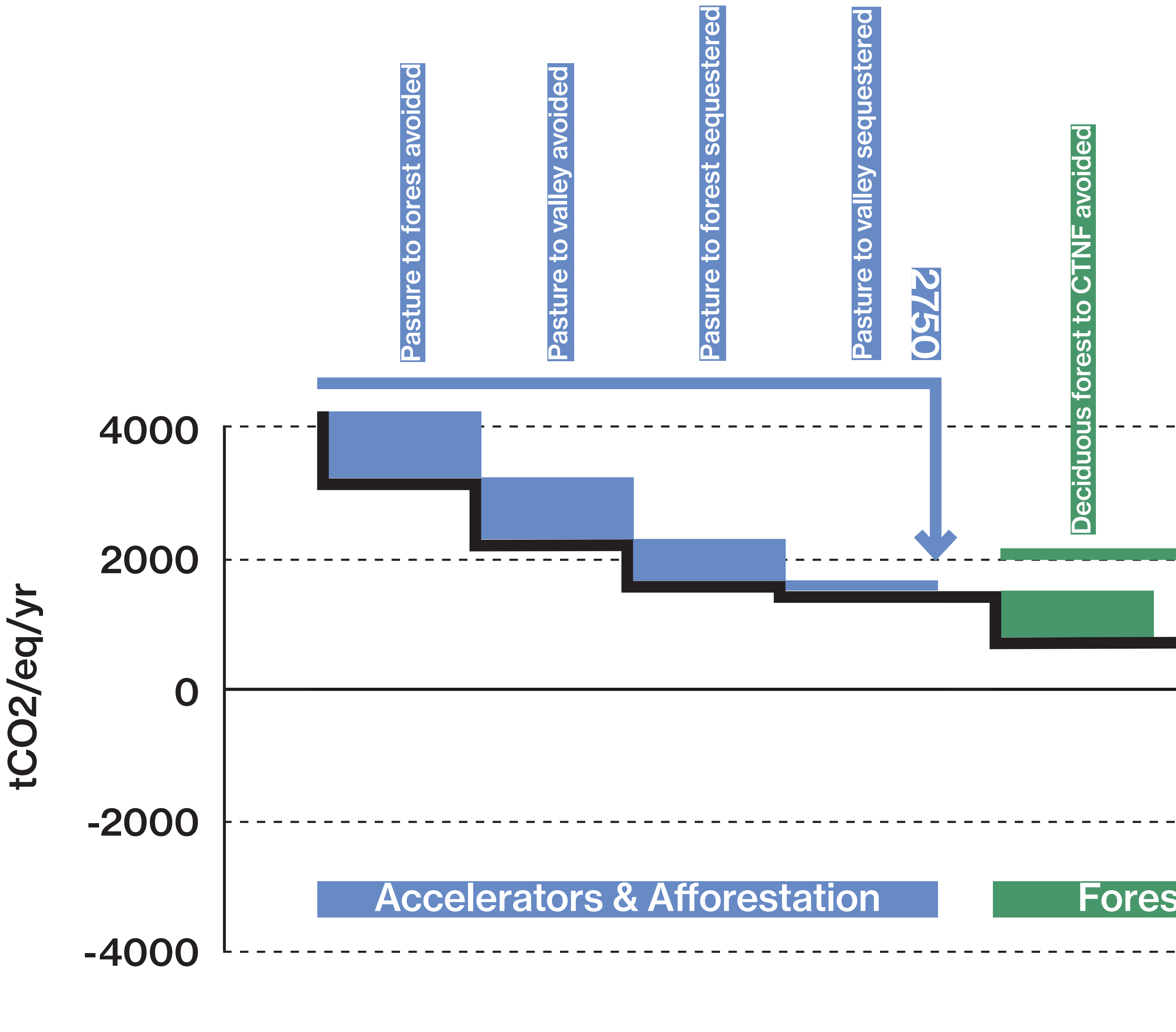
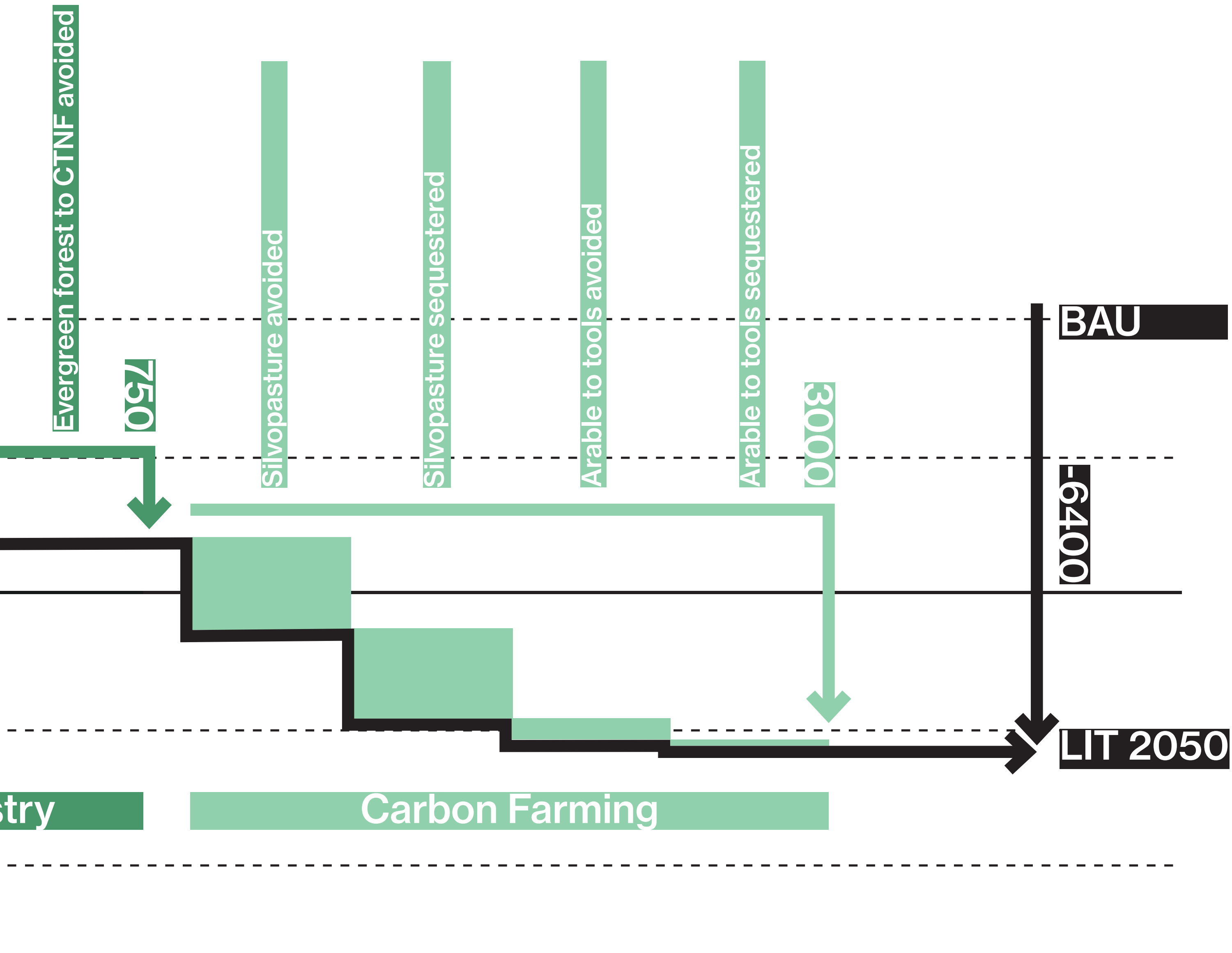



fig 6: Decarbonization menu showcase 2.



Evergreen forest to CTNF avoided
750
Silvopasture avoided
Silvopasture sequestered
Arable to tools avoided
Arable to tools sequestered
3000
BAU
-6400
LIT 2050
stry
Carbon Farming

# Helfent 2050 proposal
# Sublime Suburbia

Sublime Suburbs: surface parking and single-story commercial buildings hold the potential to centralize development rights and turn suburban archipelagos into lively mixed-used neighbourhoods.
Residual landscapes are preserved and activated as productive leisure environments, framed by high-rise timber constructions combining public gardens and generous housing experiences.

1. Parking and economic activities compose the plinths. They have a double orientation: opening towards the built tissue, their roofs extend the landscape into the towers.
2. Timber towers rise over the plinths and produce a critical mass of affordable good quality dwellings, challenging the lifestyle of the single-family house and suburbia.
3. The waterfront performs as an active connection between destinations around Helfent while preserving and enhancing its natural qualities.

# Helfent
# Transfer of Development Rights

With the current rate of landtake proposed in the PAG, Helfent will lose 128,800 sqm of its arable land. Taking the current state of affairs in Helfent into account, including structures and landscapes that are of large proportions, we came to the conclusion that the highrise typology will serve as the most land-efficient choice. We also took into account the limitation of construction with timber, to determine the height of the highrises, which are capped at 20 floors. Taking inspiration from existing multifunctional complexes such as Piwel, the plinths of the highrises were seen as multistorey industrial, civic and commercial facilities. The floors above were treated as residences and offices. With these considerations in mind, we developed new PAP tables for the sites, with emphasis on net-zero landtake and minimum soil sealing. This resulted in 163,600 of floor area in new developments over existing sealed surfaces, which surpassed the growth trajectory of the PAG within the boundary of Helfent. In this way, the area could now take in the growth that is projected beyond its edges as well.

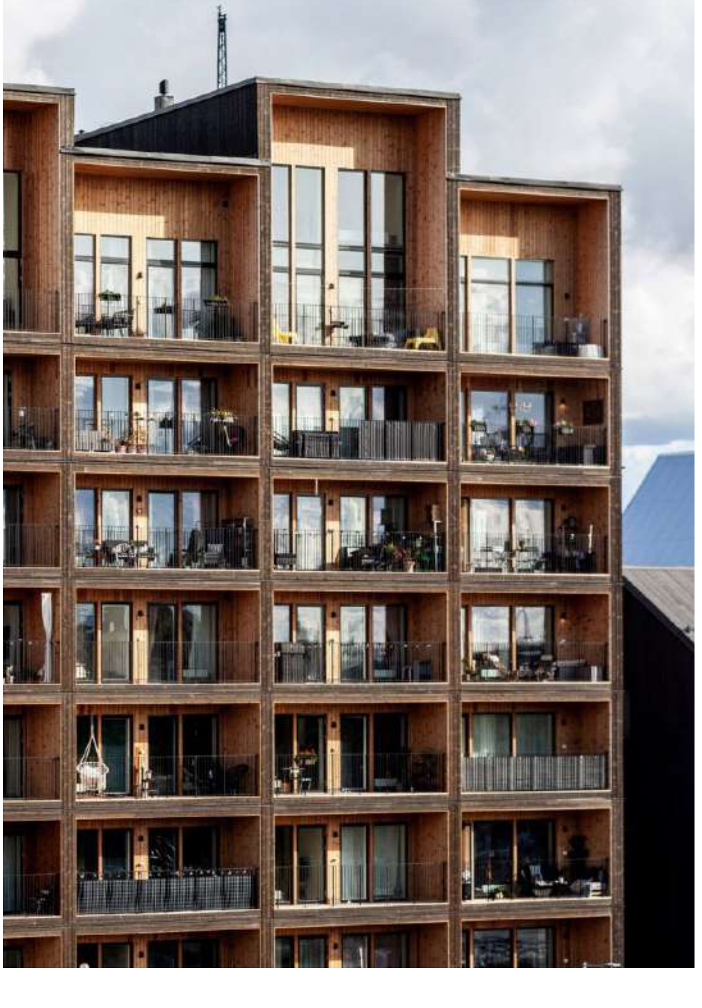
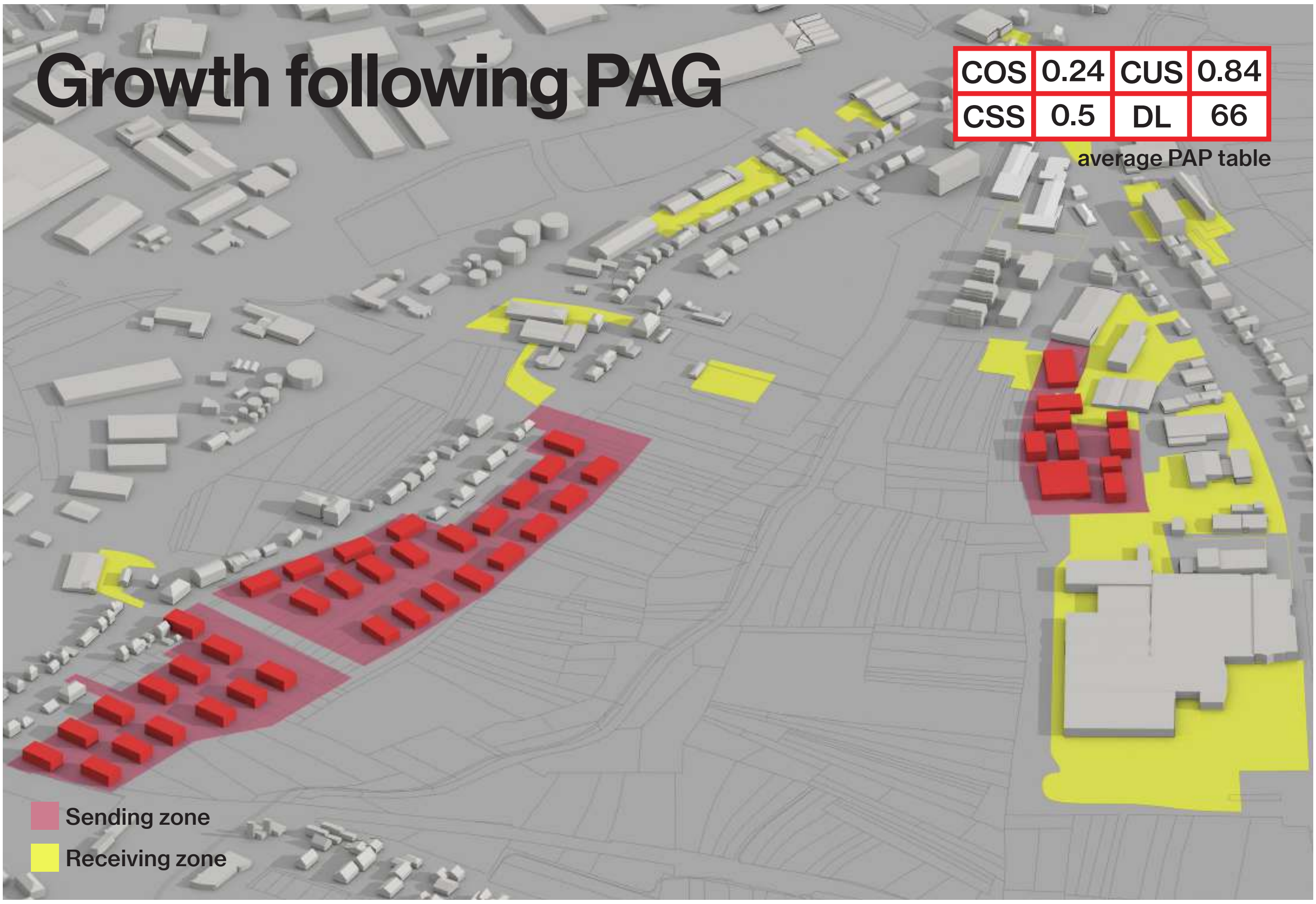
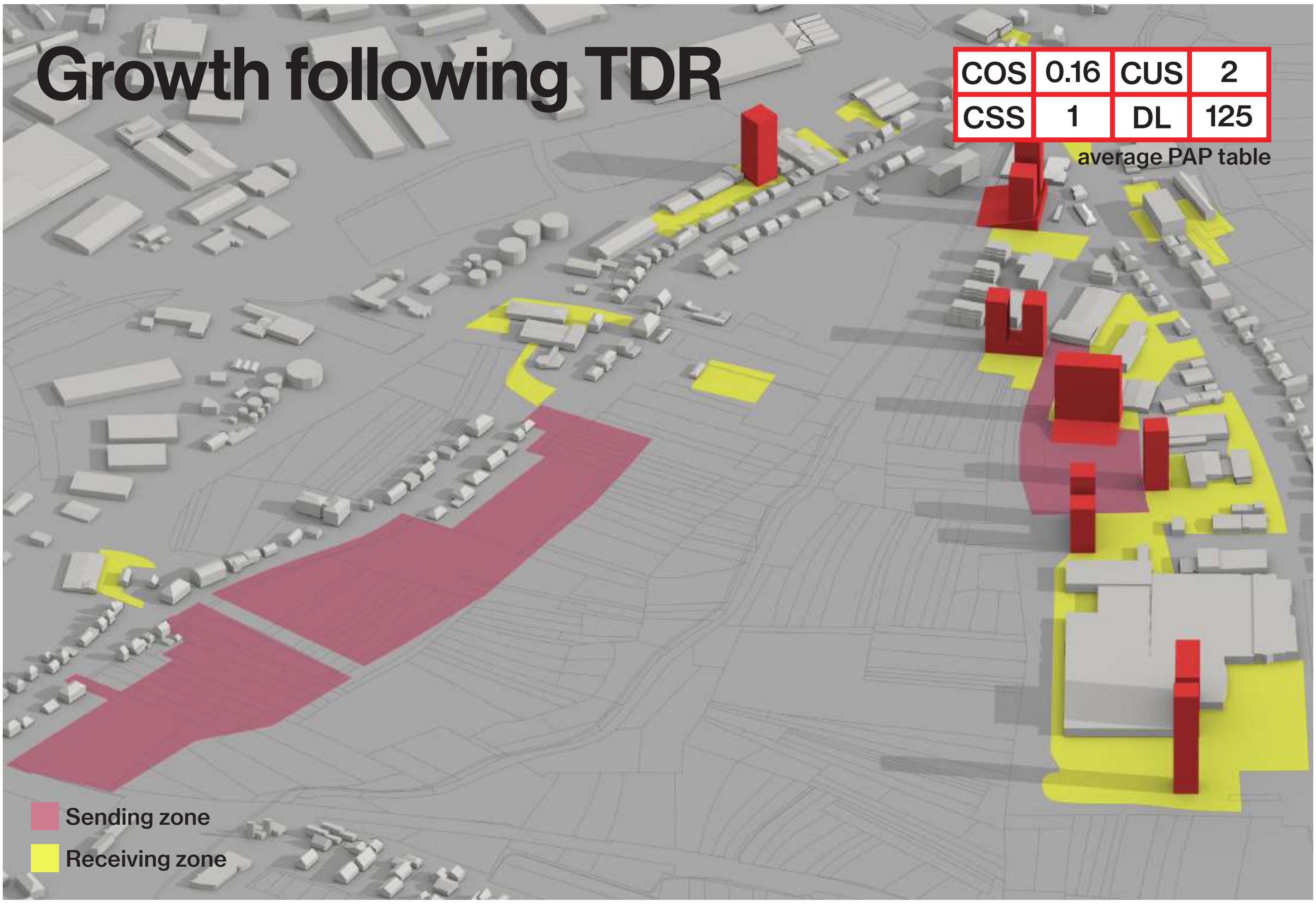


image 2: CF Moller (2020). Kajstaden tower.

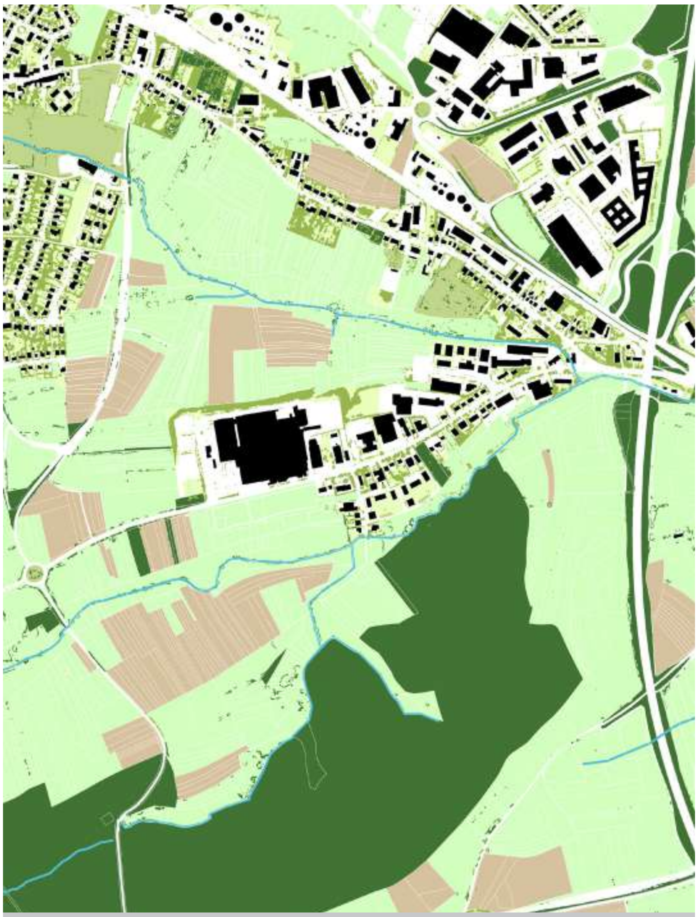

Growth following PAG
COS 0.24 CUS 0.84
CSS 0.5 DL 66
average PAP table
Sending zone
Receiving zone


Growth following TDR
COS 0.16 CUS 2
CSS 1 DL 125
average PAP table
Sending zone
Receiving zone

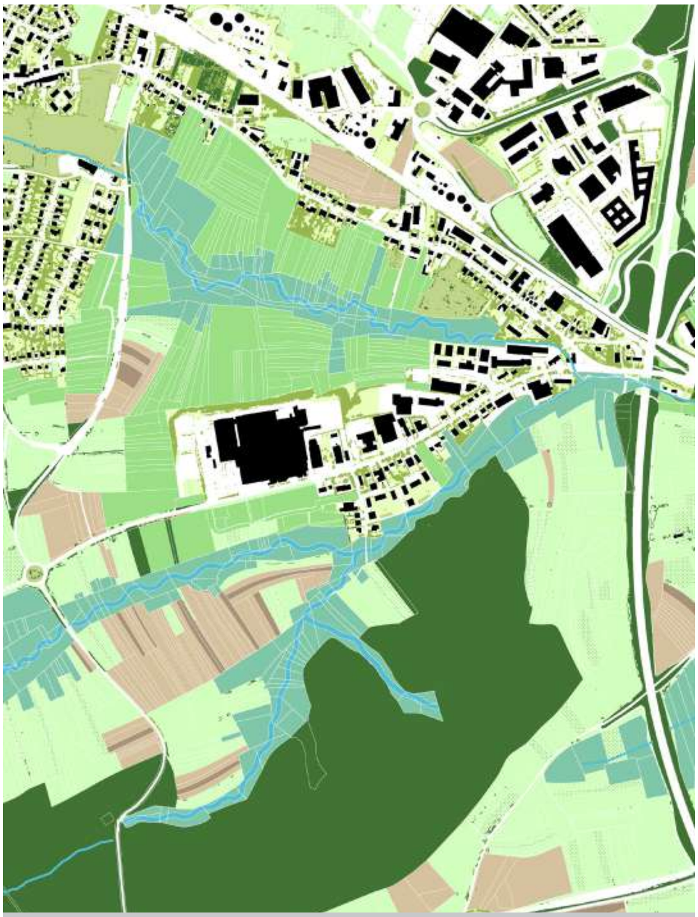
# Helfent
# Land use change 2021 to 2050

- Industrial cropland
- Pasture
- Space for river
- Urban green
- Space for river
- Forest
- Afforested (5 yr)
- Afforested (15 yr)
- Afforested (30 yr)
- Silvo-pasture (5 yr)
- Silvo-pasture (15 yr)
- Silvo-pasture (30 yr)
- Strip cropping
- Wetland
- River

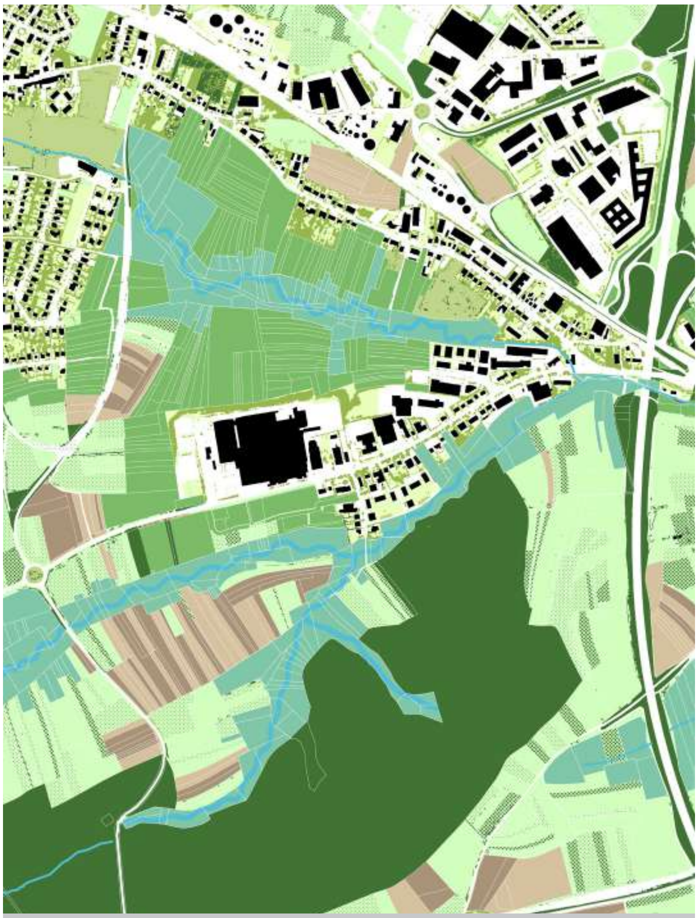

fig 4: Landuse change showcase 2.



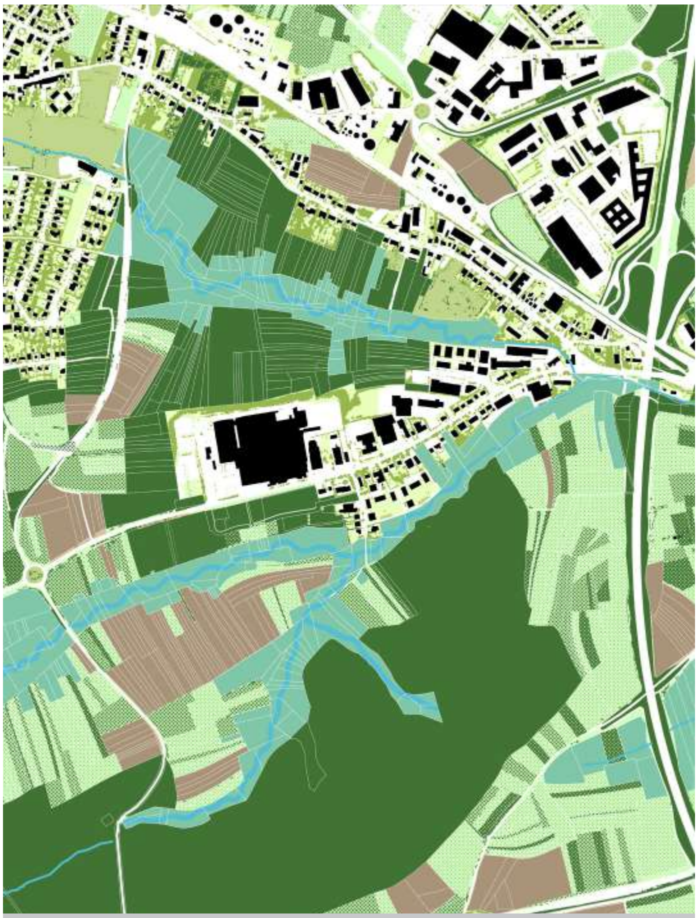
2021



2025



2035



2050

# Helfent
# Negative emissions 2021 to 2050

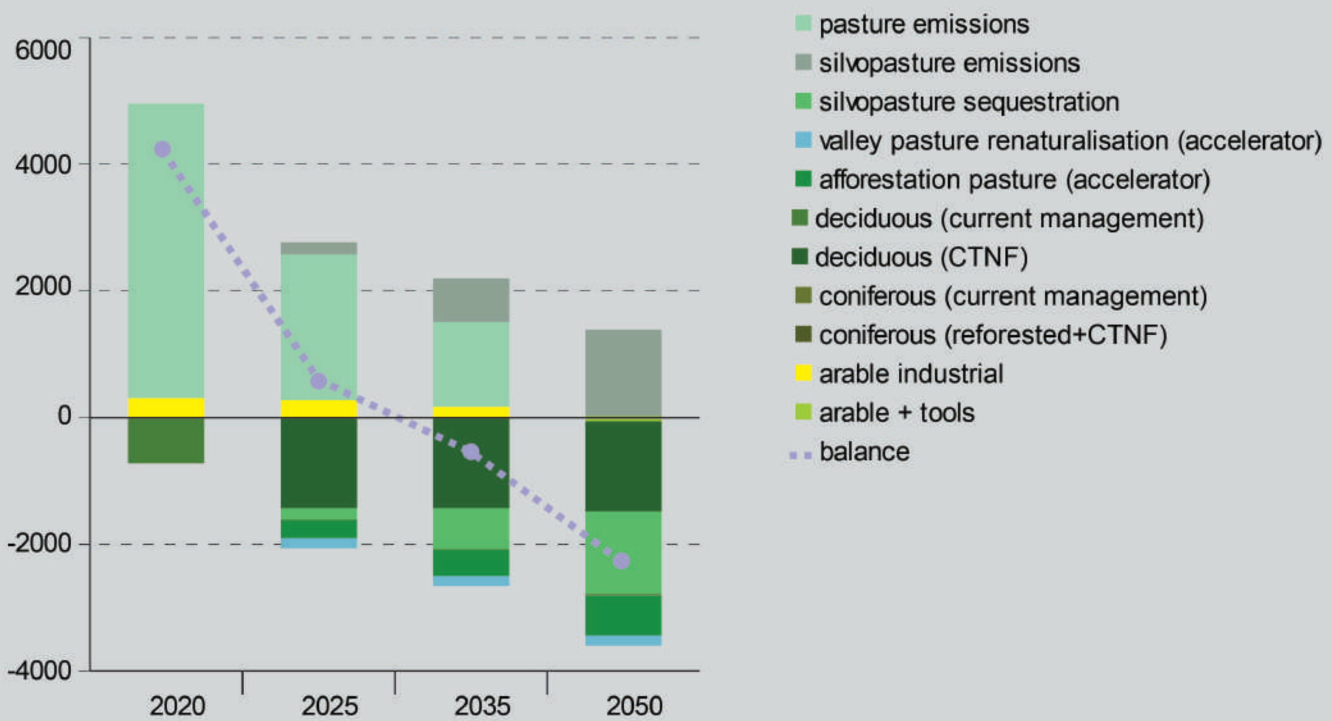
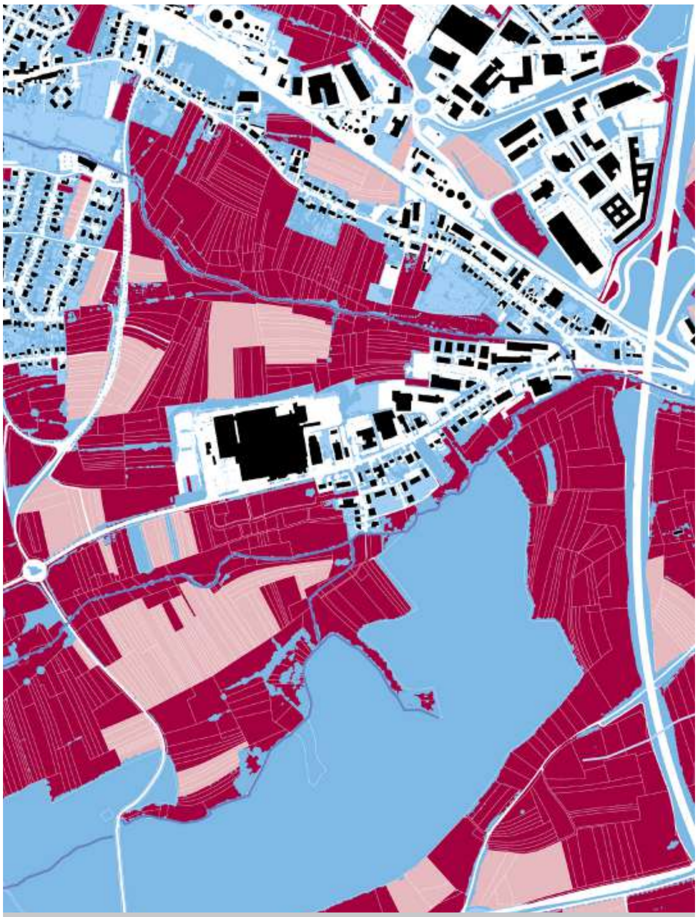
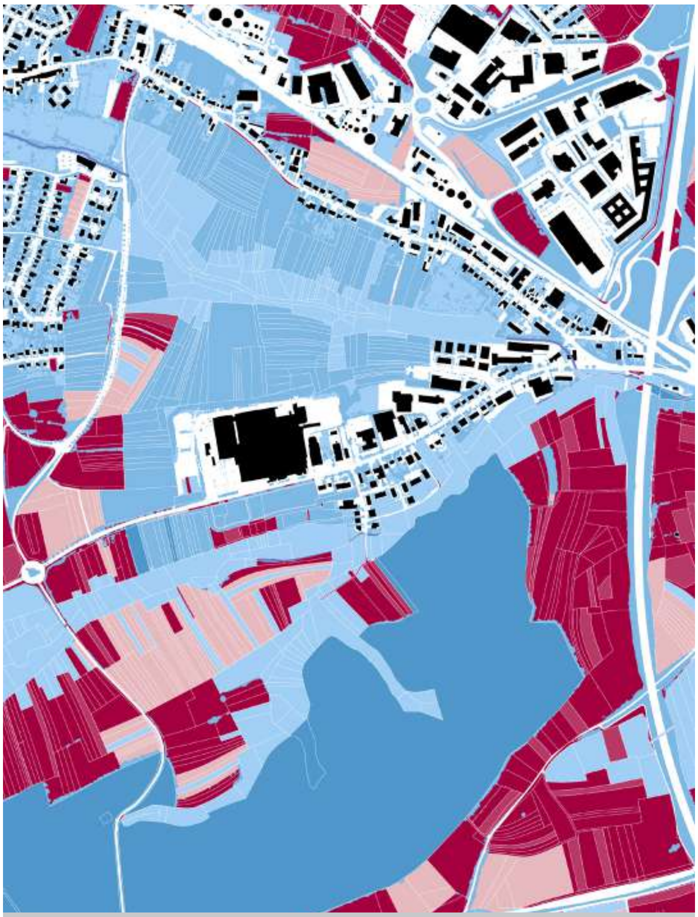


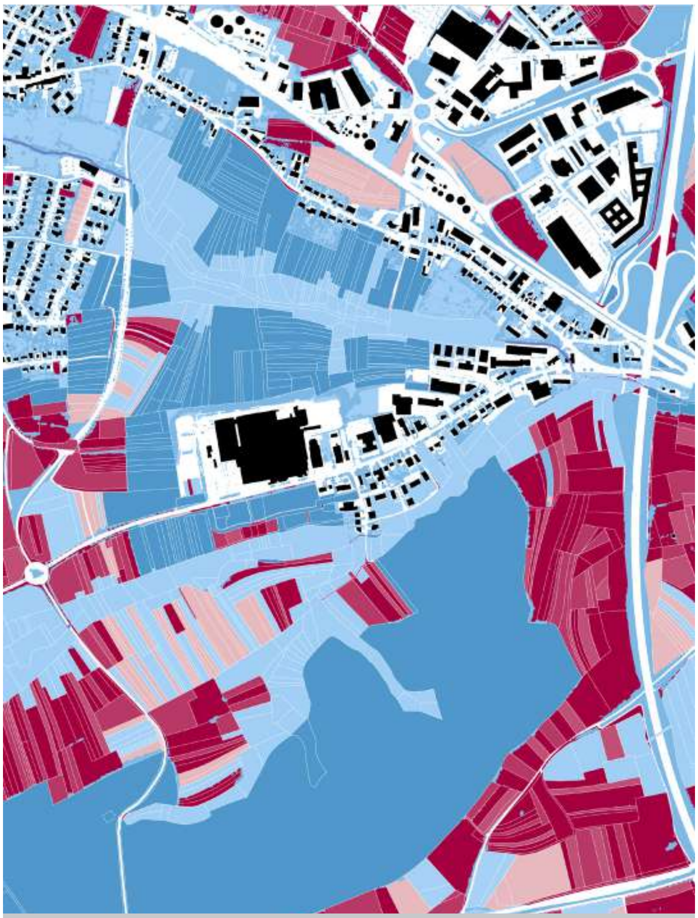

fig 5: Negative showcase 2.



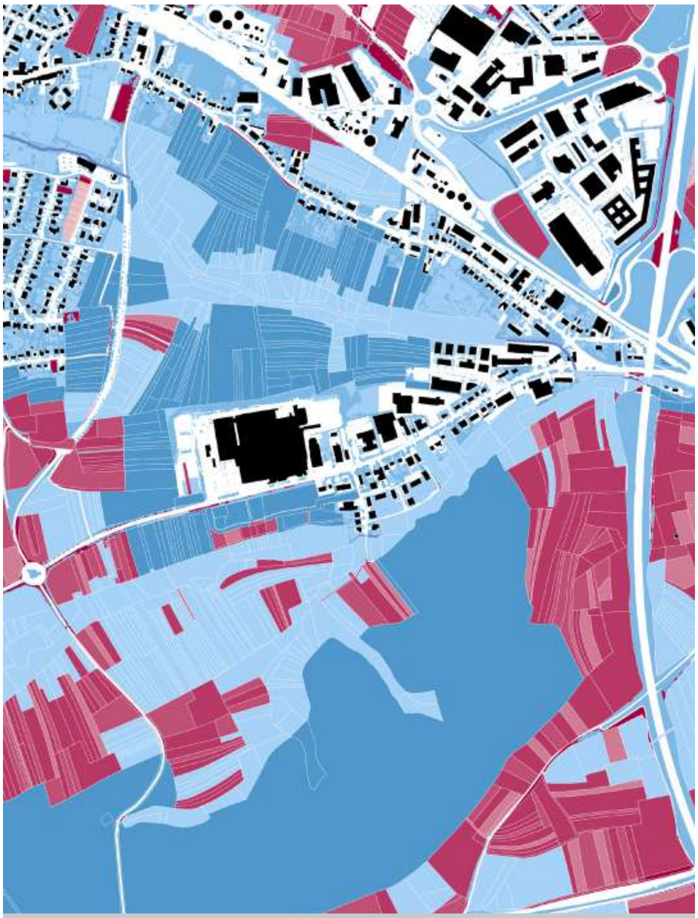
2021



2025

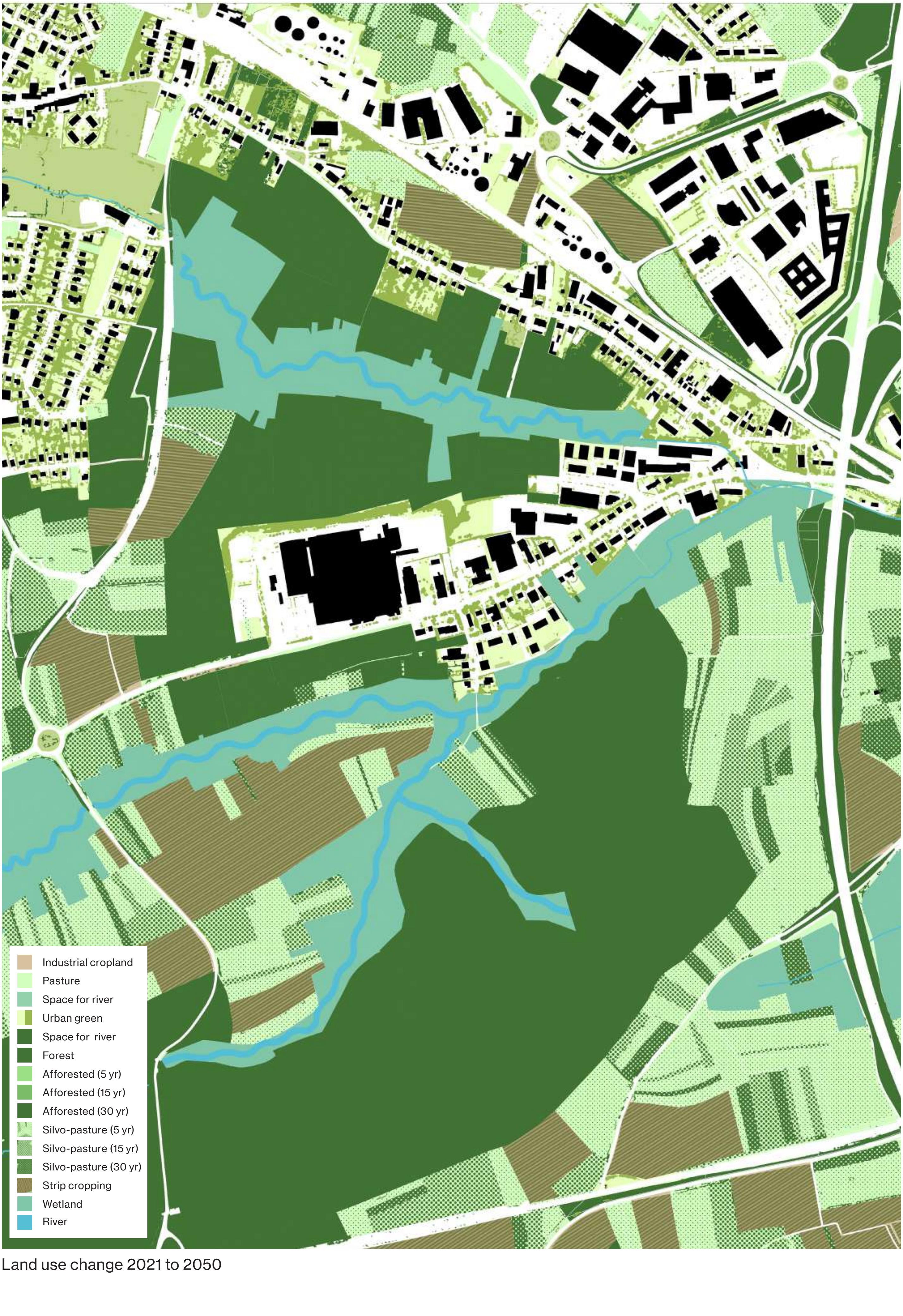


2035

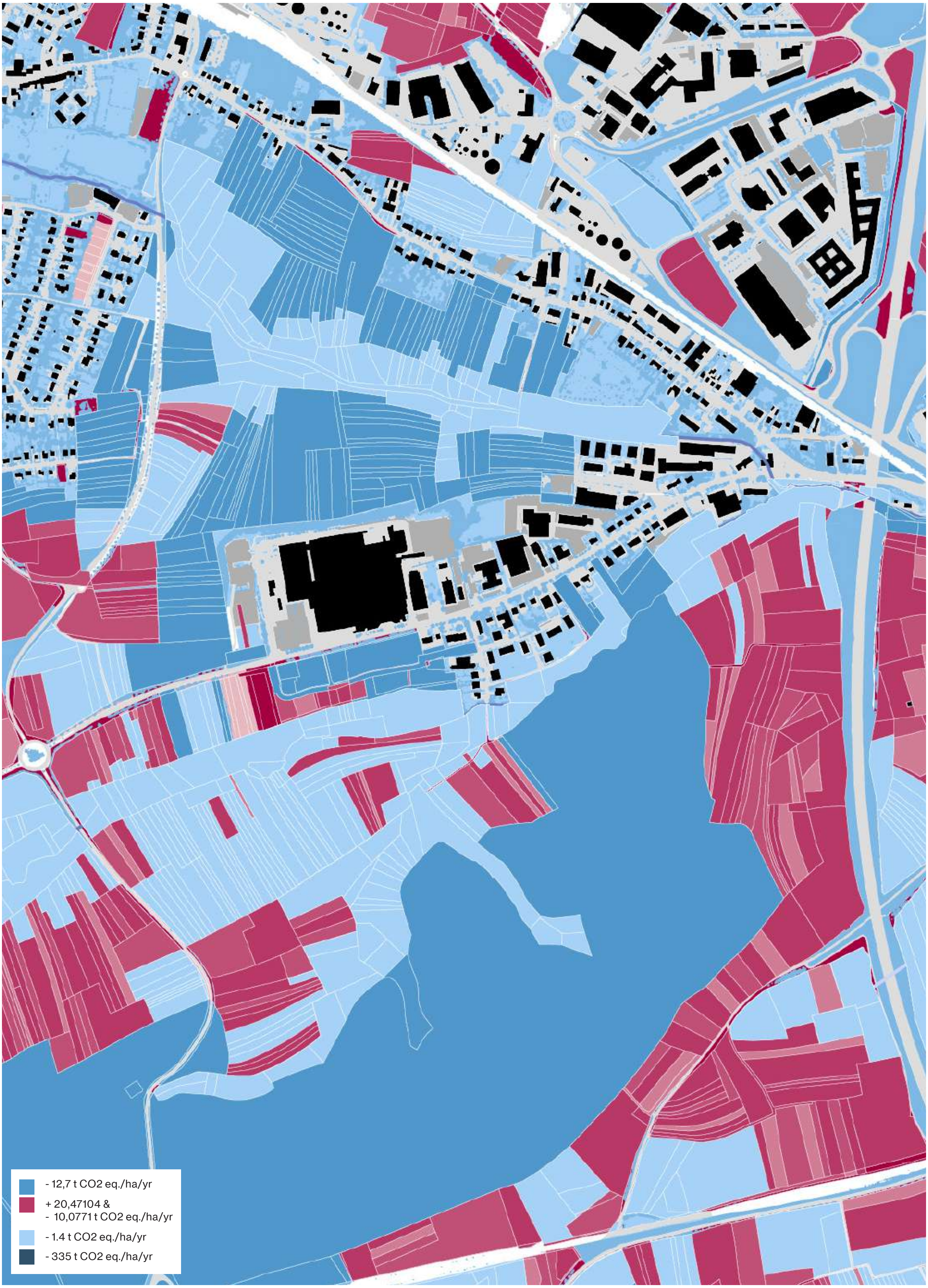


2050

- 12,7 t $CO_2$ eq./ha/yr + 20,47104 & - 10,0771 t $CO_2$ eq./ha/yr - 1.4 t $CO_2$ eq./ha/yr - 335 t $CO_2$ eq./ha/yr



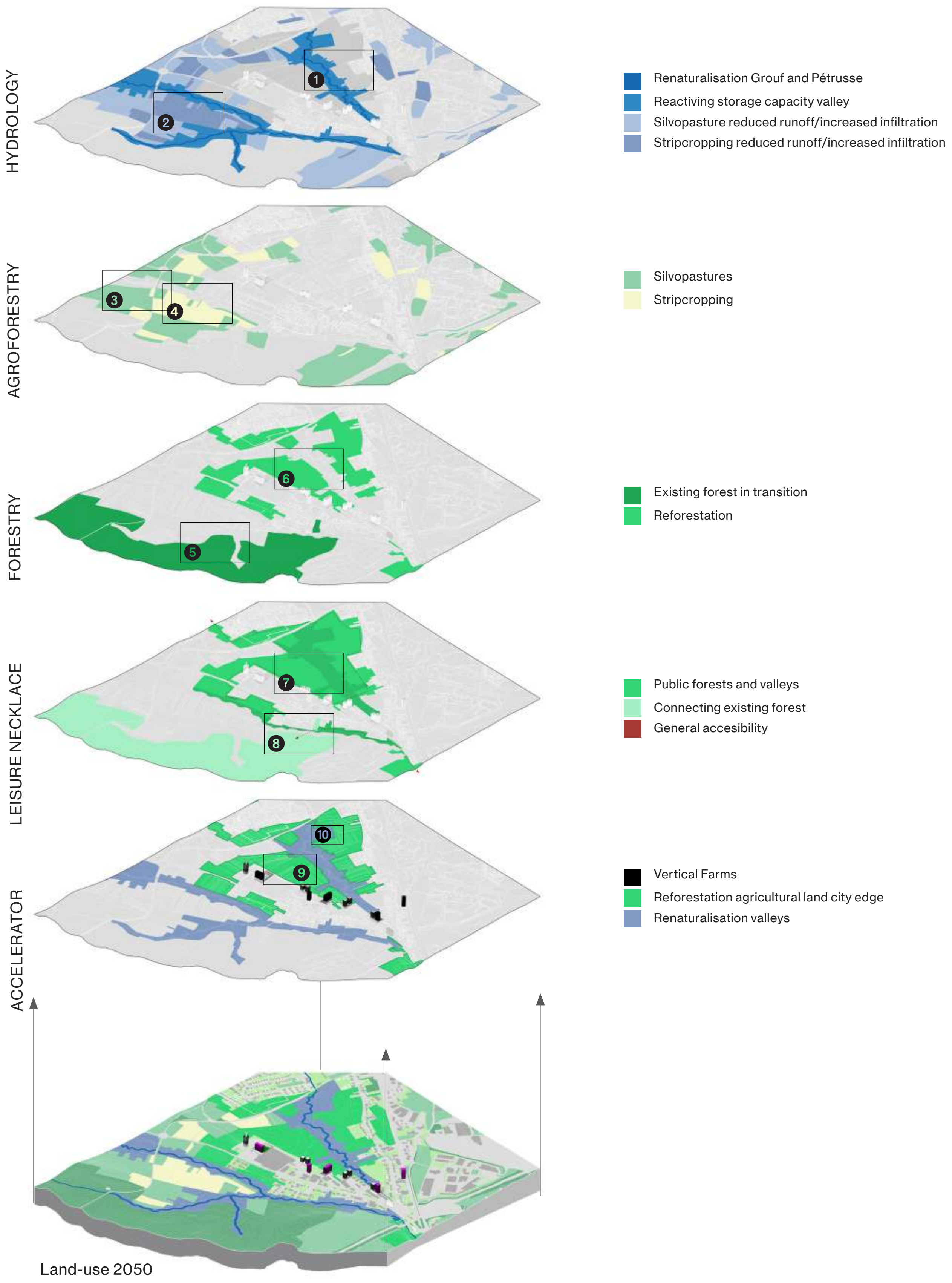

Land use change 2021 to 2050



Negative emissions 2021 to 2050

# Helfent
# Overview of tactile interventions

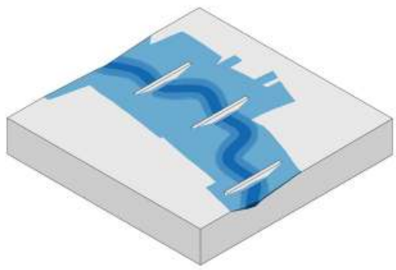
## Multifaceted landscape development



# Measures & principles

HYDROLOGY

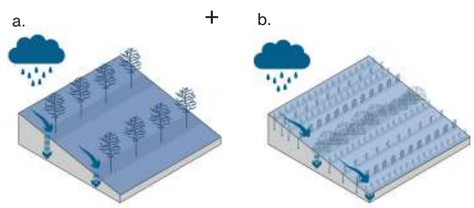
## Horizontal (river) flood relief



1

- renaturisation river
- reactivating storage capacity valley
- Maximum floodable surface during extreme events
- Weir increasing water retention capacity of valley

## Vertical (rain) flood relief

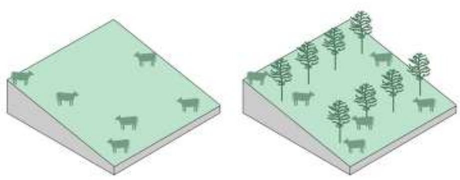



2

- a. silvopasture
- b. stripcropping
- runoff catchment
- infiltration/ groundwater recharge

AGROFORESTRY

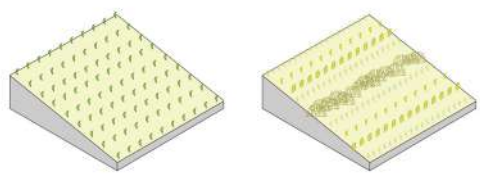
## Silvopastures




3

- Cattle
- Fruit/nuts

## Stripcropping

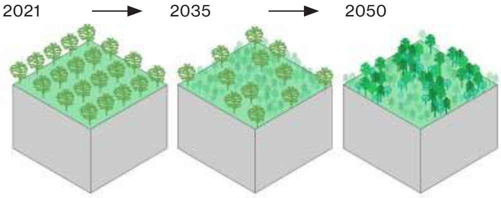



4

- monoculture
- polyculture
- ecological strip

FORESTRY

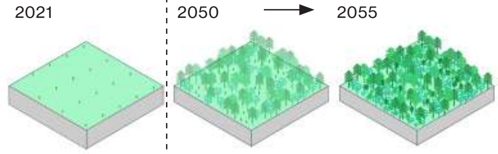
## Existing forest in transition




5

- Trees unadapted shifting climatic ranges
- Adaptive species diversifica-tion approach
- Resilient forests

## Close to nature forest management

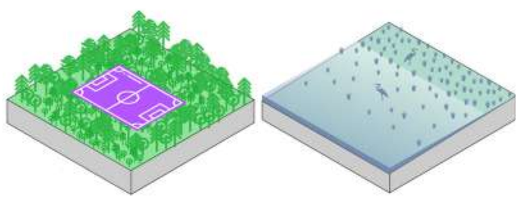



6

- clearfelling management
- selective harvest management
- mixed and uneven-aged, structurally diverse forest stands

LEISURE NECKLACE

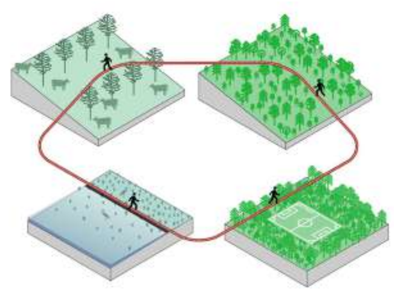
## Public functions



7

- urban program
- natural program

## Connectivity

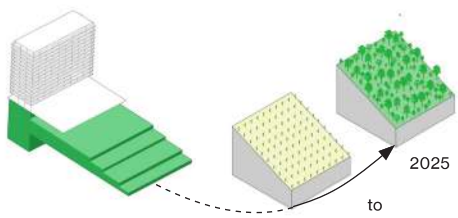


8

- General accesibility

ACCELERATOR

## CEA accelerator: food footprint reduction and afforestation




9

- Yield 1 ha VF (footprint 2000m2) = 50 ha conven-tional agriculture
- freed-up cropland
- afforested cropland

## CEA accelerator: food autarky and diet shift

10

- 3500 tons fruits and vegetables/ ha/yr
- Food autarky = exotic foods locally grown
- Diet shift accerator = diversifica-tion of local plant based products

# Helfent
# Overview of tactile interventions

Decarbonisation as leverage for Integrated landscape systems



Land-use 2050

Increased matrix connectivity by ecological intensification agriculture (sharing)

Increased matrix connectivity by sustainable intensification to set agricultural land aside for afforestation (sparing)

Heterogeneous patch types: novel and remnant natural and semi-natural habitats

- 12,7 t CO2 eq./ha/yr

+ 20,47104 and - 10,0771 t CO2 eq./ha/yr

- 1.4 t CO2 eq./ha/yr

- 335 t CO2 eq./ha/yr

Forest
Afforested
Silvo-pasture
Urban green
Strip cropping
Aquaculture
Wetland
River

# Helfent
# Overview of tactile interventions

Decarbonisation as leverage for Integrated landscape systems

RESILIENCE / ADAPTATION

LEISURE

PRODUCTIVE

Land-use 2050

- reduced run-off, increased infiltration, reduced high river levels and reduced (flash) floodrisk low located villages
- more space for the river to reduce the waterlevel of excess flows and avoid economical damage downstream due to large scale flooding
- low to extreme flood probability
- climate/drought & future disturbance resilient forests
- crop disease control, soil fertility increase, reduced erosion soil loss, increase soil water retention and availability
- climate/drought & future disturbance resilience trees, increase soil water retention and availability

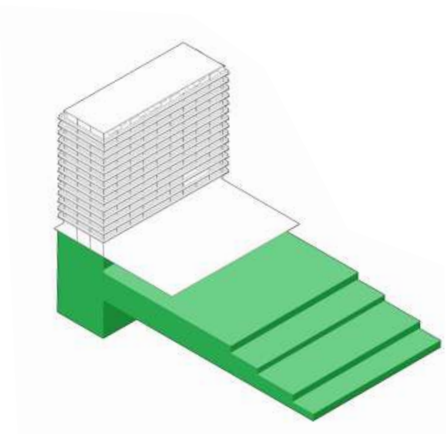
- Existing bike path
- New bike path
- Leisure necklace access
- Existing paved
- Existing path
- Leisure necklace
- Existing forest
- Bordering wetland

- mean annual increment merchantable of 8 m3/ha/yr close to nature forestry management
- Silvopasture: 0.01 to 0.23 tons/ merchantable/protein/ha/yr
- Protein crops: 1.8 tons/ merchantable/protein/ha/yr
- Vertical farm: 3500 tons fruits and vegetables/ha/yr

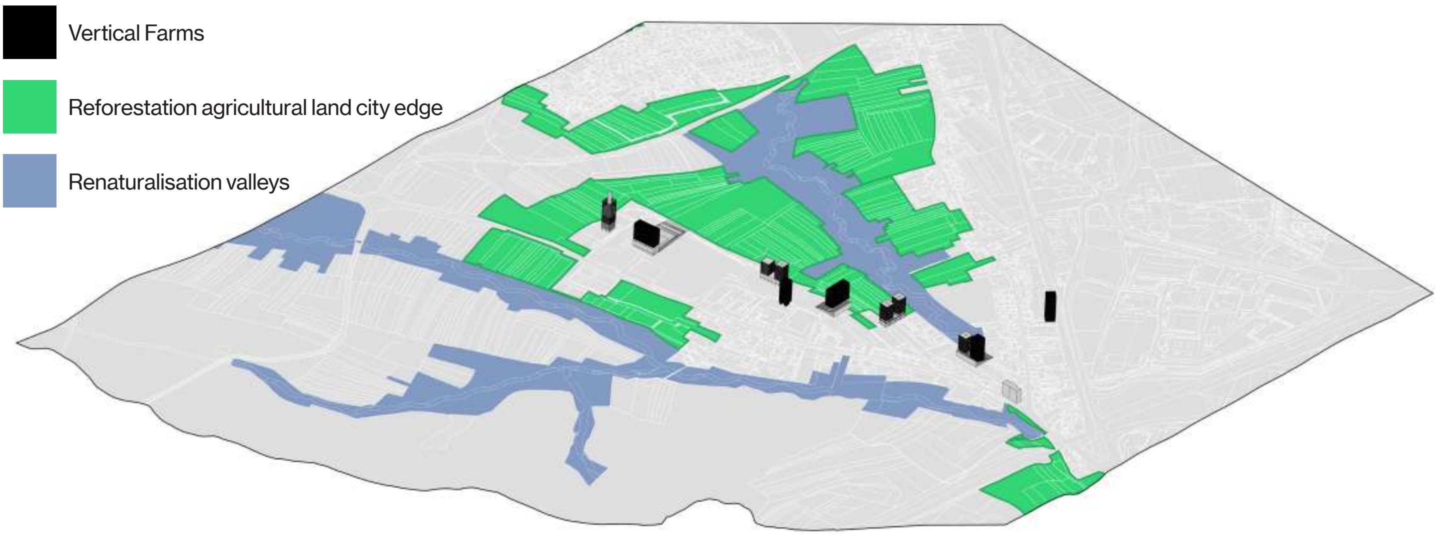
# Helfent
# Tactile recommendation

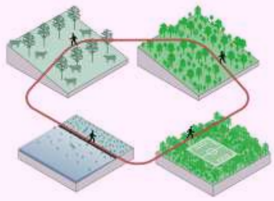
## Concordia food hub & the Luxembourg City leisure necklace

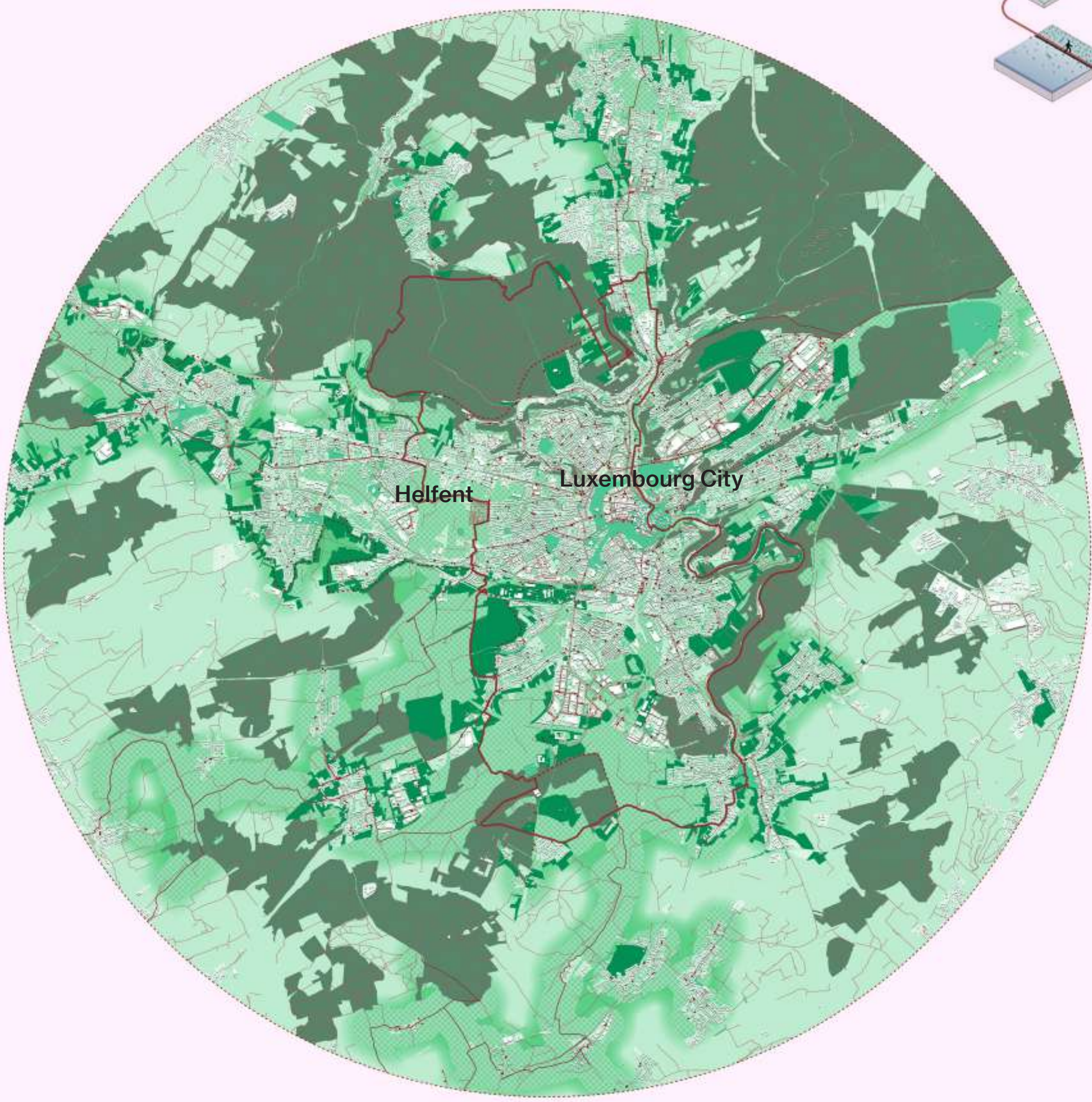
The Concrodia Food Hub, is a proposal for a vertical farm which partly occupies the current parking of Concordia, and adds an additional hybrid highrise which has vertical farm underground and housing on top. The produce from this vertical farm in combination with a number of others around Luxembourg city will allow the afforestation of series of arable lands around the city, to connect existing forests with new forests in form of a continuous accessible necklace. We also propose the addition of leisure functions along this route to further enhance the community interactions with this forested necklace.



3500 tons fruits and vegetables/ha/yr
year-round production








Existing forest

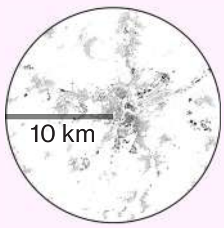
Existing public space

Search area new public forest catching development pressure

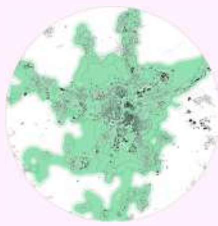
Existing recreational access

Search area new recreational access

Existing main national cycle route = main loop in leisure network




Outer Influence zone for metropolitan leisure accessibility



Highly accessible zone: within 300 meters of public transport stop or cycle way

# References

**Figures**

All figures:

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*Forest sequestration rate:* Sequestration rate management scenarios. (n.d.). [Graph]. http://www.stanrams.com/wp-content/uploads/KNAW.jpg

fig 1: Landuse change showcase 1. / fig. 2: Negative showcase 1. / fig. 3: Decarbonization menu showcase 1.

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fig 4: Landuse change showcase 2. / fig. 5: Negative showcase 2. / fig. 6: Decarbonization menu showcase 2.

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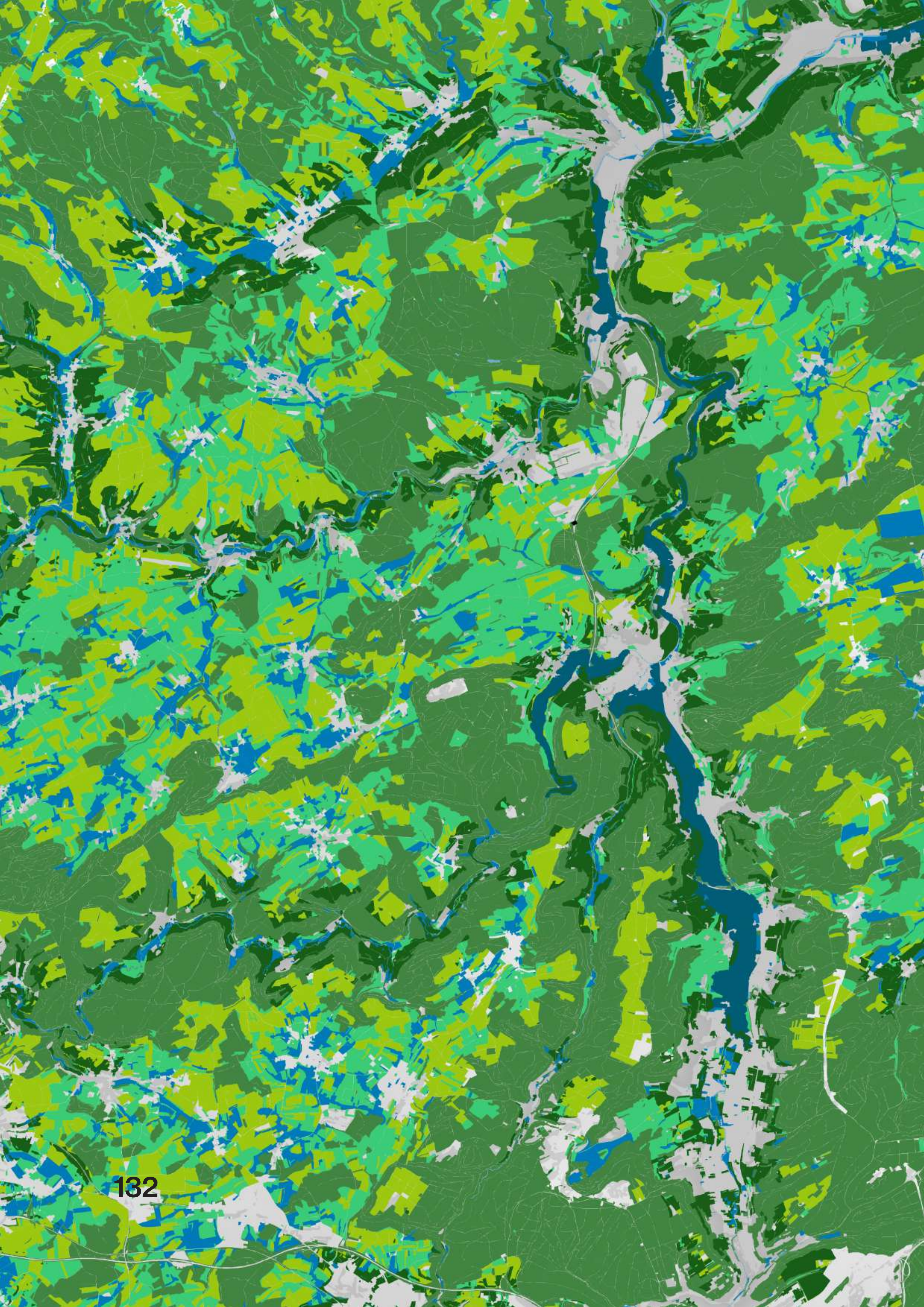
## Images

image 1: Mill of Bettendorf seen from the river Sûre (2014). Wikimedia commons. https://commons.wikimedia.org/wiki/File:Moulin_de_Bettendorf_01.jpg

image 2: CF Moller (2020). Kajstaden tower. https://www.cfmoller.com/p/Kajstaden-Tall-Timber-Building-i3592.html

# Conclusion



# Strategic recommendations

## The Bold diet

Showing the immediate correlations between centimetres of plates and hectares of land, and understanding the imported deforestation that is the consequence, would be a stepping stone for a bold diet shift. And as Line Bauer mentioned in our picnic conversation: “we need to work with all the actors in the ecosystem, resellers, retail, restaurants, and the whole environment to provide healthier and easier choices. We need to make healthy food an easy option.”

## Land Use Accelerators

As societal shifts are slow and gradual, we can accelerate the reduction of land footprint of our diets by Controlled Environment Agriculture and Aquaculture. These non-soil based cultivation mechanisms will boost the territory’s negative emissions if combined with afforestation over released land surfaces.

## Net-Zero Growth

Net-Zero Growth, the contraction between net-zero landtake and smart growth, is an attitude accepting, enabling and promoting demographic and economic growth without grabbing land from agricultural or natural landscapes in order to maximize sequestration and soil productivity. Reaching a common definition of growth across sectors is a necessary first step.

## TDR

Transferable Development Rights can act as a transititory planning mechanism to divert growth in the short-term over existing sealed surfaces. Net-zero landtake will not be possible without this tool. However, for the general legal and planning framework and criteria to be set, conversations need to continue with relative experts and policy-makers to draft the tailored variant for Luxembourg.

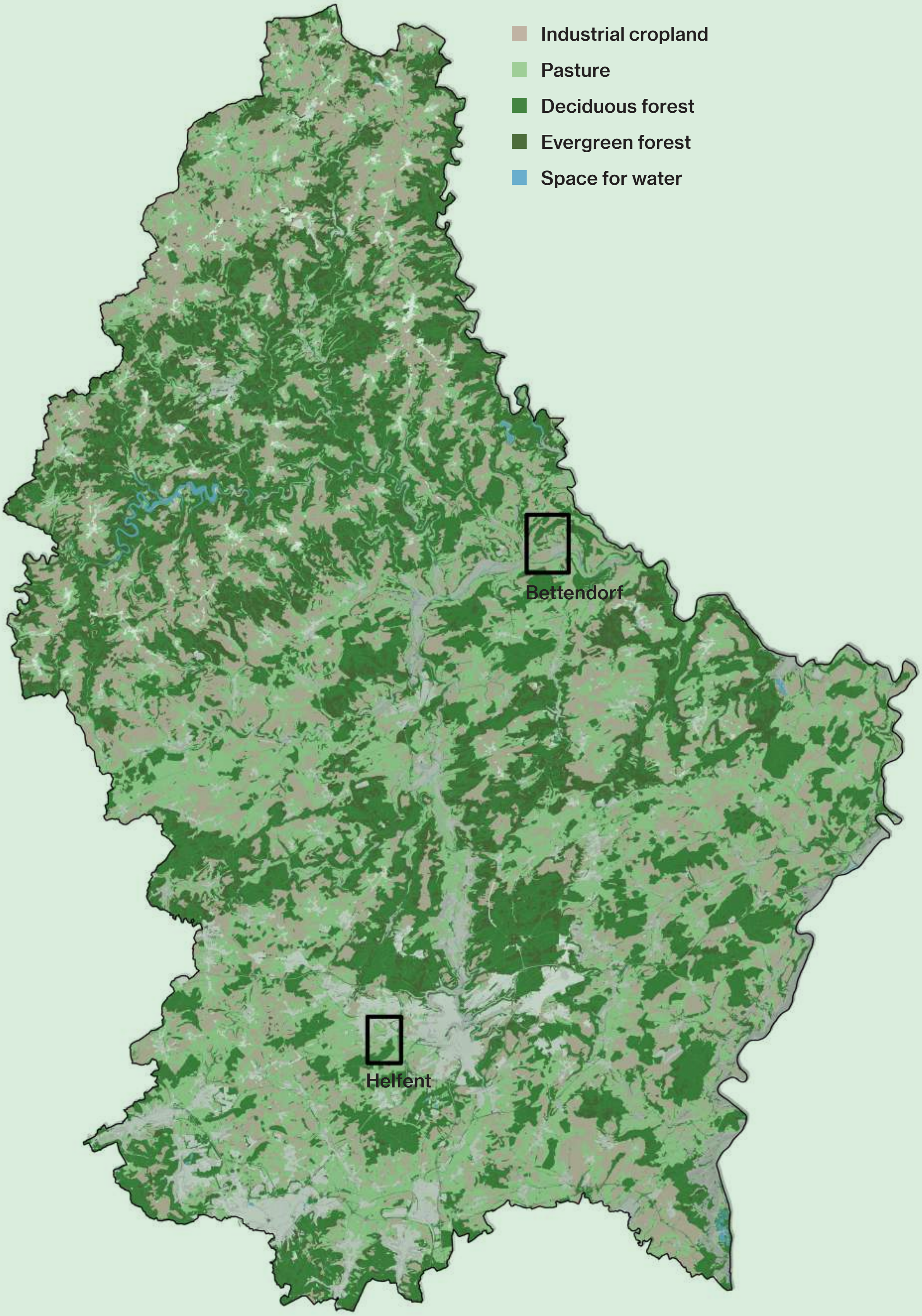
## Carbon Farming

Agricultural practices in Luxembourg are driven by cultural attachments, economics and legislation. A national debate is necessary to redefine agricultural future, and better understand what parts of the culture are integral to the community. From an economic perspective, farmers need business and marketing consultation to economically manage a transition towards sequestering practices. And lastly, legislations must provide room for farmers to experiment.

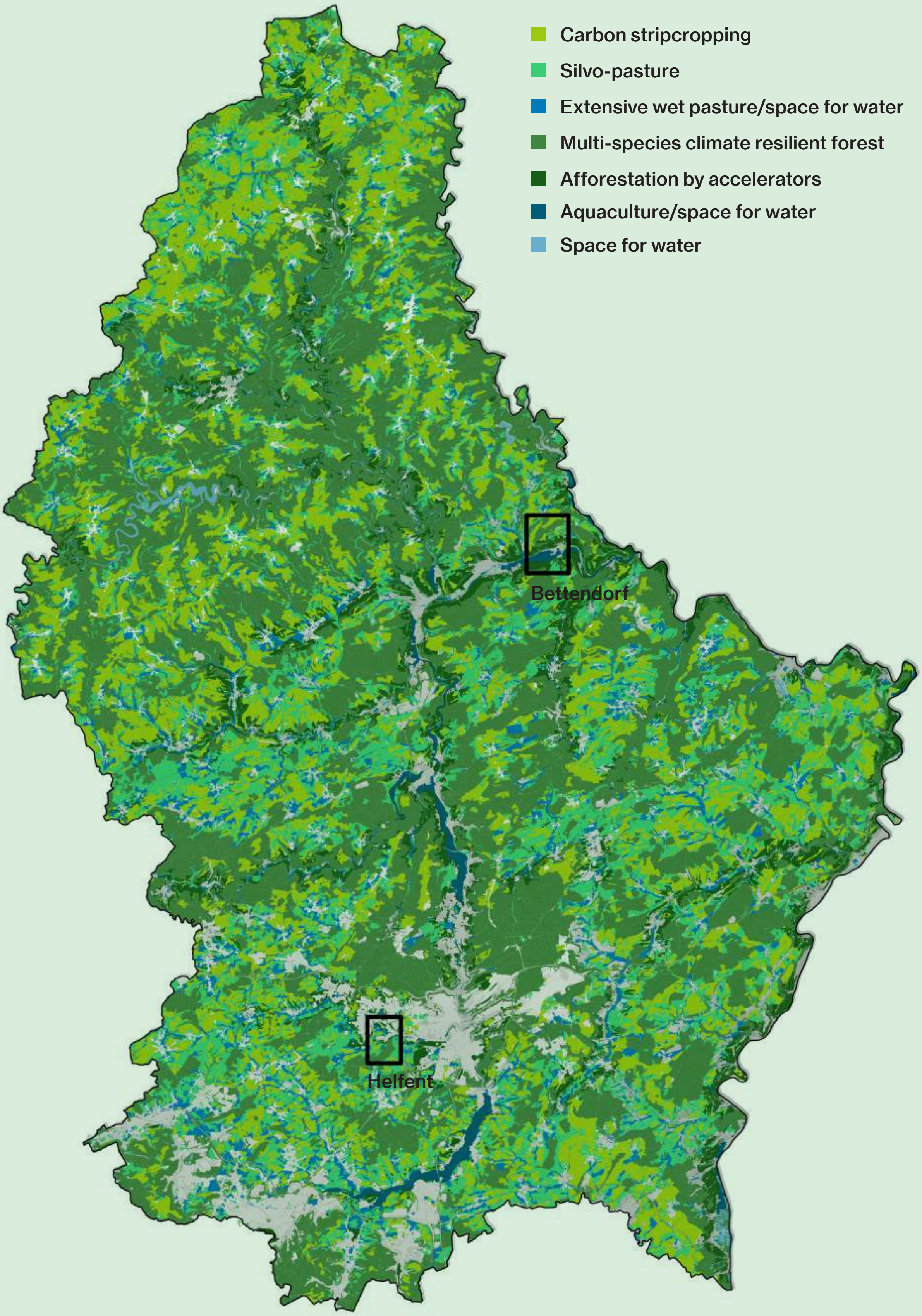
## Afforestation

Afforestation in combination with close to nature forest management is the final piece in the nature-based carbon capture puzzle. Healthy forests can also be productive. Raising awareness around this topic is necessary for the large number of small forest owners and conservationists to reach a consensus about the territorial role forests can play in enhancing negative emissions, in addition to timber production and climate adaptation at large.

# Territorial landscape footprints 2018



# Territorial landscape footprints 2050



# Pleasures of Decarbonisation in the Lifetime of Marie

Marie is 10 years old. She is visiting the algae pools of Bettendorf for the first time.

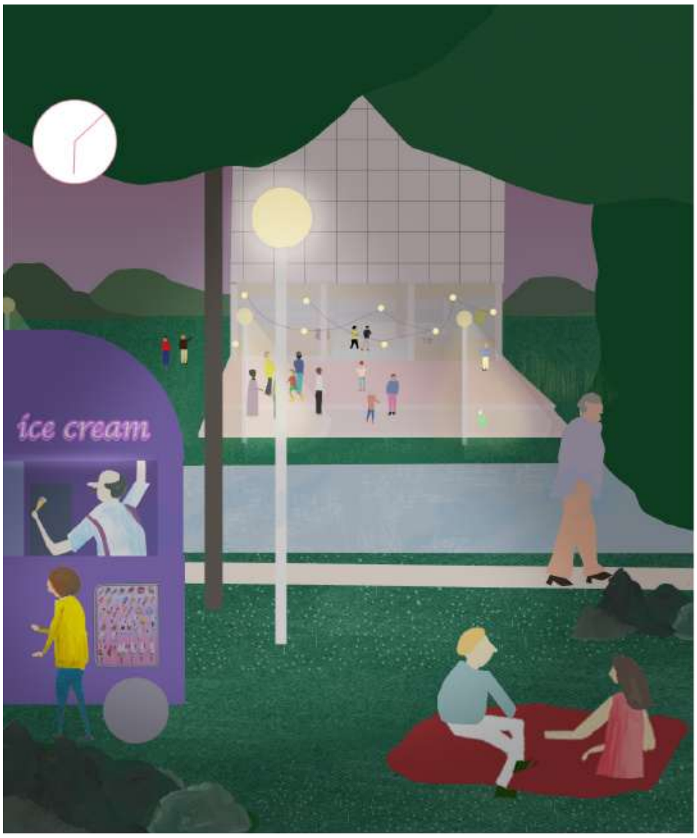
Marie and her mom stop on the dyke path to learn more about the new crops of Bettendorf.

They then take a canoe tour of Nordstad together with local tourists.

At the age of 15 Marie learns about tree species and wood types in the forest workshop at her school.

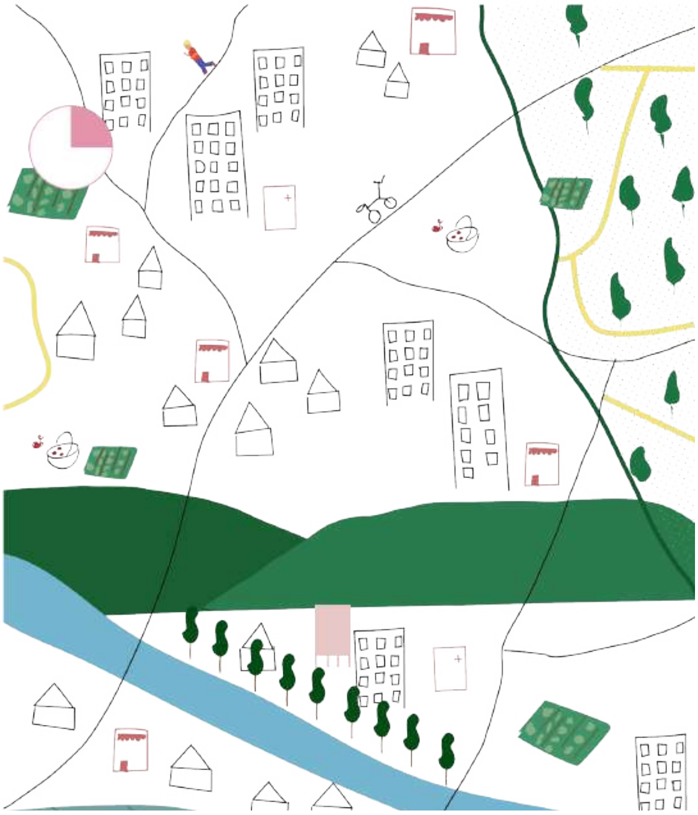
Close to nature forest management is now part of their curriculum.


There they learn about ecological & economic aspects of " close to nature forest management ".



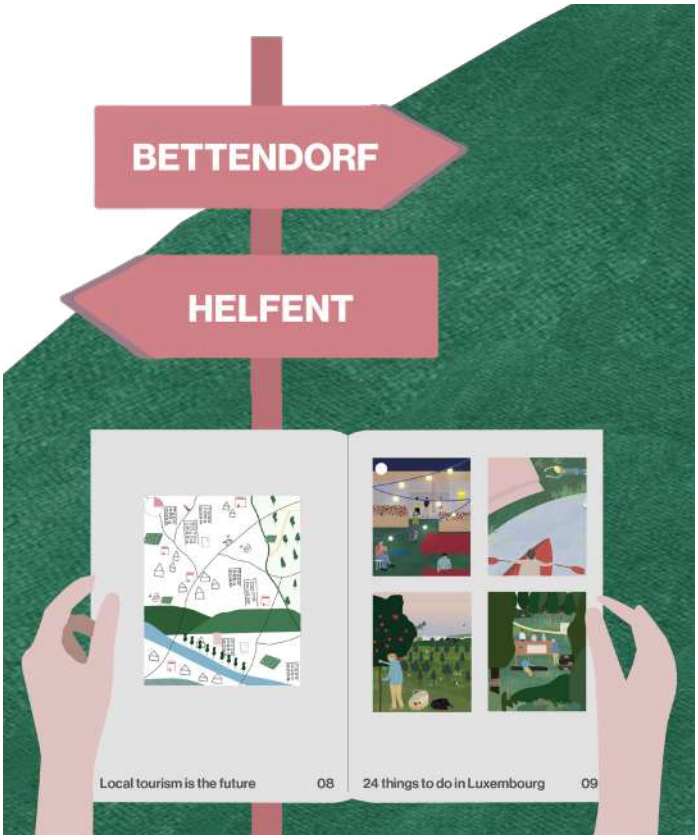

As Marie reaches 20, she moves to Helfent to continue her studies. She lives not far from the Petrusse waterfront.


The waterfront has a very active nightlife thanks to new demographies and typologies.



It is now much easier to move around the city, with every destination within reach by 15 minutes.

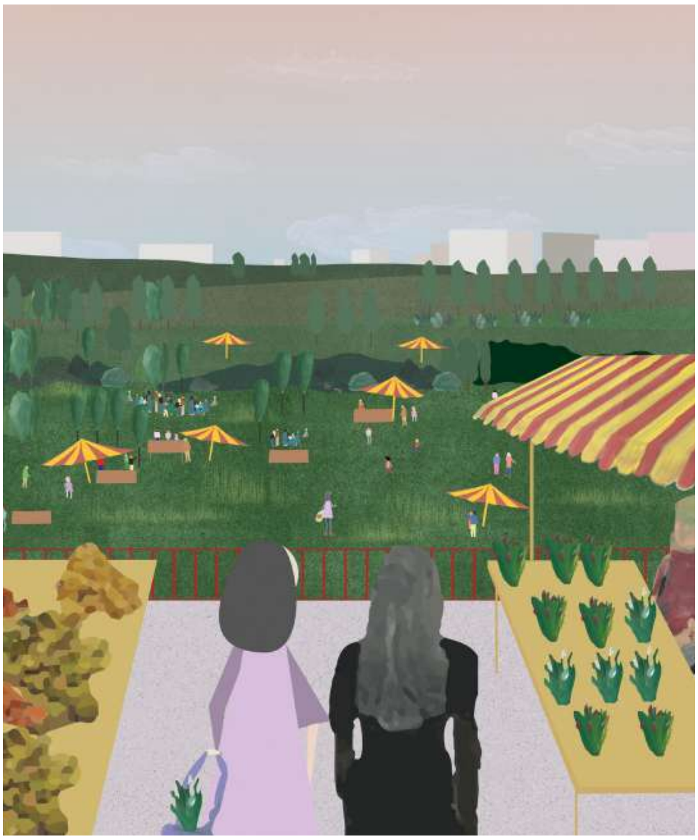

Marie’s father like to take Adam, his grandson, to weekend trips around the country.




They are excited to try the newly added destination introduced in the local tourism magazine.


The summer camp they choose, has a few hiking tracks which Adam enjoys very much.

Marie, 30, has her studio in the City Concorde highrise, sitting on top of a market and vertical farm.



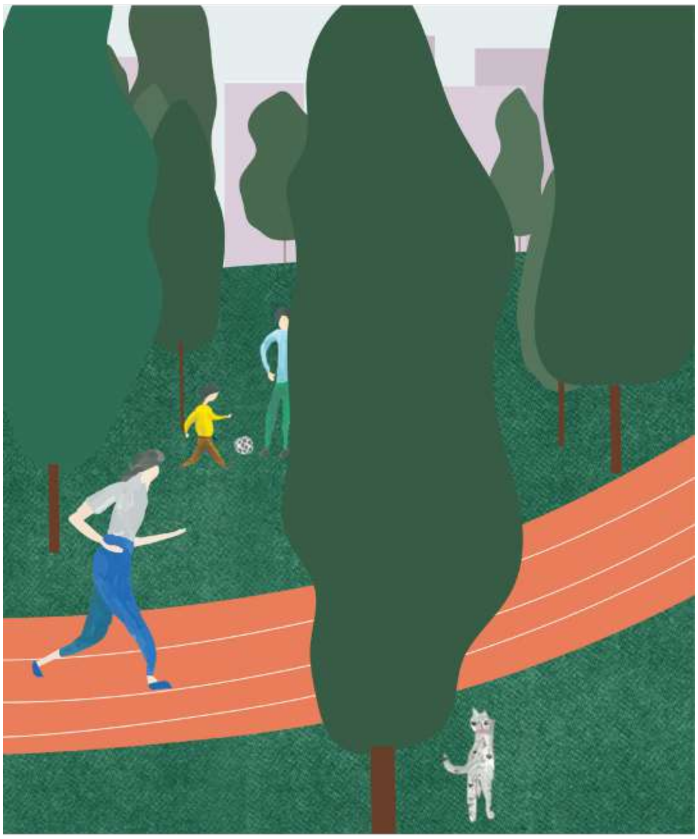
She visits the market on Thursdays to discuss the parsnips of next year with the local farmer.

Luca works at the Concorde vertical farm and co-created the market stand with other food producers in the area.

Silvopastures are now commonplace across Luxembourg, resulting in enhanced water infiltration and record negative emissions.

Citizens are invited to pick the fruits of silvopastures on specified harvest days.

Maria, now 35, is enjoying some fresh cider on silvopasture fields with her friend Noah.



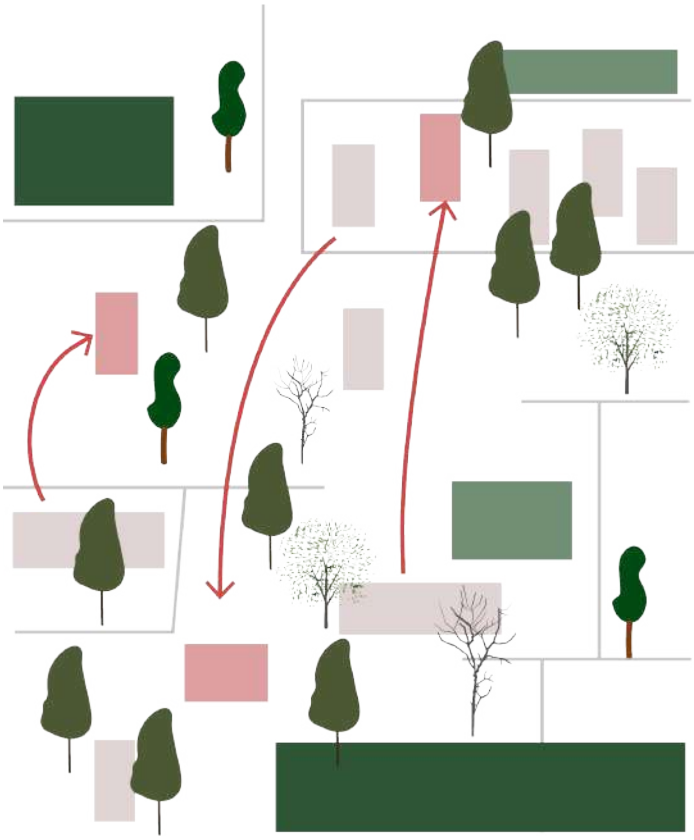
Marie goes for a morning run in running track that is within the forest next to her flat.

The track goes along the Petrusse river where she gets to meet her neighbours.

Now a grandmother, she works from home every other day and can enjoy the forest's view.

Transferable development rights has been in practice for decades now.

Marie is playing a key role in the recent round of votes for assigning sending and receiving zones.



She takes pride in having been a pioneer advocating for Net Zero Landtake.

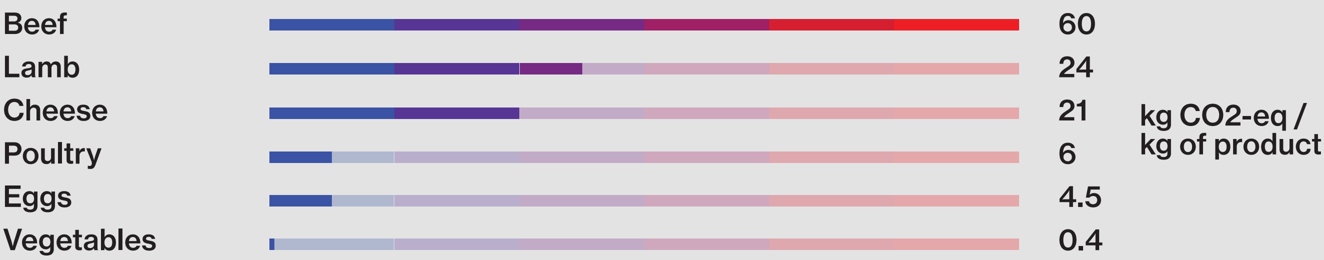
# *Deep*
# report

# Index

# The Bold Diet

2050

# Current average diet; carbon price of our plate




# 0.96

ha/capita/year


fig. 1: Food emissions for food type and equivalent land use.

# Footprint of our diet

Food consumption is responsible for almost a third of total global emissions. This is not purely due to emissions from farming or packaging. It is an interconnected network of carbonising activities spanning from land use change, farms, animal feed, processing, transport, retail and packaging. That being said, land use change and agricultural practices are the activities which play the major role, and take up 71% of the emissions.

From a carbon footprint perspective; to put in comparison, the average diet in the US accounts for 2050 kgCO2-eq/capita/year, while a vegan diet is only 250 kgCO2-eq/capita/year.

From a land use perspectice; the current global diet requires more than 7 times the land a plant-based diet would consume.

***These two factors in combination, make a shift in our diets, the most effective measure to take for reaching carbon neutrality targets of 2050 by means of nature-based solutions.***

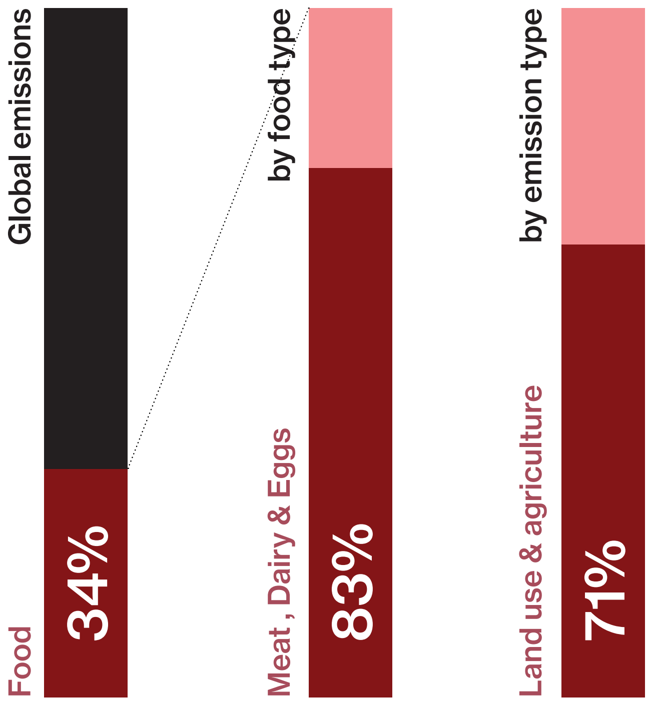
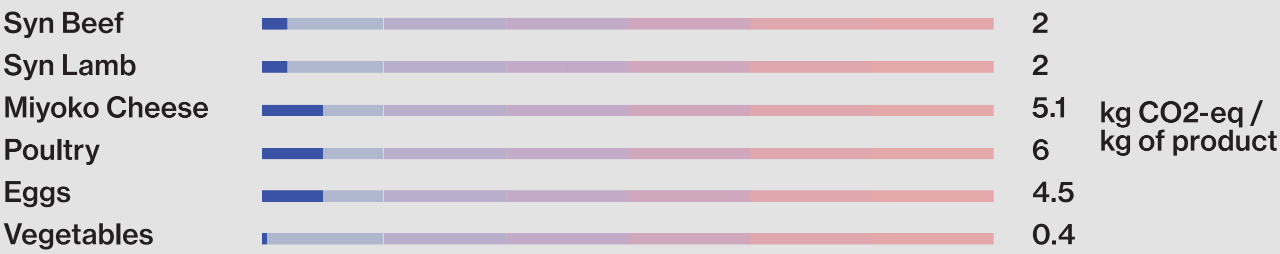



fig 2: Role of food in global emissions.

# Bold diet;
carbon price of our plate




**0.13**

ha/capita/year

a plantbased diet

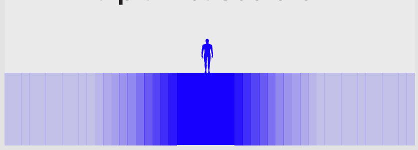


fig. 3: Food emissions for food type and equivalent land use.

# Comparison of possible diets

The shift in diet is a highly sensitive topic and it is due to this reason that it is either not discussed, or even when discussed only mild shifts are seen as plausible. This assumption is reflected in the EU's proposal for a diet shift which only recommends a modest replacement of consumption of beef and mutton with meat of goat (European Commission, 2018).

What we have decided to explore, is what we have called the bold shift. We do not believe in a total vegan diet for everyone. However, we anticipate a gradual shift to diets that have a much lower carbon footprints. This shift will not need to occur over night, and does not mean never eating meat or dairy. It is a step by step balancing act towards a healthy future for our ecosystem and a resilient future for our food security. By exploring the bold diet shift, we prove that it is possible for the region the feed itself, reduce its food-related carbon footprint, and enhance negative emissions beyond any of the current projections.

***A bold diet shift driven by citizens, has the power to parachute the total emissions of the region towards neutrality.***

It is a step by step balancing act towards a healthy future for our ecosystem and a resilient future for our food security.

By exploring the bold diet shift, we prove that it is possible for the region the feed itself, reduce its food-related carbon footprint, and enhance negative emissions beyond any of the current projections.

image 1

# Comparison of possible diets

For the purpose of making the calculation and presentations more tangible, we have translated the current dietary practices into two models, each representing one end of the spectrum of possibilities. The assumptions made to carry out this interpretation are laid out in the final spread of this chapter.

On one end of the spectrum we have the plant-based diet, which includes the current vegans, vegetarians but also other potential diets which are still within the bounds of a similar carbon footprint. For example, advances in foodtech have resulted in meat and dairy products produced in laboratories which mirror the taste and texture of natural meat, while greatly reducing the carbon footprint.

On the other end of the spectrum we have featured a diet called Omni100, which in simple terms is an omnivorous diet that includes a healthy balance of all ingredients.

All the other diets such as flexitarian and vegetarian, have been taken into account in this division as well. The process of translating diets to each other have been explained at the end of the chapter.

The timeline on the next page shows the shift in 3 ways. On the right end vertical axis, we can follow the blue line to understand if everyone in Luxembourg (100% of the population), had the same diet, they currently only consume 1 plant-based meal per week and the rest is omnivorous. This changes gradually to 6 days a week practice of a diet that has a footprint equivalent to a plant-based diet (Bold diet) by 2050. The top end horizontal axis, shows the percentage of the population which are fully practicing a bold diet. And finally the greenline represents a more nuanced and layered view of the shift.

# Proposal for a bold diet shift; dietary habits of Luxembourg

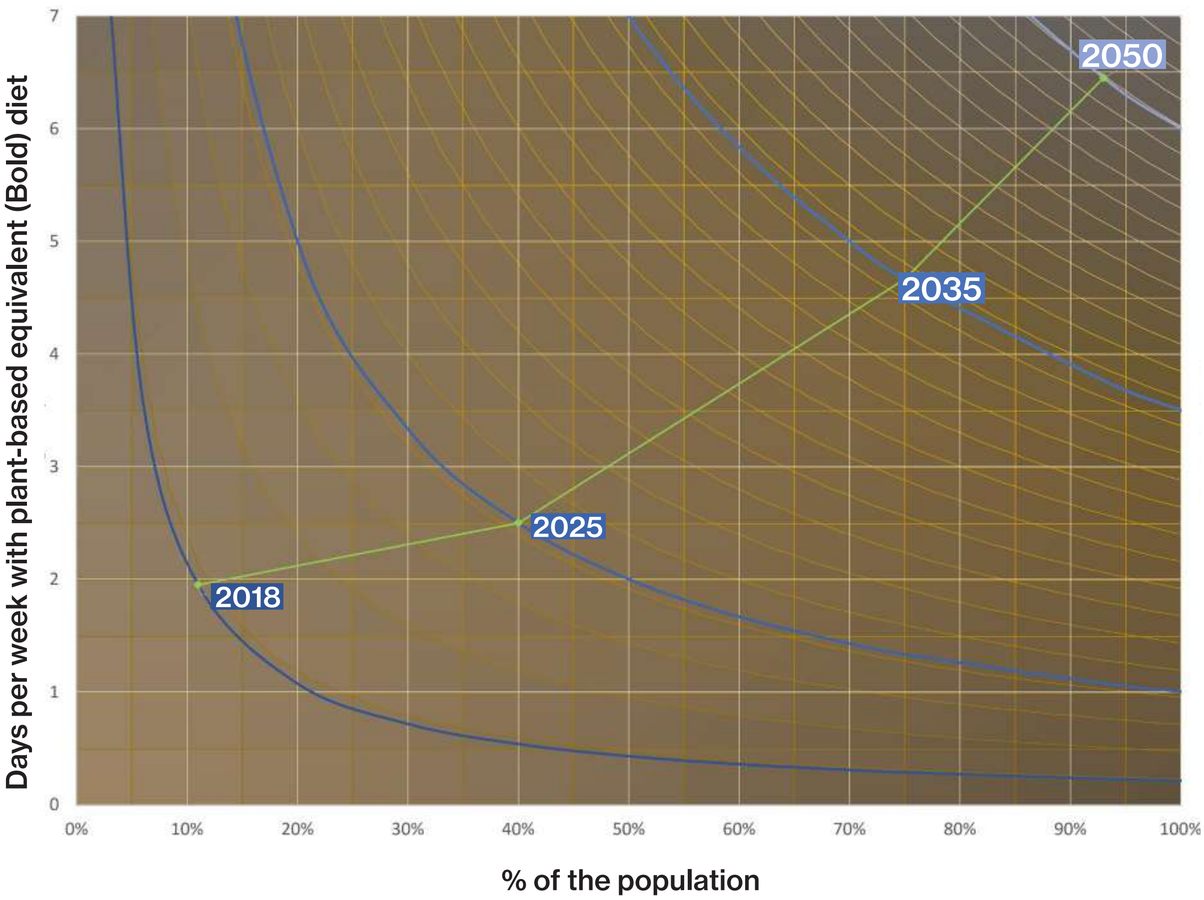
We envision a fundamental but plausible dietary change by 2050, which is illustrated in the following graph. It shows how many percent of the population practice a diet with a similar footprint to a plant-based diet on how many days per week, while the remaining percentage eat meat daily.
The blue lines stand for constant land use requirements, and the green line shows the evolution over time.
We recognized other diets, such as vegetarian and flexitarian, by converting them into plant-based.

Starting from the latest survey from 2018 (TNS Ilres, 2020), we picture the following scenario, which builds on projected market shares of meat and alternative products (Kearney,2020) and political support.

**The Bold diet shift if everyone had the same diet would be as follows;**
**100% of the population will practice a bold diet on 1 day/week in 2025,**

**100% of the population will practice a bold diet on 3.5 days/week in 2035,**

**100% of the population will practice a bold diet on 6 days/week in 2050.**



# 491,724 ha

of pastures & croplands can be freed by 2050

The freed land can be cultivated towards decarbonisation rather than carbonising food production.


image 2

# Outtake 1 : The 2000sqm farm

The IBLA considers (Das Projekt – 2000m2.lu, 2019), on a global scale approximately 2000sqm of agricultural surfaces are available per person, and for Luxembourg, this is roughly the same (STATEC, 2019), even though in decrease.

However, the current agricultural surface use in Luxembourg unveils a behavioral pattern with considerable environmental impacts:

Of the 2000sqm per person, 1750sqm are used on average for livestock; either for its fodder, or for meat and dairy production.

Merely 250sqm, i.e. 1/8 of our 2000sqm are used for vegetables, fruit and/or cereals. Since 87,5% of Luxembourg's agricultural surfaces are used for animal products, the country relies heavily on imports of food.

The 2000sqm case study project launched worldwide and in Luxembourg by IBLA, NATUR&EMWELT and CO-LABOR at the Kockelscheuer, aims at demonstrating a sustainable use our available soil and the conditions under which we can feed of this land.

The project splits the surface in 2 parts:

1. 1000sqm are available for production, of which:
- 650sqm are for human use,
- 350sqm for animal fodder.

This is sufficient to cover the per capita demand in eggs, but not in chicken or pork meat.

2. 1000sqm remain pastures, characteristic for Luxembourg's landscape, and are used for dairy and meat, but especially biological manure/fertilizer.

This split implies major diet shifts, especially a drastic reduction in meat and dairy, in order to be able to feed of this land. Hence, the current meat consumption of ± 100kg/capita/year needs to be reduced to ≤55kg/capita/year in order not to over-use space.

***Since 87,5% of Luxembourg's agricultural surfaces are used for animal products, the country relies heavily on imports of food.***

"Howcome we have practically no local vegetable production?"

Karin
citizens committee

"Gardens produce so much harvest, but so much is thrown away, because the sharing or distribution network is not in place"

Yolande
citizens committee

"Could there be a community supported agriculture?"

Sue
citizens committee

"If everybody goes for soy milk, where is the soy coming from? "

Sandra
citizens committee

"Could quality food be made less expensive?"

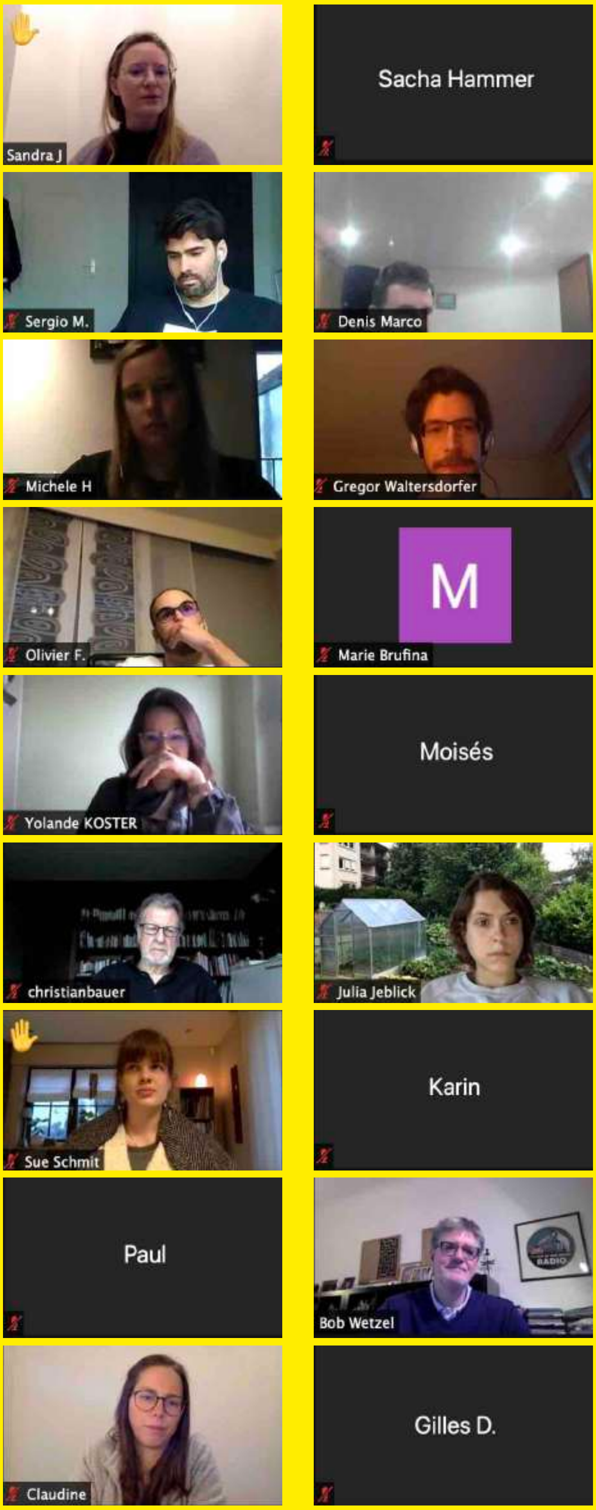
Julia
citizens committee

"Most people will tend towards low-budget solutions"

Claudine
citizens committee

# Outtake 2:
# Citizen Committee's feedback;

In a closed session with the Citizen Committee, we discussed the carbon footprint of food with the members and shared with them our outlook on diet change. In addition we asked them to fill a questionnaire so that we better understand their eating habits and their beliefs about the future of food in the region. The session was filled with insights and interesting questions for us. Some of the points discussed are featured in the opposite page in form of quotes. And the questionnaire response can be found in the appendix to this dossier. We would like to continue our conversation with the committee and work with them in developing the in depth proposals of the 3rd stage especially regarding community gardening, consumer habits and role of private gardens.



# Drivers of dietary change

The change has already started: sales of meat substitute food based on soy and peas grow by roughly 10% per year (Fleischatlas, 2021). Similar to the development during the energy transition, it is only a matter of time until cultured meat becomes cheaper than animal-based meat. Both, meat substitutes and cultured meat, require significantly less arable land.

We expect that raised awareness of consumers on meat-related health concerns, such as the use of hormones and antibiotics in meat production, processed meat being carcinogenic (WHO, 2015), and increased risk for cardiovascular diseases and diabetes, will accelerate the change in user preferences. Additionally, as young people are more affected by climate change, the generational shift will reinforce the transition (Fleischatlas, 2021).
Dietary change can get a boost, when the production of "Bold" food gets incentivized through carbon tax or credits for sequestrated carbon, and thus these products become cheaper than animal-based products.

As more options for meat substitutes and cultured meat will become available and demand will increase as well, restaurants, food trucks, grocery stores, canteens, magazine and book publishers and (TV) chefs will react to these trends, and by that make bold diets convenient, abundant, interesting, and culturally ingrained.

## Key drivers for dietary change

### Carbon tax and incentives;
prices to reflect true embeded emissions

### Cultured meat;
more efficient than animal-based meat and eventually cheaper

### More bold diet options;
become available in supermarkets and restaurants

**Supply**

### Raised awareness;
on meat related health concerns

### Generational shift;
climate change as the young generation's paradigm.

### Changes user preferences;
becoming eventually culturally ingrained

**Demand**

fig. 4: Key drivers in dietary change.

# Role of politics

Politics needs to support forward thinking farmers and other business actors in this transition so that Luxembourg's society and economy can benefit from this global development as a whole.

Farmers need to be freed from an outdated subsidy system focussing on food security, leading to overproduction of carbon-intense food. The current system was absolutely necessary after WW2, however led to conserved agricultural structures and financially dependent farmers (1), which does not appreciate their contribution to society.

ad (1): Financially dependent farmers: without subsidies farmers would not be profitable, and in most cases profit is the farmers' income; they don't have a salary. (Landwirtschaft2.0, Ein Plädoyer für die neuausrichtung der luxemburgischen agrarpolitik, 2017)

New, smart and flexible subsidy systems based on carbon sequestration and other ecosystem services allow farmers to find economically viable opportunities and niches, which fit their individual conditions and available resources. A clear national agricultural long-term strategy provides planning reliability to farmers when investing in this transition.

Politics can establish whole value chains for meat substitutes and/or cultured meat in Luxembourg: providing and channelling green investment capital, campaigning for soy and pea cultivation as raw material respectively nutrient solution for culturing meat, and attracting know-how for food processing.

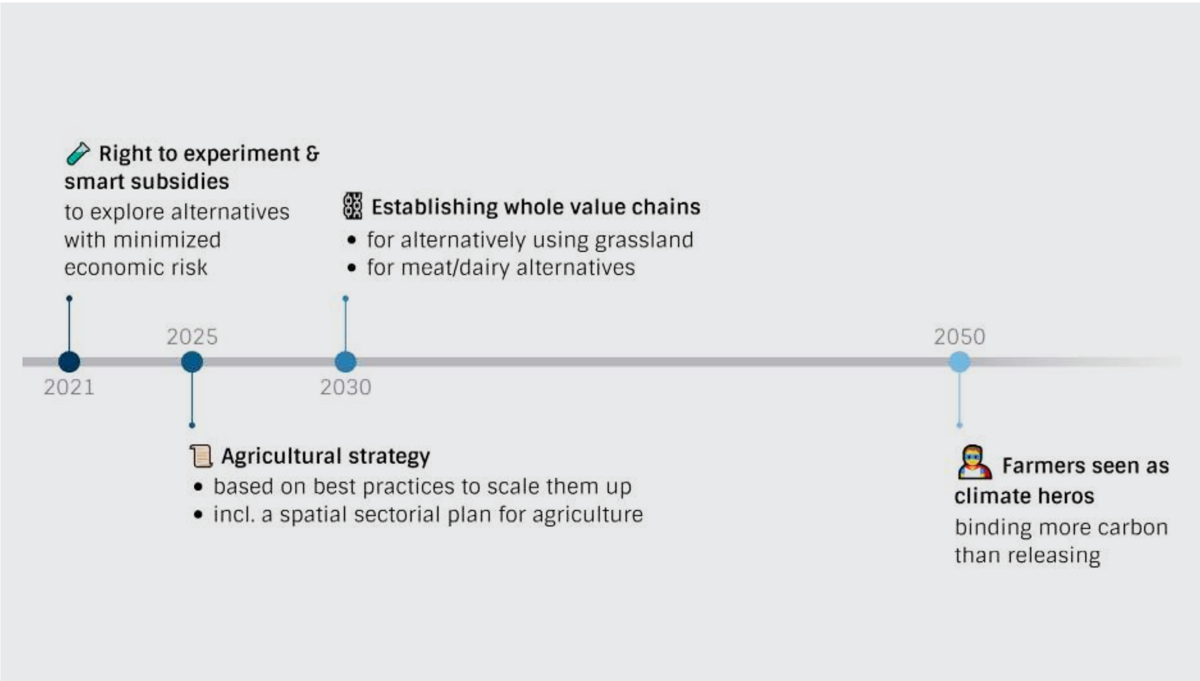



fig. 5: The role of politics.

image 3

# Assumptions and uncertainties

In order to combine different diets into plant-based, we assumed that a vegetarian diet translates to eating vegan on 5.5 days/week in terms of land use. Uncertainties arise from flexitarians. TNS Ilres categorized participants of the survey as flexitarians, if they sometimes have days without eating meat. 18% of the participants fell into this category. In order to be precautious we valued their diet as being little plant-based (less than 1day/week vegan), due to the consumption of dairy products (TNS Ilres,2020).

Further, we envision to slightly surpass the projection by A.T. Kearney due to political interventions, which estimates that cultured meat will have a share of 22% in 2035 and 35% in 2040 in global turnover of meat and meat substitutes (Kearney,2020). Additionally, we assumed that cultured meat translates to 5.5 vegan days/week in terms of land use, such as the vegetarian diet, since it is not clear how substitutes for dairy products will be accepted. There are studies which estimate a 95% reduction in land use for cultured beef compared to animal-based beef (The Good Food Institute, 2018).

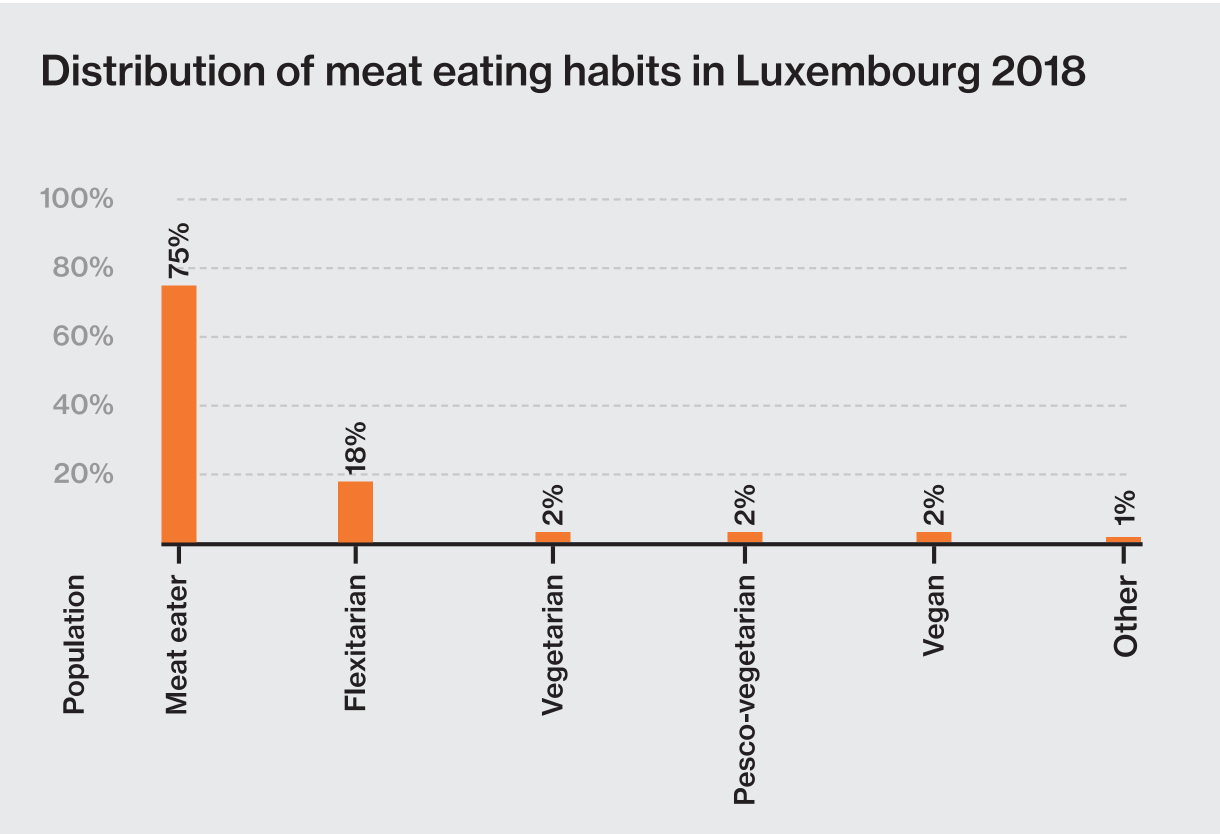



fig. 6: Distribution of meat habits in Luxembourg in 2018.

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**Images**

image 1: Nathan, P. (photographer). (2021). Luxembourg [photograph]

image 2: Nathan, P. (photographer). (2021). Luxembourg [photograph]

image 3:Nathan, P. (photographer). (2021). Luxembourg [photograph]

**Figures:**

fig. 1: Ritchie, H. (2020a). Environmental impacts of food production. Our World in Data. https://ourworldindata.org/environmental-impacts-of-food?country=#breakdown-of-where-food-system-emissions-come-from

fig. 2: Ritchie, H. (2020b) You want to reduce the carbon footprint of your food? Focus on what you eat, not whether your food is local. Our
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Fick, G. W. (2016). Carrying capacity of U.S. agricultural land: Ten diet scenarios. Elementa: Science of the Anthropocene, 4,
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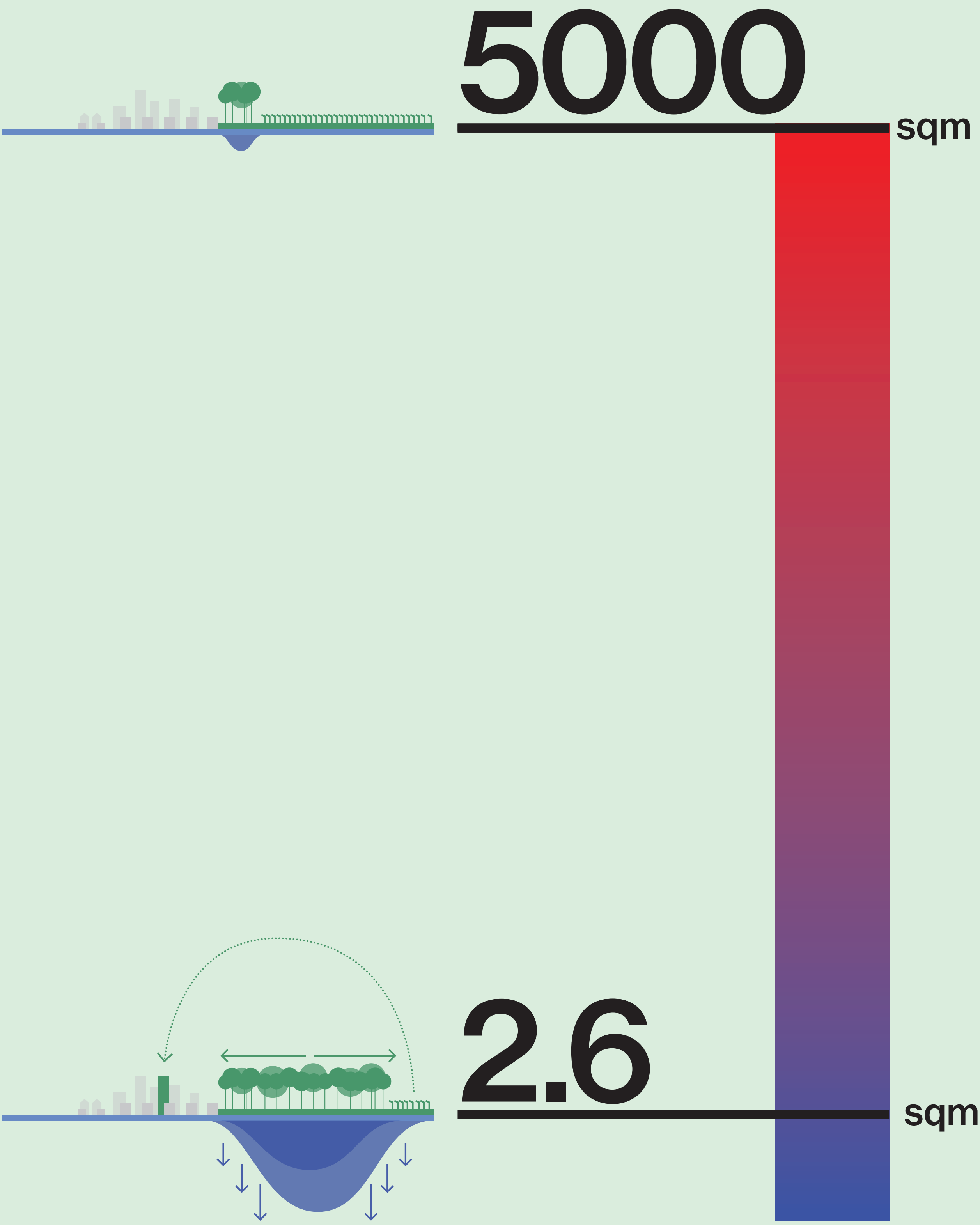
fig. 6: Kearney, A.T. (2020). Umsatz mit Fleisch und Fleischalternativen weltweit bis 2040. STATISTA. https://de.statista.com/statistik/daten/studie/426592/umfrage/umsatz-mit-fleischersatzprodukten-in-deutschland/

# Land Use Accelerators

2050




Land footprint ratio; If compared to a 5000 sqm traditional farm, a 30 floor high vertical farm will need only 2.6 sqm of land to produce the same amount of produce. 2.6 sqm will contain 78 sqm of floor area over 30 floors.

# Land release by Land Use Accelerators

As a diet shift, is a society-wide undertaking which can only happen gradually, we have looked into alternatives to reduce the land footprint of food production. Non-soil based farming practices such as Controlled Environment Agriculture and Aquaculture, can produce much higher yields. They can also have stacked floors as they do not need soil. As a result, they can act as boosters in land reduction, and give us the time we need to shift our diet as a society in addition to producing with local and exotic products all year.

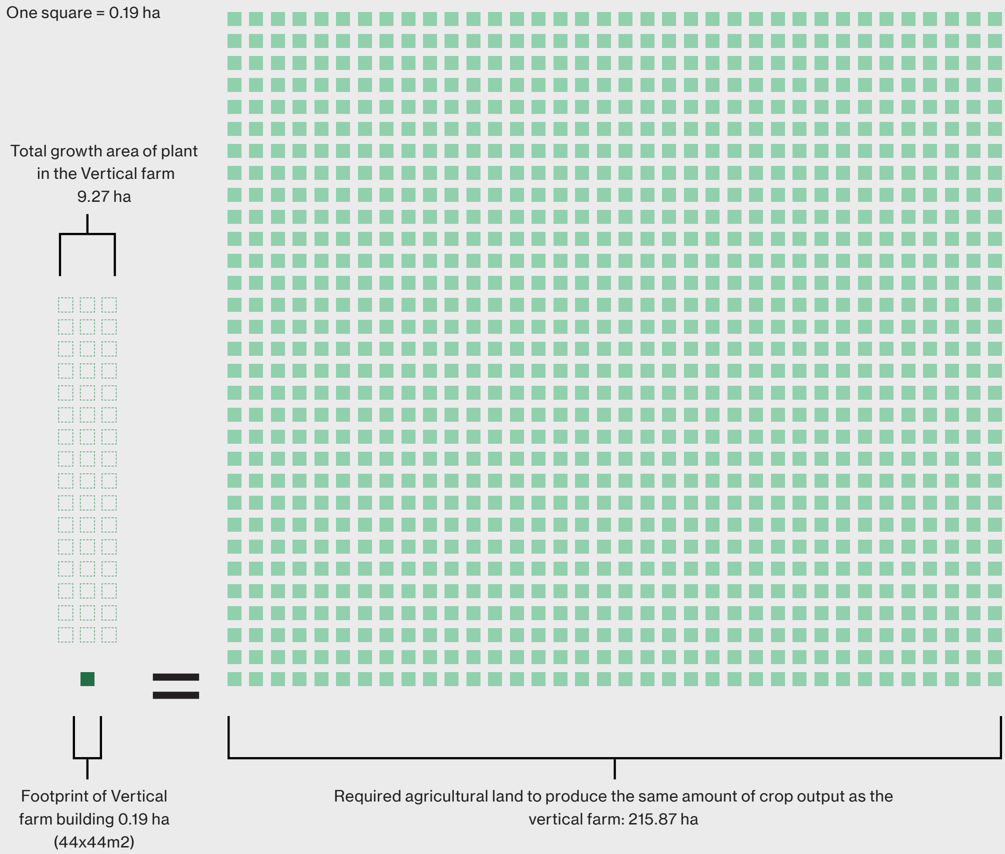



fig 1: Vertical farm compared to traditional agriculture

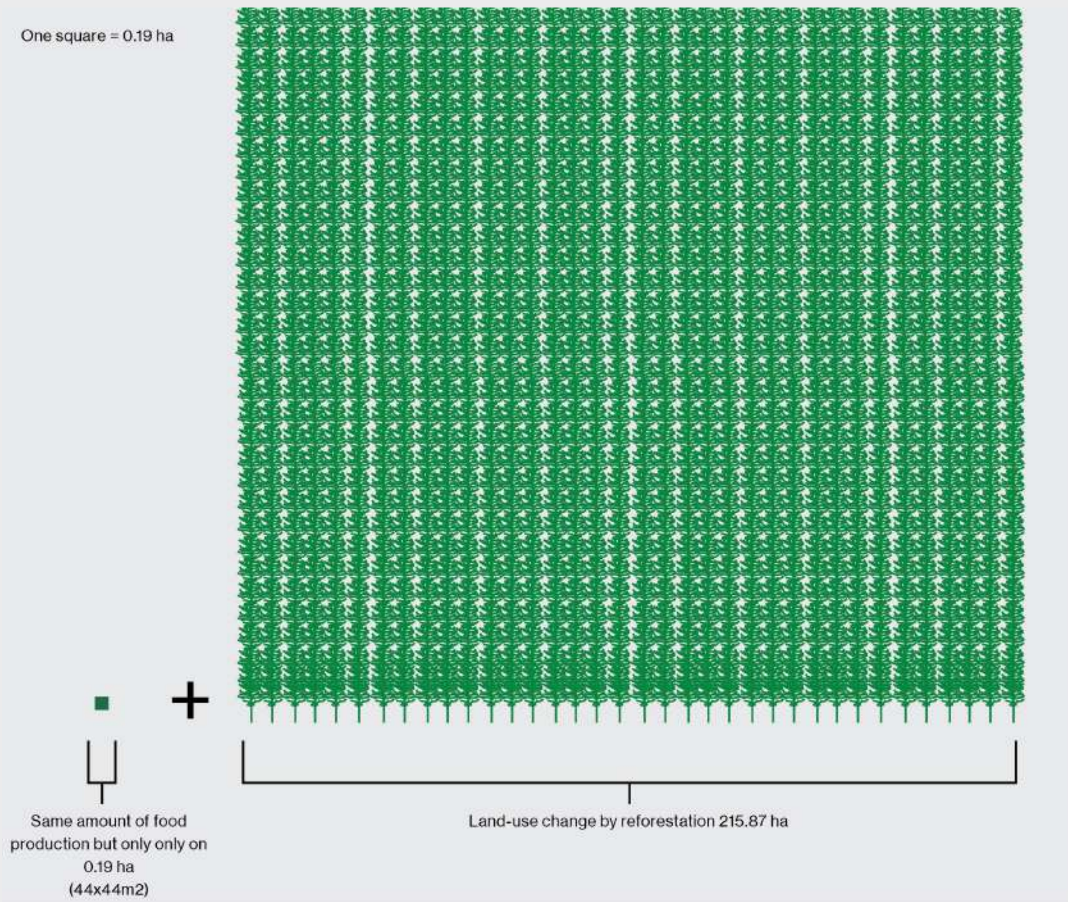



fig 2: Vertical farm compared to traditional agriculture

# Reducing the footprint of food production

Strategic implementation of high-tech food production systems can accelerate the ecological transition. Due to their land- and carbon footprint efficiency. Their strength lies in the fact that they can be developed as individual projects with far reaching impact.

In the case of Luxembourg there is potential in integrating highly efficient aquaculture production systems in synergy with already proposed flood basins that deal with water safety. Secondly, controlled environment agriculture in the form of vertical farming can be integrated in bigger cities in proximity to consumers.

Both production systems have very high yield per surface area ratios and in the case of aquaculture cultivation can produce plant-based foods with high protein values or in the case of vertical farming more exotic foods that otherwise need to be imported. In this sense they can also support and accelerate the transition towards a plant-based diet and towards local production and food autarky.

Algae is up to 400 times more efficient than a tree at removing CO2 from the atmosphere. That means that while we are learning to reduce carbon emissions and augment our consumption patterns, we can already start to make big reductions in atmospheric carbon. (Lamm, 2019).

## *How can we accelerate the land use transition from food to timber?*

As these technological production systems are highly space efficient, this opens possibilities to grow more food on less land and dedicate more land to maximize sequestration and ecological resilience.

Aquaculture in the form of algae cultivation for instance has a yield up to 13 t protein/ha/yr.
In comparison legumes and soy have up to 0.5 - 1.8 t protein/ha/yr and animal-based protein only goes up to 0.01 - 0.23 t/ha/yr. (More protein and good for the planet, 2020). CEA in the form of vertical farming occupies 95% less land than traditional open field agriculture while generating an equivalent food production output.

A one-hectare algae farm could substitute 13 hectares of open field agriculture. A one-hectare vertical farm (footprint of 2000 m2) can substitute 50 ha of open field agriculture. Land that potentially can be afforested in favour of maximizing sequestration, ecological connectivity and timber production (Gerecsey, 2018).

**Microalgae cultivation can contribute to the urgent need to address climate change, as the photosynthetic process of microalgae can mitigate eutrophication, treat wastewater and capture/sequester carbon. [*2]**

image 1

# Aquaculture

Aquaculture is the cultivation of aquatic animals and plants in natural or controlled marine or freshwater environments. Potential for Luxembourg lies in land-based aquaculture systems such as pond systems. These are constructed water bodies that need to be filled at the start of the production cycle and continuously supplemented with water to compensate for evaporation and seepage during the production cycle.

Microalgae cultivation can contribute to the urgent need to address climate change, as the photosynthetic process of microalgae can mitigate eutrophication, treat wastewater and capture/sequester carbon.

Non-toxic microalgae can be directly consumed as human foods. Primarily as a source of proteins and micronutrients, The nutritional value and health benefits of microalgae have been well recognized. Various microalgae extracts are used as dietary supplements or food additives. (Sijtsma et al., 2020) (Cai et al., 2021).

**Carbon sequestration capacity of different productive landscapes (tons CO2 eq./ha/yr)**

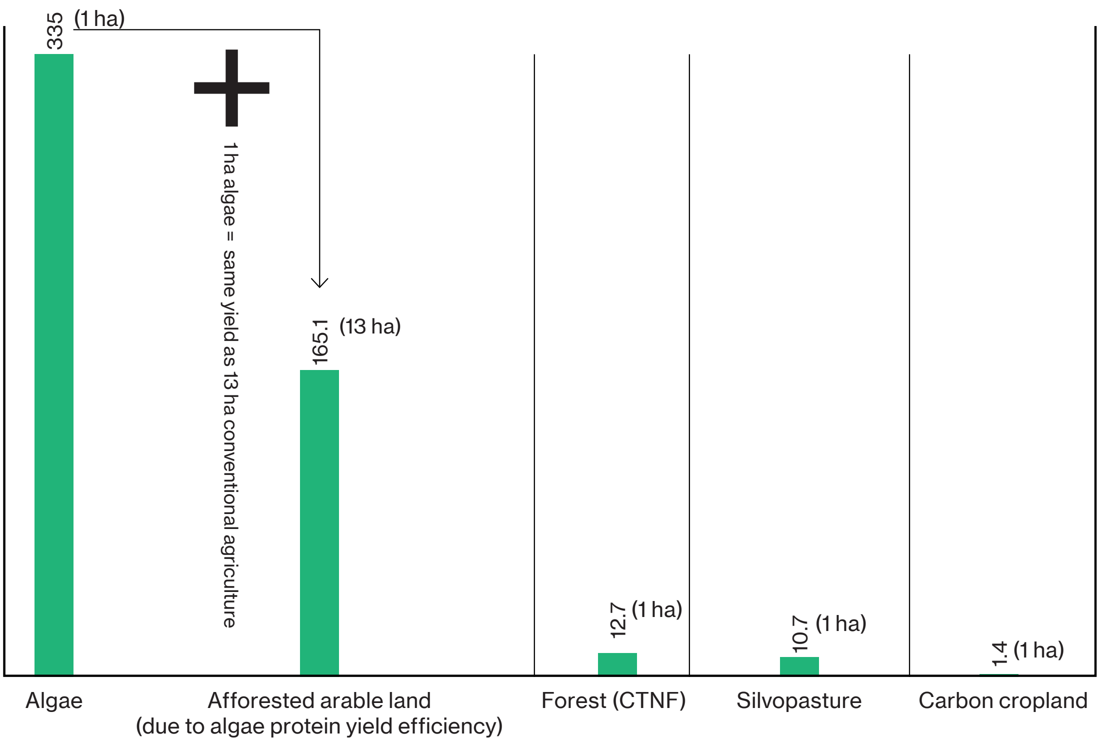
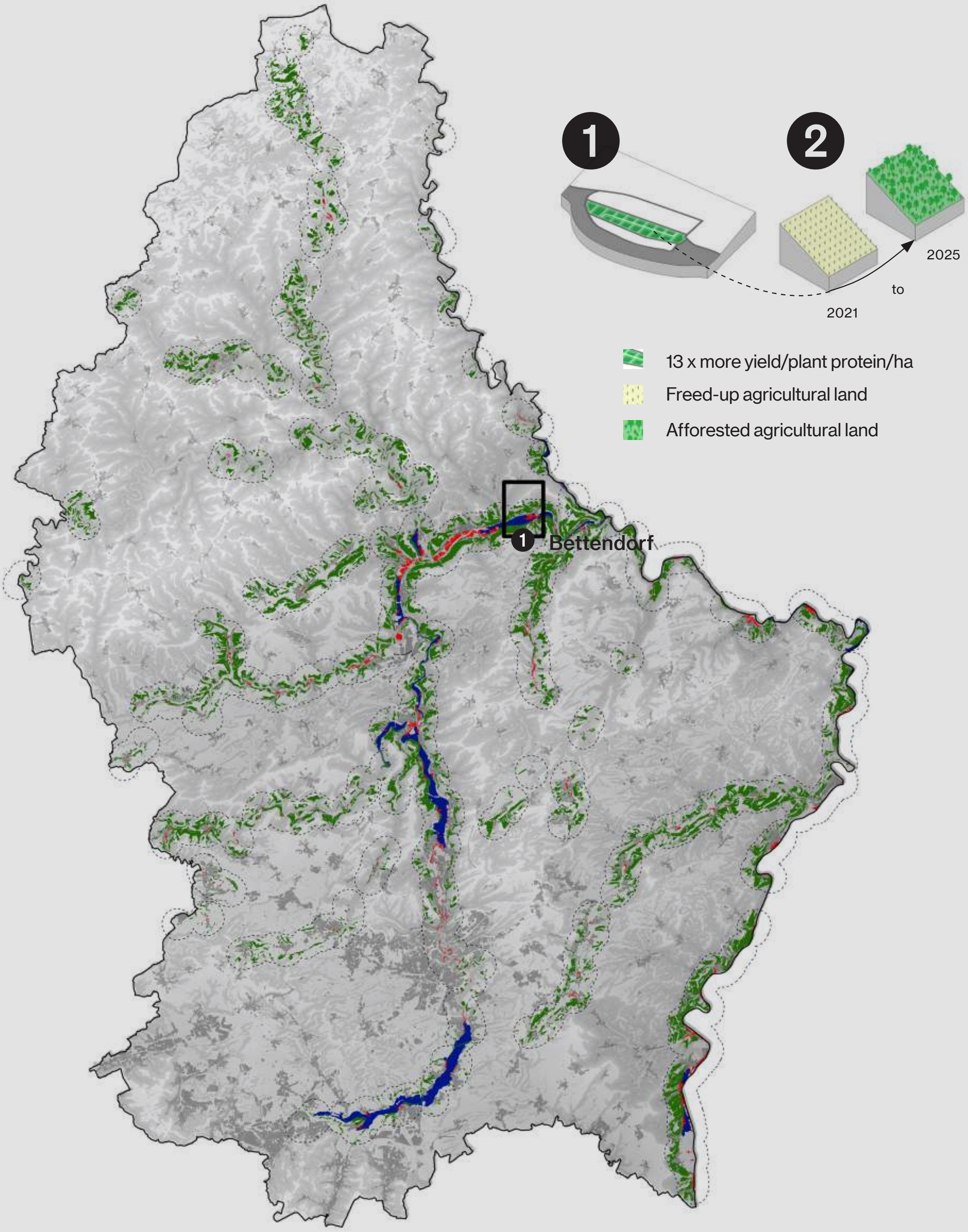



fig 3




- Afforested agricultural land
- Urbanisation in flood risk zone
- Search areas suitable for aquaculture

# Reduction of food land footprint with aquaculture yield efficiency & afforestation of steep slopes with runoff to urbanization prone to flooding

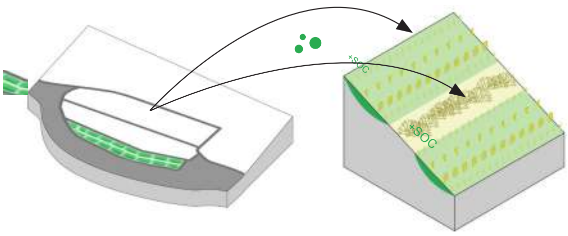
# Impact on land release and accelerated sequestration

Algae have the highest potential for $CO_2$ sequestration per hectare of any plant. Since algae proliferate rather quickly, year-round, they can be grown in three-dimensional space and all of their parts can be used, so the amount of biomass to be harvested in one unit of a field (even up to 150–300 t ha−1) is many times that of field crops. In the future, algae could represent the most significant reserve for $CO_2$ sequestration both for the environment and for food

When algae are consumed as food their carbon is emitted again so to lock sequestered carbon a percentage of algae production can be used as organic fertilizers to lock carbon in soils and improving soil fertility. Algae used for food production still have a positive impact on decarbonisation due to their land efficiency and carbon sequestration by afforested agricultural land.

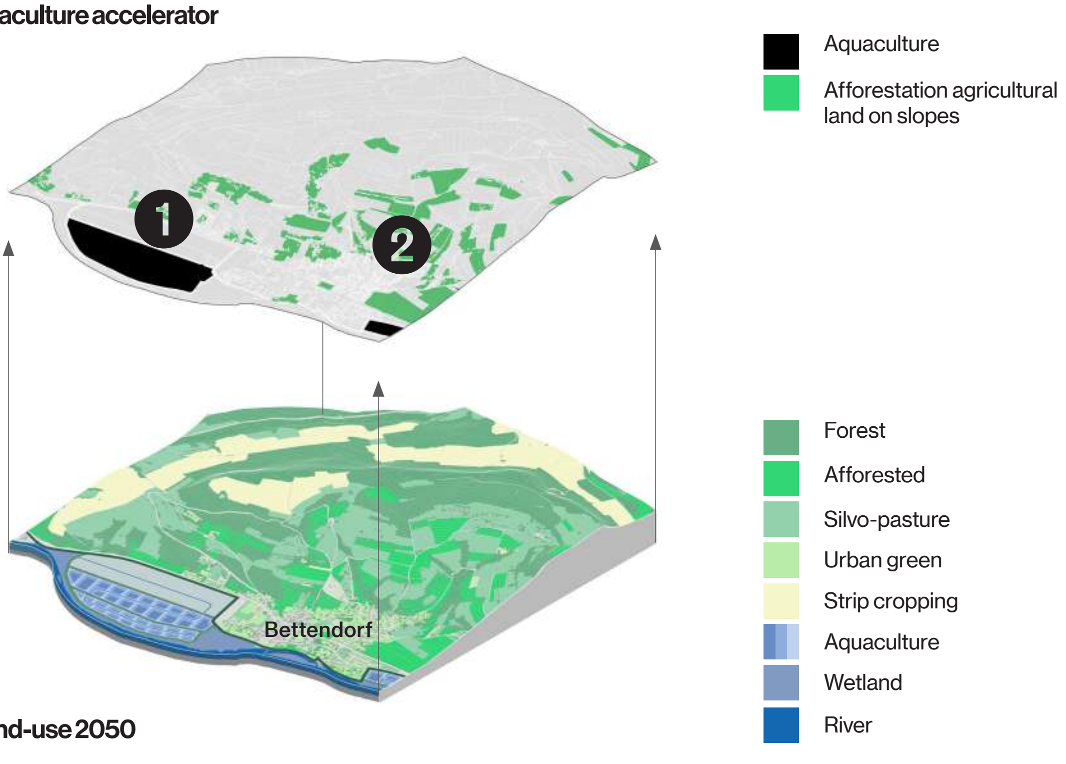
Algae have a mean of 188.5 (127–250) t biomass/ha/year with a sequestration value of 1.78 kg $CO_2$/kg biomass/year (Bai, 2017)

**Aquaculture accelerator: organic fertilizer and SOC source**




algae organic fertilizer production
335 t biomass $CO_2$ eq./ha/yr sequestration

**Aquaculture accelerator**




**Land-use 2050**

# Combining food production and water storage

Dozens of people were evacuated and emergency services responded to more than 1,000 calls for help after flooding in Luxembourg following heavy rain on 14 July 2021. The government said material damage is significant. MeteoLux reported torrential rains broke two records for the month of July at the weather station at Luxembourg-Findel Airport. The maximum precipitation in 12 hours and 24 hours reached accumulations of 74.2 mm and 79.4 mm, beating the previous records set on 22 July 2016 of 60.4 mm/ 70.6 mm. (Davies, 2021)

Extreme precipitation and pluvial flooding are projected to increase at global warming levels exceeding 1.5°C. Observed increasing trend in river flooding and projected further increase at 2°C and above of global warming (high confidence). Projected increases in hydrological, agricultural and ecological droughts at mid-century warming levels of 2°C or above, regardless of the greenhouse gas emissions scenario (medium confidence). (IPCC, 2021)

15 of Luxembourg major rivers are subject to a significant risk of flooding and which, as a result, were the subject of a mapping of flood-prone areas and flood risks (GGDL, 2021a)

One of the measures for flood adaptation that is put forward is promoting water retention by lowering of diked vertical banks h <1m. (GGDL, 2021b) This is similar to the Dutch Room for the river strategy.

The core of the room for the river concept is giving more space to the river in order to increase the velocity of the flow or to reduce the water level of excess flows and time of exposition to large floods. It can be described as a ''simultaneous move from vertical flood defences [reinforcing embankment's] to horizontal expansion (widening) of rivers, it is a resilient approach accepting that flooding may occur now and again, but seeks to exploit the advantages of flooding and mitigate the disadvantages. Room for the river is based on a strategy of 'working with nature'. Relocating a dike inland widens the floodplain and increases room for the river. This creates space for excess flows in extreme high-water situations (Room for the river, 2013).

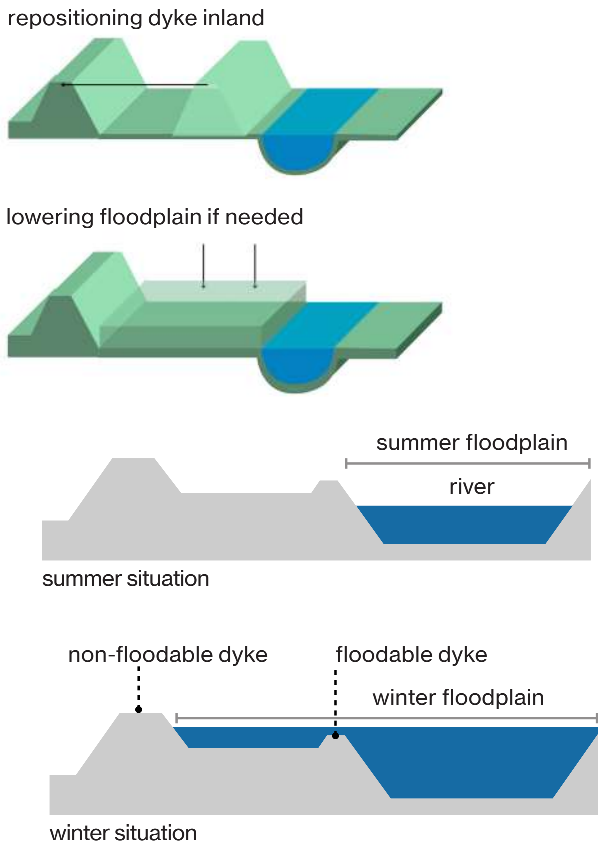



fig 4: Room for the river concept

The East Kolkata Bheris Wetland system in India is a living and incredible resilient urban circulatory system. The system is synonymously a fishery, waste management system, agricultural field, rice paddy network, community hub, grazing lands and heritage site. Stormwater management is another vital service offered by the wetlands. As these wetlands offer water storage, groundwater recharge and flood protection during heavy monsoon rainfall. (Watson, 2019). This is just one example of a rich pallet of traditional technology in aquacultural systems that are widely applied in the East, where wet crops and other production function go hand in hand with flood mitigation.

**image 2: The East Kolkata Bheris Wetland system**

Open ponds for algae production are shallow (between 10 and 50 cm deep), and the algae culture is gently circulated by a paddlewheel. (More protein and good for the planet, 2020). This creates potential to integrate algae production with flood mitigation. As the basins only need to be filled up to 50 cm this leaves a lot of capacity to buffer high river levels. During most of the year these ponds can be fed from a water body such as a stream. These may be fed directly (e.g., barrage ponds), by water running straight out from the water body to the ponds, or indirectly (e.g., diversion ponds), by water entering a channel from which controlled amounts can be fed to the ponds. The diversion pond is fed indirectly by gravity or by pumping through a diversion canal (which becomes the main feeder canal), from a stream. The water flow is controlled through a water intake. There is an inlet and an outlet for each pond.

During dry periods seepage supplies from the water-table by seepage into the pond. The water level in the pond will vary with the level of the water-table. [*3] Various methods have been used to recover nutrients from wastewater for agricultural purposes, including sewage sludge (directly or treated). The ability of algae to accumulate nutrients, directly and specifically, make them a valuable vector for recycling nutrients in waste water systems (FAO, 2020). Combining algae production with waste water treatment gives algae a continues and reliable supply of water also during dry periods.

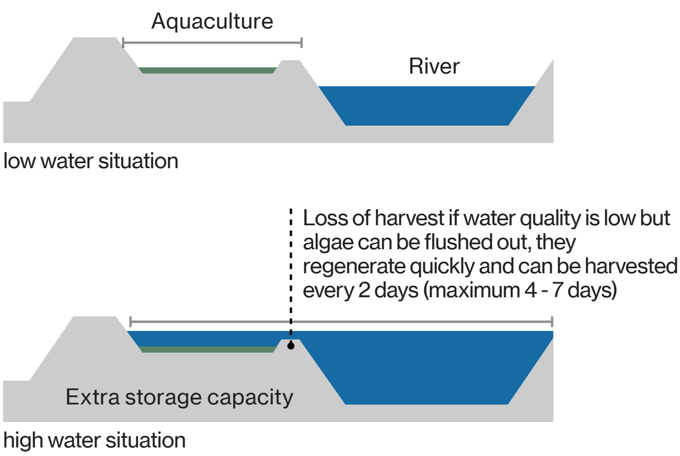
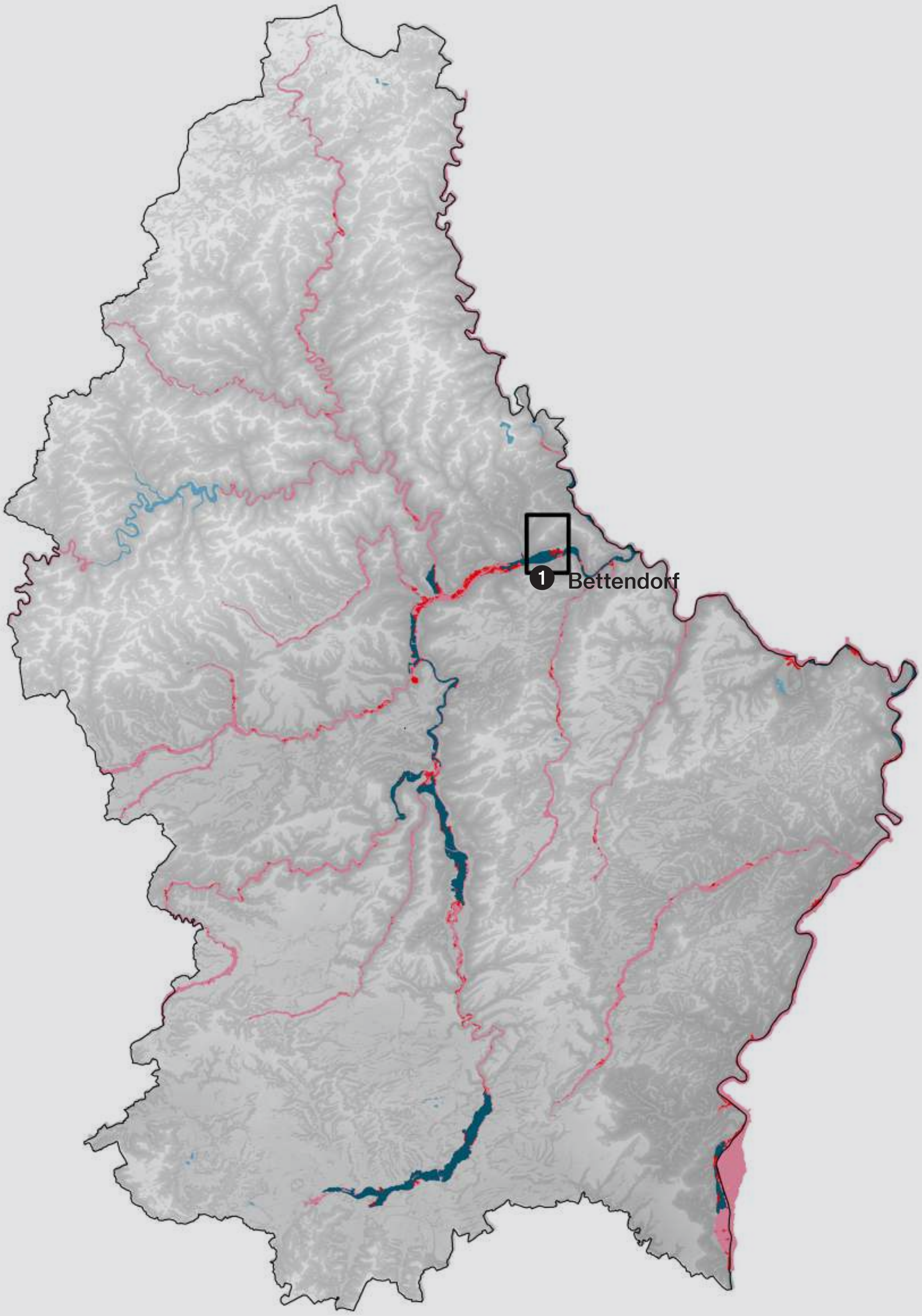



fig 5: Combination potential of aquaculture and water safety

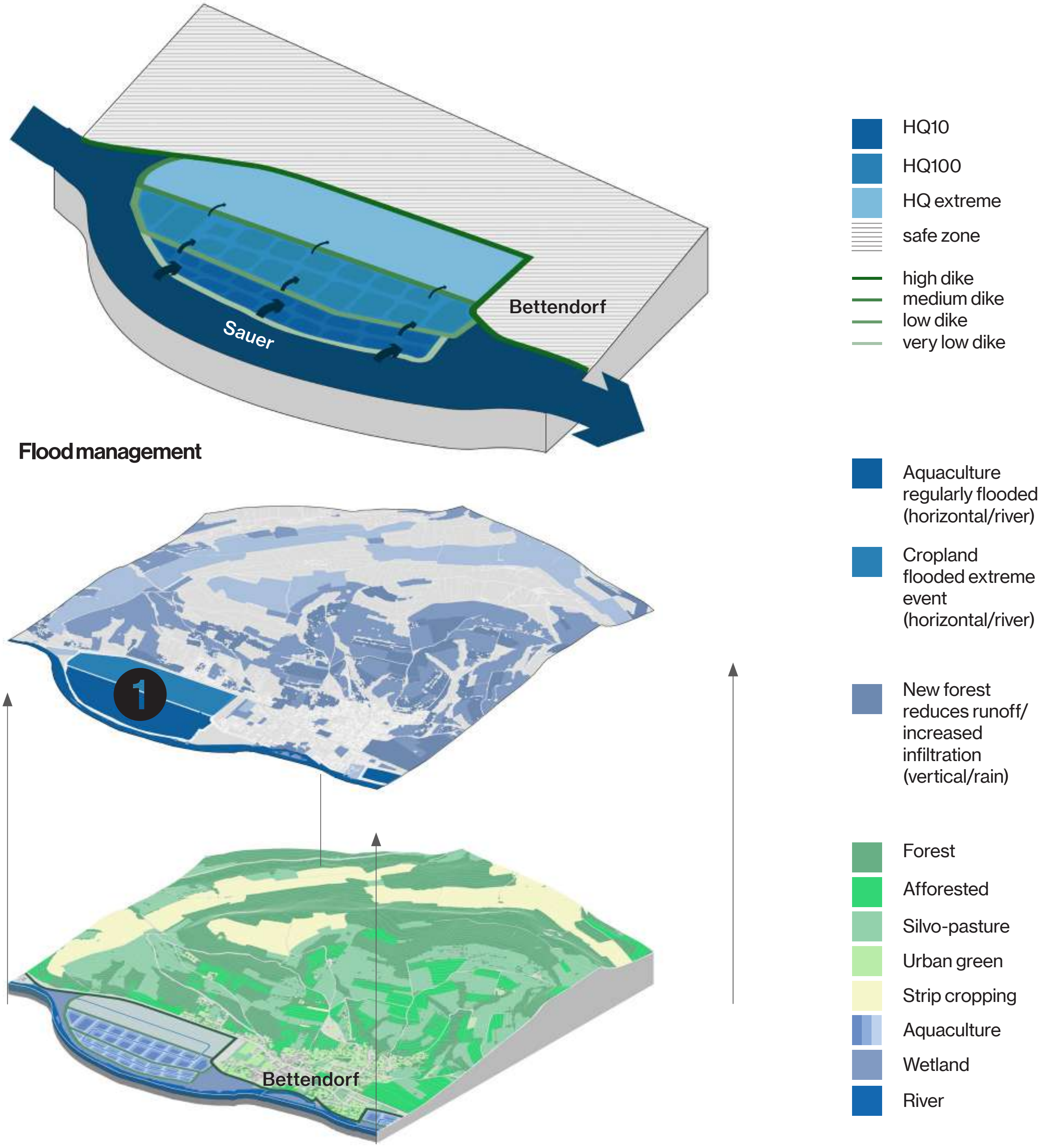



Urbanisation in flood risk zone
Search areas suitable for aquaculture
Flood risk zone HQ extreme

## Aquaculture’s yield efficiency enables reduction of food production’s land footprint in addition to providing flood water storage.

# Combining food production and water storage

Horizontal (river) flood relief




Flood management

Land-use 2050

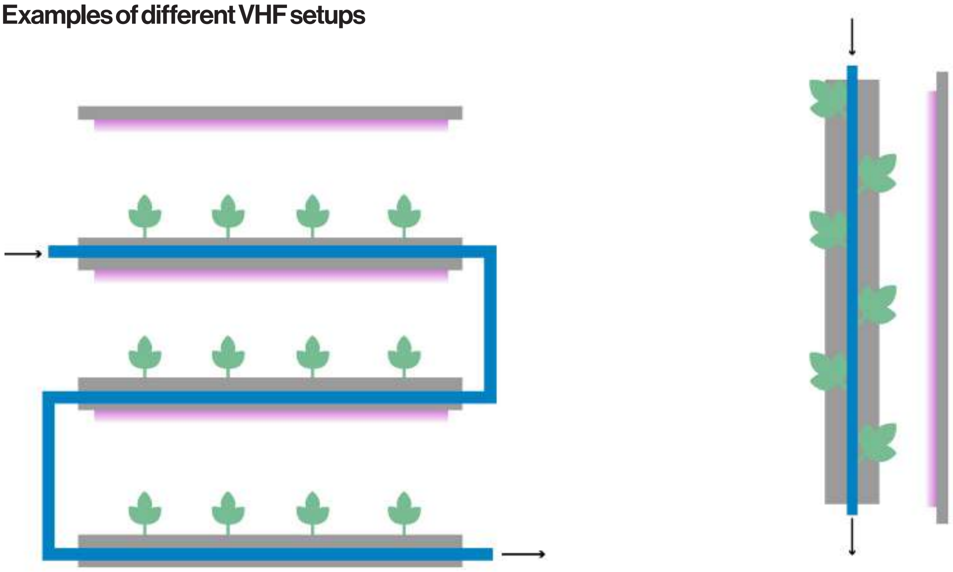
# Controlled Environment Agriculture

Controlled Environment Agriculture (CEA) is technology where all environmental factors are controlled. These facilities utilize artificial control of light, environmental control (humidity, temperature, gases...) and fertigation in isolated closed environments. The CEA typology 'Green vertical farming' is an important piece in the many efforts to establish urban food security in a world of changing climate (Gerecsey, 2018).

The CO2 abatement potential for green vertical farming compared to open field agriculture in is 70% reduction with additional benefits of 95% less land used 80 to 90% less water use, compared to traditional agricultural systems with equivalent production (Gerecsey, 2018).

Vertical farms reduce input costs, allow for production to be geographically close to the point of consumption, and create the opportunity to produce crops year-round. Vertical farming correlates more to creating different and controlled environments for growing produce than preventing or minimizing the damage caused by the climate in traditional farming locations. Vertical farms are deployed close to the point of consumption, their products reach their customers quickly, and therefore more nutrients of the crops are preserved (Gee, 2021). This in effect reduces spoilage and food waste by growing exotic crops locally (Warzynski, 2021).

**Examples of different VHF setups**



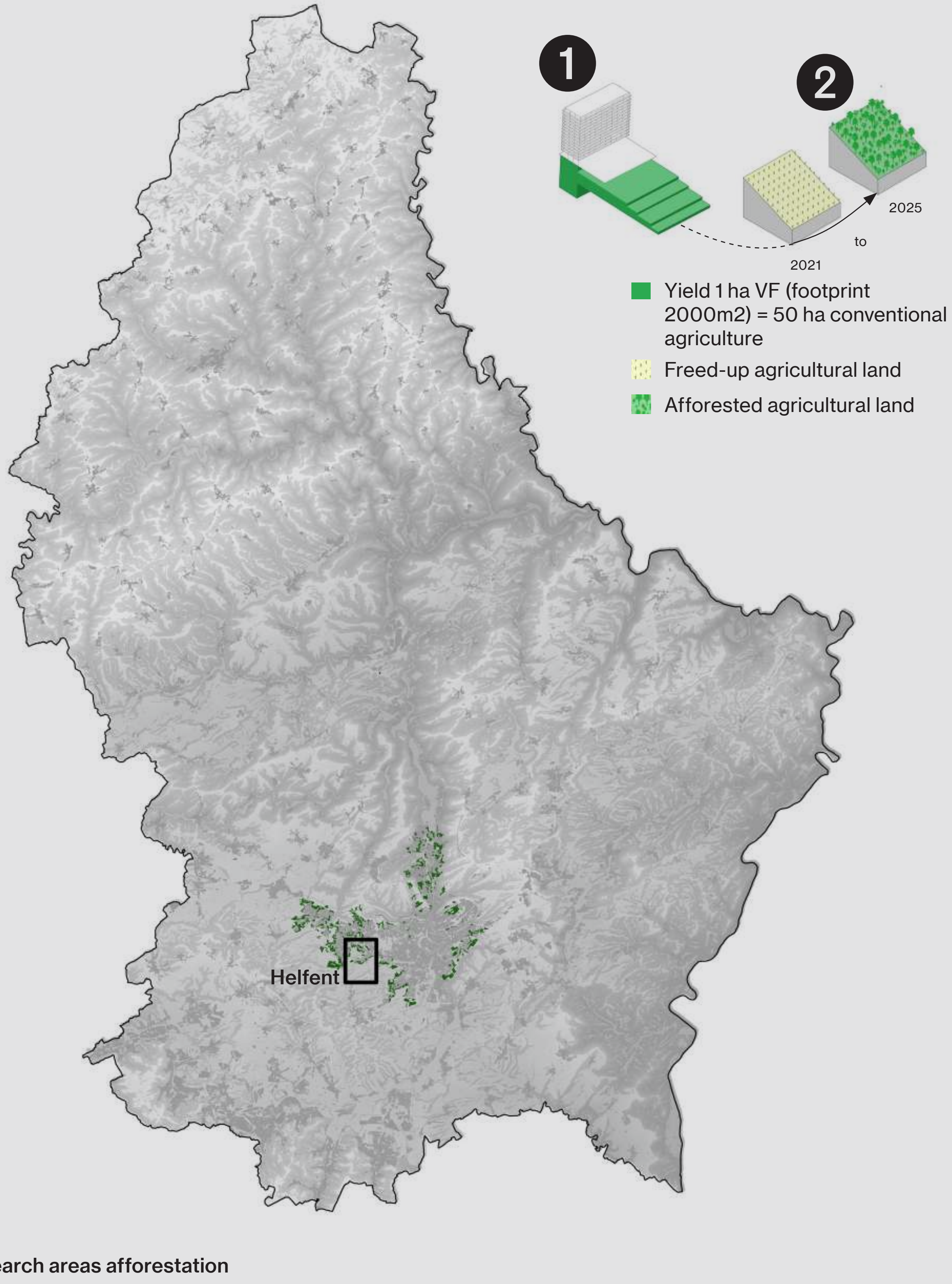
**A) Nutrient film technique**

**B) Drip irrigation system**

fig 6

Controlled Environment Agriculture (CEA) is technology where all environmental factors are controlled.

image 3



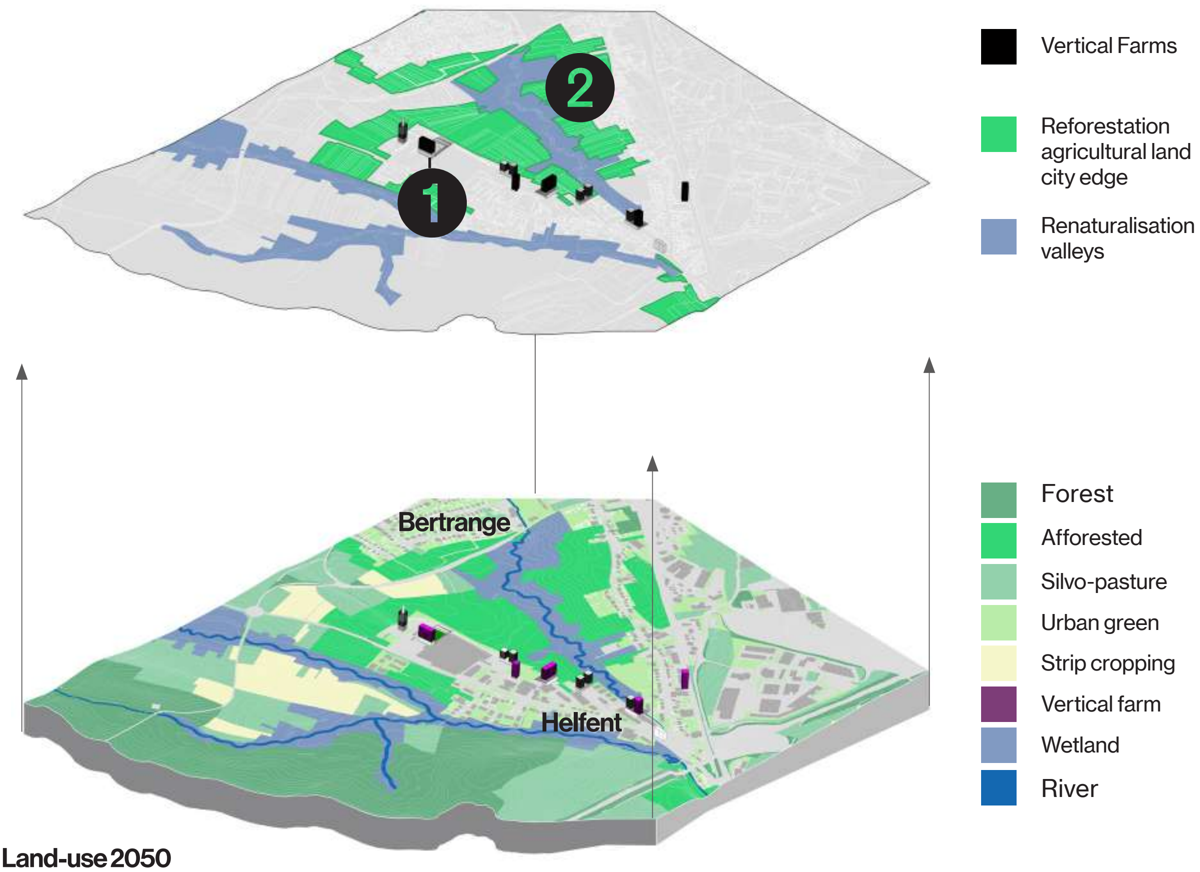

## Afforestation by land release vertical farms of city edge and areas with high development pressure

# Impact on land release and accelerated sequestration

A Vertical Farm of 0.93 ha1 (roughly the size of a city block) with a total of 37 floors (total building height of 167.5 meters with a length (and width) of 44 meters. Can support 15,000 people with enough food. The total number of sowing and harvest events is 215 in 365 days. The total yield increases 516-fold compared to traditional agriculture through stacking the production. In total this leads to an estimated production of 3,573 tons of edible fruit and vegetables (Banerjee and Adenaeuer, 2014).

These values for 1 ha of vertical farming would result in: a reduction of around 916,680 kgCO2eq 130,000,000 litres less water 50 ha less land used per year compared to open field agriculture with equivalent food production (Gerecsey, 2018).

**Vertical Farm Accelerator**




**Land-use 2050**

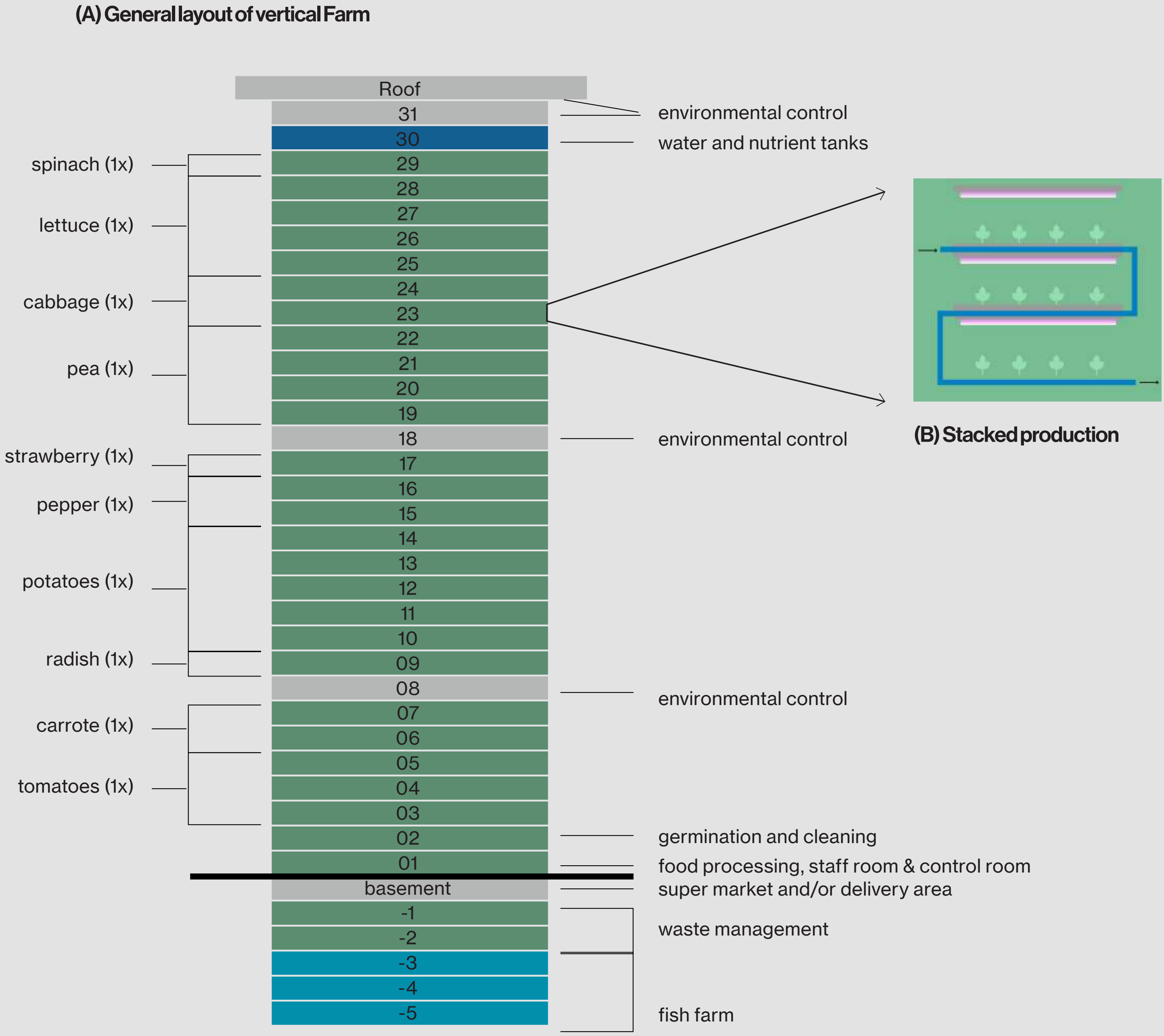



fig. 7

## Small land footprint due to multiple production floors (A) and stacked production (B)

# Benefits in reliable production and local crop diversification

Such a fully controlled environment with no losses from weather and pollution impacts with lowest food losses (linked to transportation, pest loss, reduction of unsold products) results in a reliable and year-round marketable production (Gerecsey, 2018).

Another group of foods that could be profitable are 'exotic foods', since these do not have to be imported (Geemente Rotterdam, 2018). An enticing example is Banana cultivation in greenhouses in Hveragerði. Where Icelanders operate the northernmost banana plantation in the world. The Icelanders have a dream of completely self-reliant. That goes for their tropical fruit consumption as well (Icelanders operate northernmost banana plantation in the world, 2019).

image 4: the northernmost banana plantation in the world

image 5: Stacked production

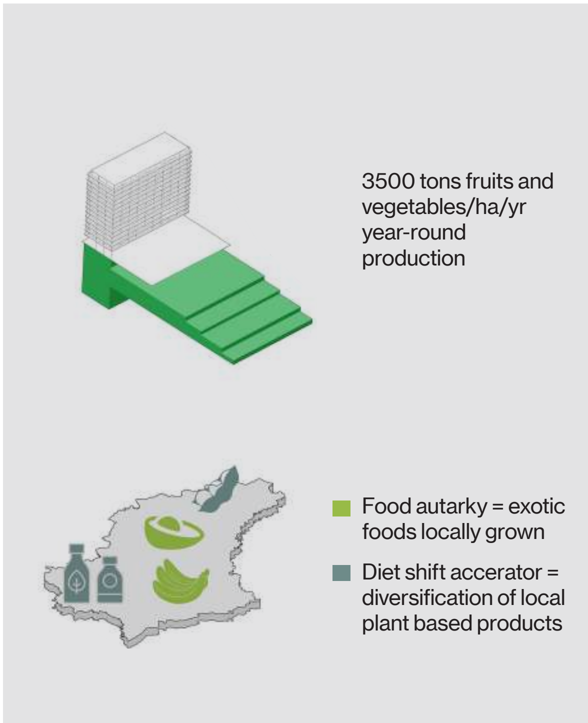



fig. 8: CEA accelerator: food autarky and diet shift

**Algae can efficiently take up excess nutrients from waterways, making them a valuable resource potentially capable of replacing synthesized and mined fertilizers for agriculture.**

image 6

# Outtake 1 :
# Aglae, wastewater management and sustainable products

Algae can efficiently take up excess nutrients from waterways, making them a valuable resource potentially capable of replacing synthesized and mined fertilizers for agriculture. Various methods have been used to recover nutrients from wastewater for agricultural purposes, including sewage sludge (directly or treated). The ability of algae to accumulate nutrients, directly and specifically, make them a valuable vector for recycling nutrients in agricultural systems (Mau, 2021).

Freshwater algae are ubiquitous and can be grown in media of varying quality, from sterile through to different types of wastewaters. They require only water, light, nutrients, and CO2.

Microalgae are increasingly being used as sustainable components of other products, including cosmetics, nutraceuticals, industrial enzymes and bioplastics. Many microalgae have high levels of palmitic acid. This acid is also the principal component of palm oil - a widely used oil in food production which drives mass deforestation and loss of animal habitat. Replacing palm oil with microalgae would reduce reliance on this unsustainable industry. (More protein and good for the planet,2020)

Dutch designers Eric Klarenbeek and Maartje Dros use algae to create polymers that can be used in 3D printing as a replacement for plastic from shampoo bottles to tableware or rubbish bins". Their goal is to ultimately turn an industrial manufacturing process—a source of pollution that contributes to global warming—into a way to subtract CO2 from the atmosphere. Using algae as a raw material would turn any mode of production into a way to help the environment."

The production of algae biomass as a fertilizer has dual value; the use of algae for the purification of wastewater coupled with the application of obtained biomass as fertilizer. The underlying concept is circular economy fertilization (Mau, 2021).

A bioactive developed from the algae known as "blue-green" (Cyanophyta) can increase the rooting and growth performance of plants such as soybeans and corn by up to 10% (Azevedo, 2021).

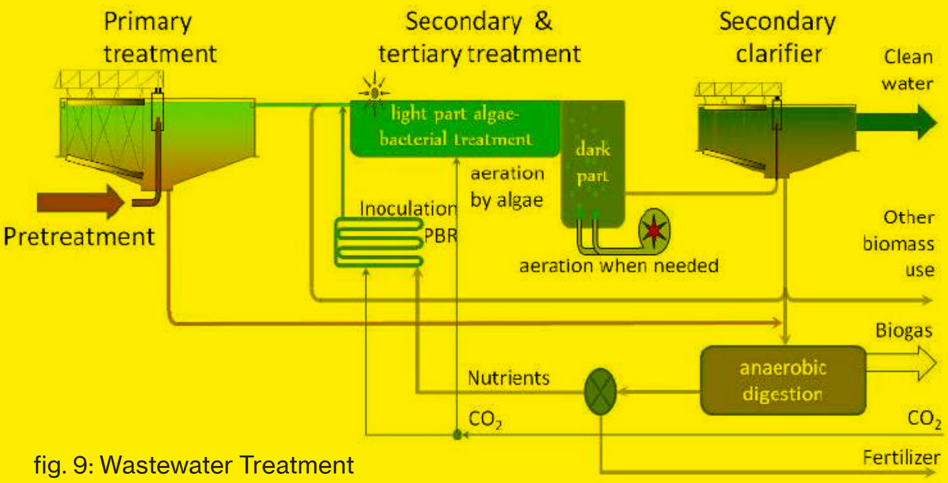
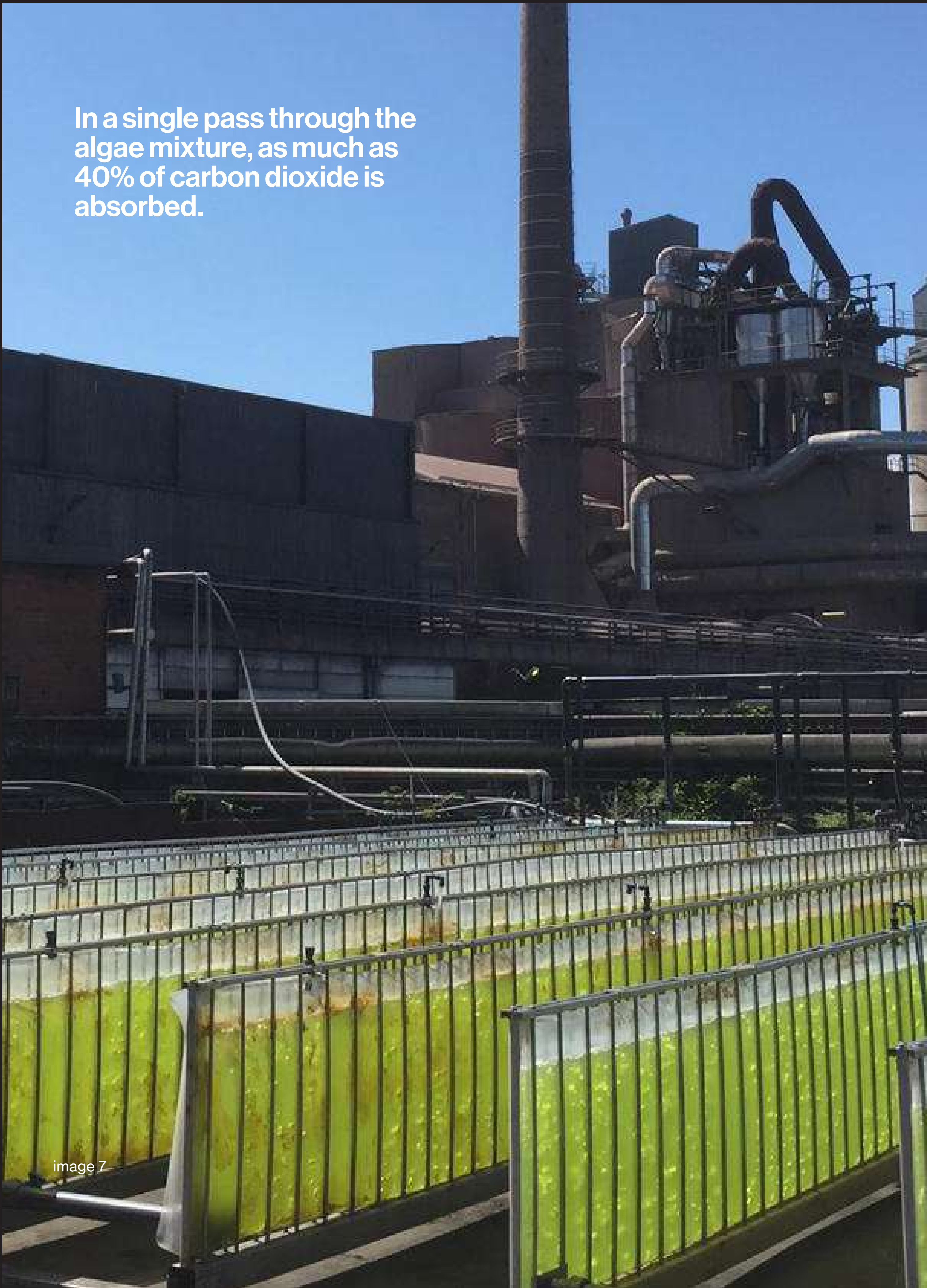



fig. 9: Wastewater Treatment



**In a single pass through the algae mixture, as much as 40% of carbon dioxide is absorbed.**

image 7

# Outtake 2 :
# Algae and net negative power plants

In Sweden a team of researchers from Linnaeus University are using algae to capture carbon dioxide coming from a cement plant before it enters the atmosphere. In a single pass through the algae mixture, as much as 40% of carbon dioxide is absorbed. Run it through the system a few times, and it will remove almost all of the greenhouse gas (Torres, 2017)

Bioenergy carbon capture and storage (BECCS) has been proposed to reduce atmospheric CO2 concentrations, but concerns remain about competition for arable land and freshwater. The synergistic integration of algae production, which does not require arable land or freshwater, with BECCS (called “ABECCS”) can reduce CO2 emissions without competing with agriculture (Beal et. al., 2018).

Algae need surplus CO2 to optimize their productivity. Power plants have long been considered a source for this captured CO2, but such a system would not be carbon neutral if the carbon comes from the burning of fossil fuels. So, the CO2 should come from direct-air capture. That sounds expensive. Former Energy Secretary Ernest Moniz estimates the cost at about $1,000 per ton, much higher than the $40-$50 social impact of a ton of carbon. This next step could render these systems carbon negative (McMahon, 2019).

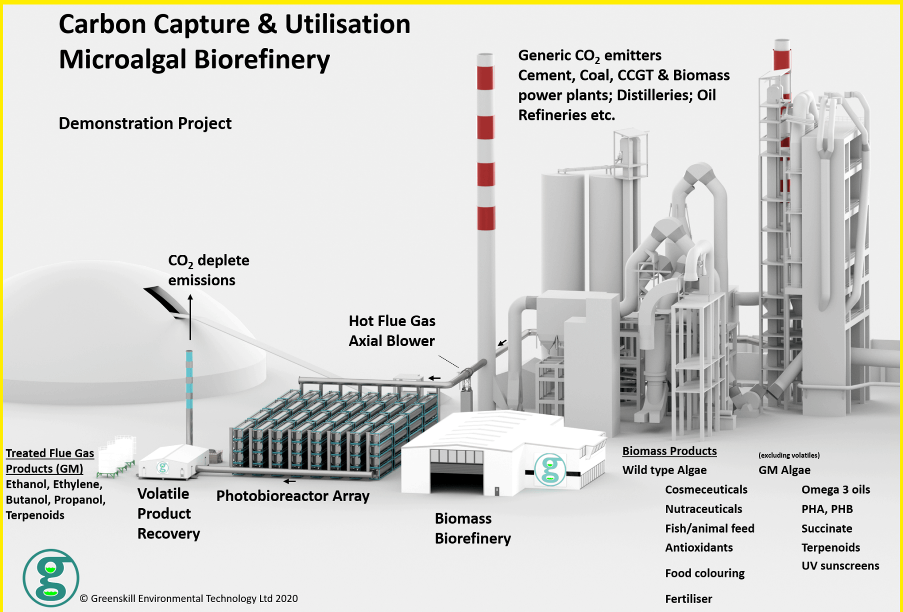



fig. 10: Carbon Capture and Utilisation Microalgal Biorefinery.

**Combining controlled environment agriculture and residential units in one joinded concept aims at closing circles through implementing greenhouses strategically at district level.**

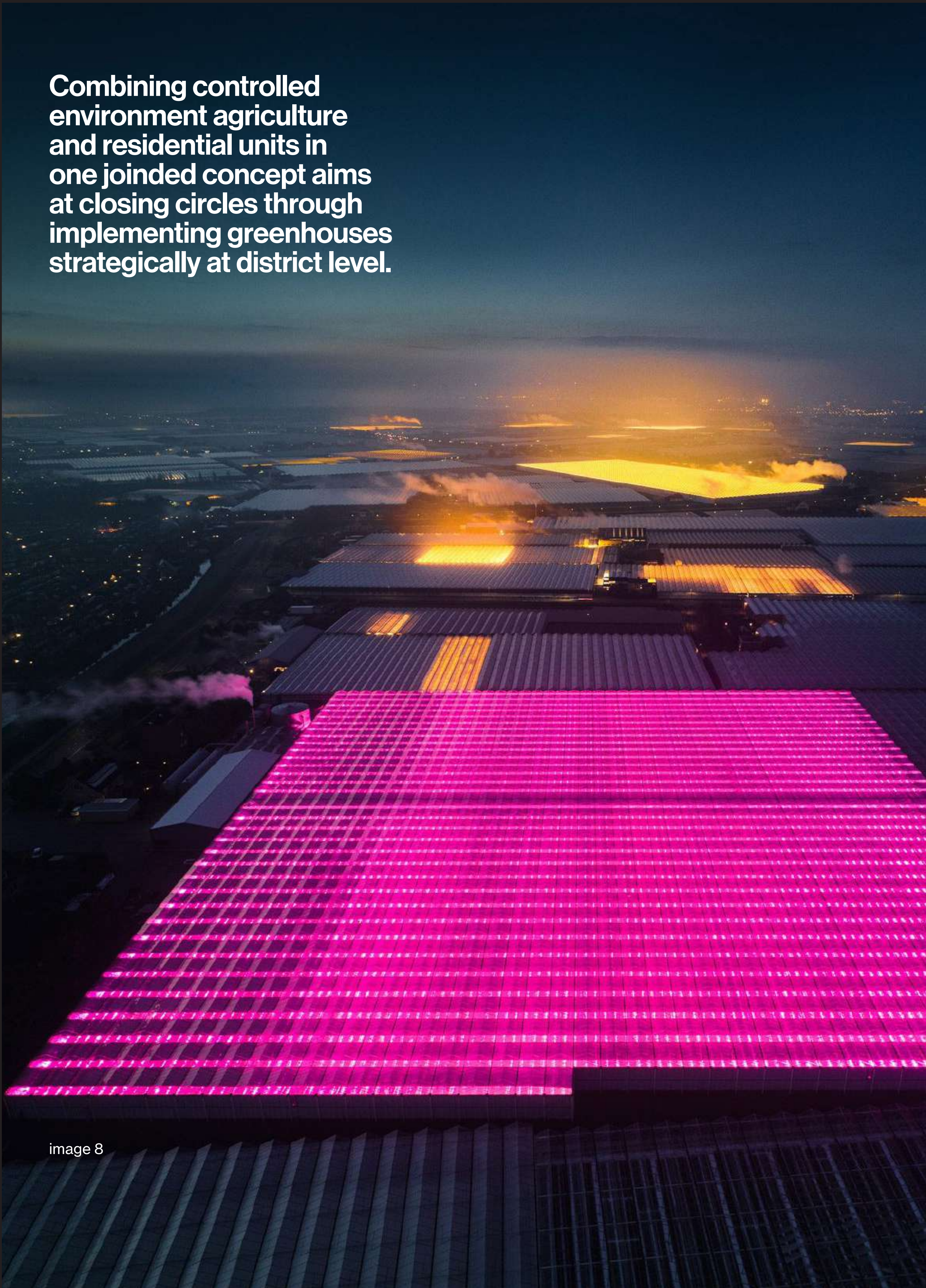


image 8

# Outtake 3 :
# CEA and residential hybrids

Combining controlled environment agriculture and residual units in one joined concept aims at closing cycles through implementing greenhouses strategically at district-level. The 'Greenhouse village concept' aims at largely closed energy-, water and nutrient cycles and high self-sufficiency, which the combined resource cycles. For instance, domestic waste(water) from connected dwellings can be collected, and treated in such ways that water, organics and nutrients will be recovered for use in greenhouses. On the other hand, greenhouses could provide heating and cooling as well as food and leisure possibilities. Thus, residential units become a) direct users for energy streams (with or without storage) and water produced in the greenhouse, and b) provide biogas, recovered nutrients and organics via source-separated sanitation concepts for the operation of the greenhouse. Core technical elements of the Greenhouse village are a) source-separated sanitation concepts with resource recovery (New Sanitation) and b) an Aquifer Thermal Energy Storage system for heat and cold storage and supply in combination with a highly efficient heat exchanger (Mels, et. al., 2006).

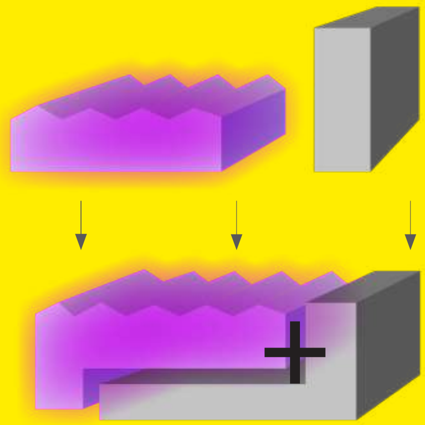


fig. 11: Integration CEA/residential units

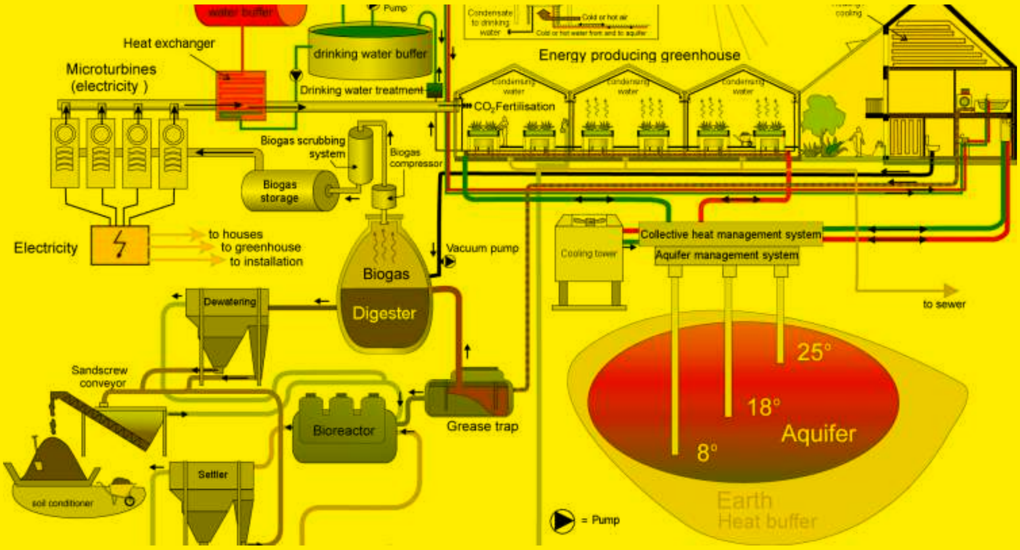



fig. 12: The Greenhouse village concept

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fig. 7: Small land footprint due to multiple production floors (A) and stacked production (B)

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fig. 9: Wastewater Treatment

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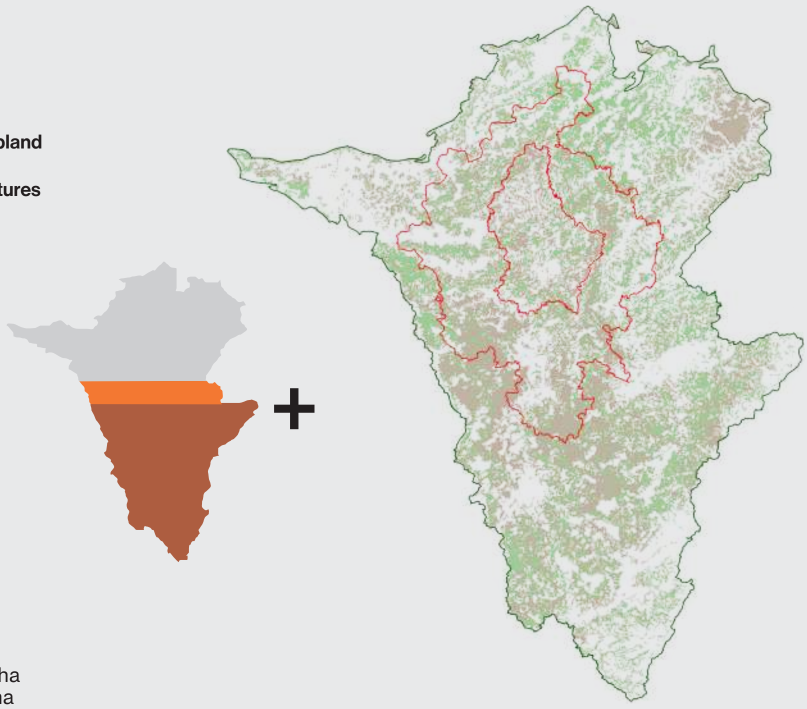
# Afforestation

2050

## 2018

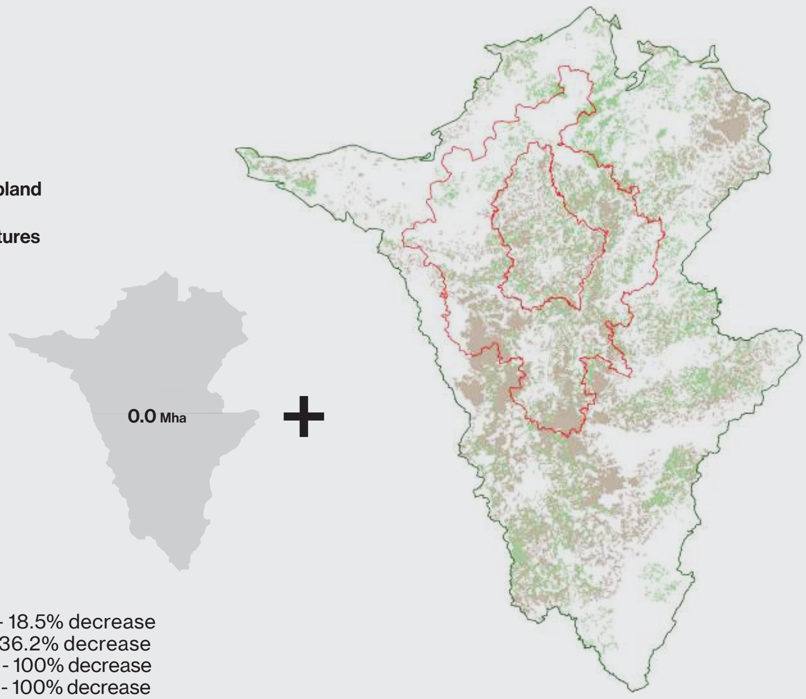
- Cropland
- Pastures
- International cropland
- International pastures



Cropland: 1.06 Mha
Pastures: 0.81 Mha
Int. cropland: 0.32 Mha
Int. pastures: 2.21 Mha

## 2050

- Cropland
- Pastures
- International cropland
- International pastures




Cropland: 0.86 Mha - 18.5% decrease
Pastures: 0.51 Mha - 36.2% decrease
Int. cropland: 0.0 Mha - 100% decrease
Int. pastures: 0.0 Mha - 100% decrease

# -3,3Mha

**decrease in land footprint of food consumption**

## The land surplus; drivers & quantified impact

The Bold diet shift with assistance of Land Use Accelerators, are able to release half a million hectares of land from food production in the bioregion. Other than protecting this valuable natural land cover which we will elaborate on in the next two strategies, we need a vision for what role this surface can play for the territory. Based on our maximum sequestration ambition and the increase of carbon sink surface area discussed in the introduction, we have developed a variety of afforestation scenarios in the second phase, which guide our territorial outlines.

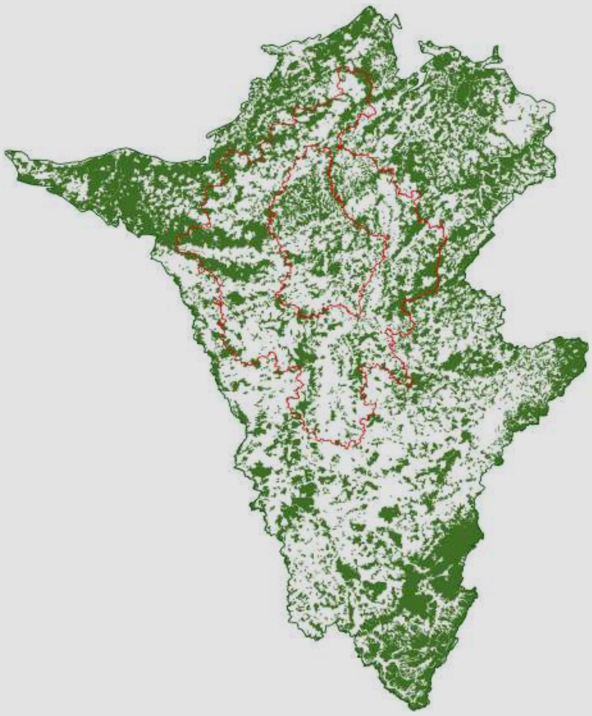
By afforestation, we have tried to connect the existing forests and biodiversity corridors, in addition to preserving the land parcels which have the suitable abiotic conditions in 2050 for food production.

**500,000**

**hectares of pastures & croplands of BFUR can be freed by 2050**

## 2018

Forest

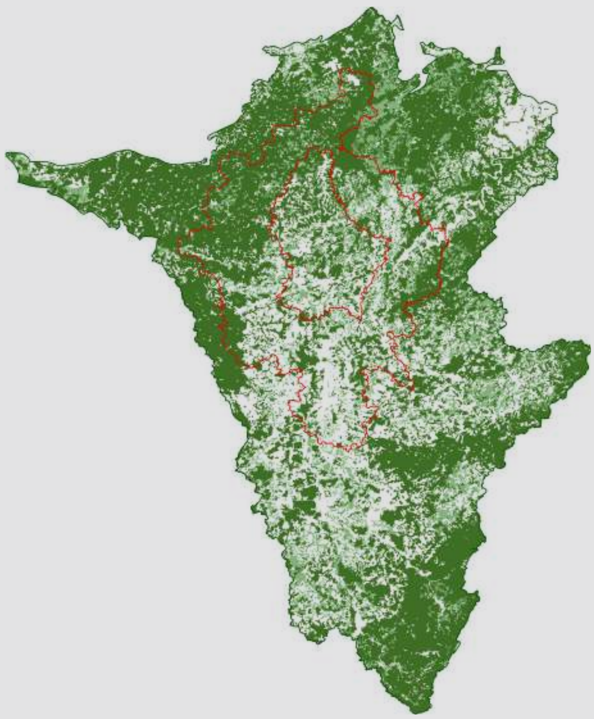


Evergreen production forest: 0.61 Mha
Deciduous Forest: 1.00 Mha

## 2050

Agroforestry

Forest



Reforested Deciduous Forest: 0.61 Mha
Regenerated Deciduous Forest: 1.00 Mha
Afforestated agricultural land: 0.49 Mha
Agroforestry/silvo-pastures: 0.51 Mha

**+1Mha**

**increase in surface area of forestry and agroforestry**

# The land surplus: afforestation towards maximum SOC

Afforestation is our primary sequestration vehicle. As maximum sequestration and soil carbon stock is our ambition, we have envisioned the land released from food production and protected by Net-zero growth, to be afforested. These afforested lands also contribute to strengthening water infiltration, biodiversity, timber production, and leisure networks. The forests have been placed in positions which weave the network of existing forests to create continuity in biodiversity corridors. With close to nature forest management, ecological resilience could be married with timber production. With the help of transparent cross-border timber value chain platforms, smaller multi-species forests can also become an active member in the timber market, generating financial incentives for the many small forest owners to take part in the forestry sector more actively.

## Leisure

The belts and necklaces created by afforestation, provide the opportunity for accessible green passages around and between cities and villages. These treks can be complemented with other leisurely activities, and services. Together they form vibrant ecofunctional spines for communities who live around them.

## Timber

The wood cluster in Luxembourg has developed a platform where small forest owners and timber purchase enquiries will gain visibility. Trees will be registered in type and tagged, so that when a demand emerges, there is a clear understanding of where and what are the available trees. They will then be harvested with close to nature forest management.

## Biodiversity

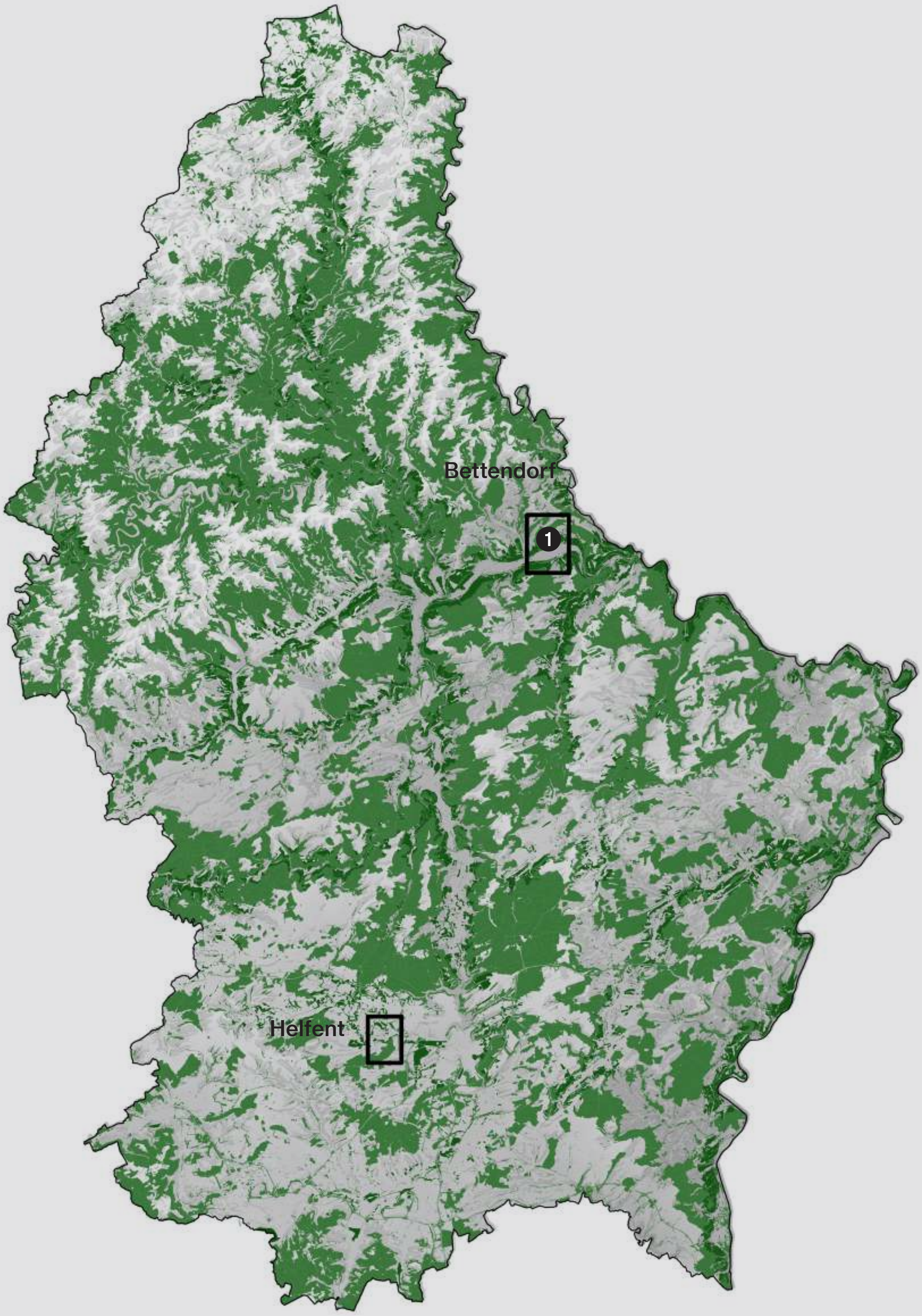
a productive forest is not in contrast to a healthy forest. With close to nature management we can enhance the health of our forests. In addition, by connecting the disconnected clusters of forests through afforestation, we can regenerate biocorridors which contribute to biodiversity, and bioeconomy.

## Water

A systematic approach towards forestry, agroforestry and silvopastures, will result in long-term benefits for the regional water footprint. By enhancing water infiltration and absorption of water run-offs before they reach the rivers, they can play an active role in flood mitigation.

*“Healthy forests can be productive too. We need to work on the false perception that productivity and preservation stand in contrast to each other”*

Johnny Brebel
Director
Luxinnovation




■ Afforestation

■ Existing forest in transition

# Close to nature forest management in current forests and increase in forest footprint by afforestation

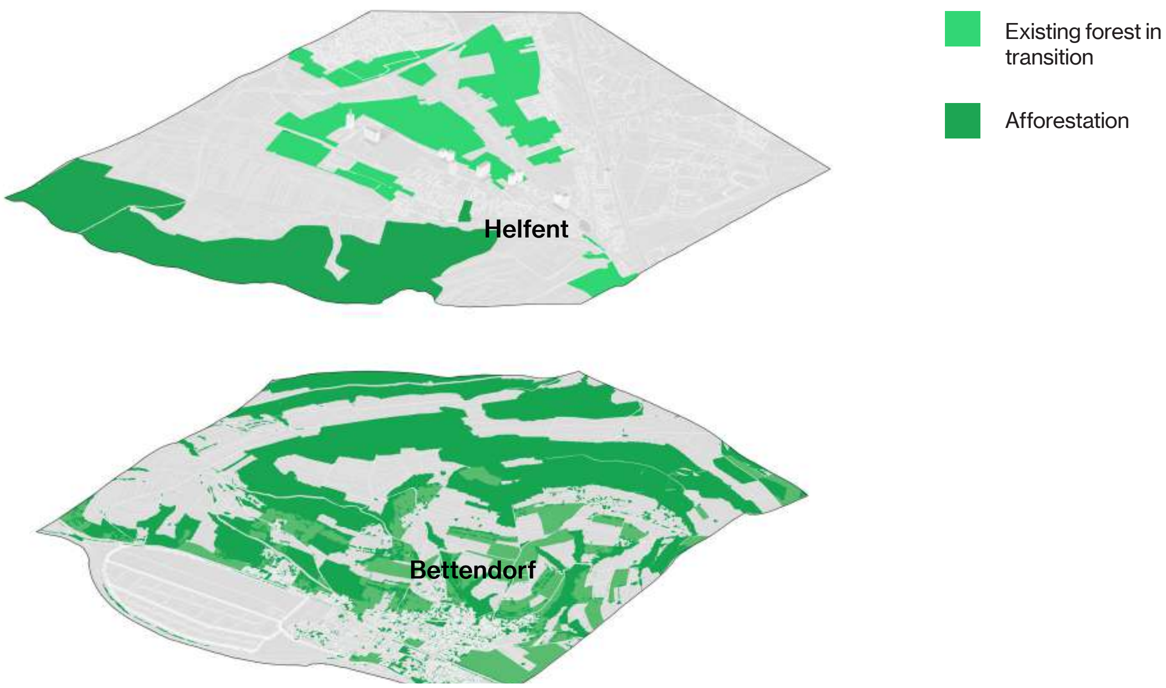
# Maximising sequestration

Urban expansion continues to intrude into rural landscapes, with predictable and dramatic consequences for biodiversity through land cover changes, habitat fragmentation, and degradation (Tan and Rinaldi, 2019). Losses from vegetation removal and land use changes also result in carbon losses. Sound spatial planning that considers urban growth at both the regional and global scale can make a big difference (Seto et al., 2012).

In cities both the aboveground and subterranean environment create considerable challenges for the optimal growth of urban vegetation (cables, piping, ...), especially for trees that form the backbone of most urban landscapes (Tan and Rinaldi, 2019). Limiting the capacity of cities to generate ecosystems with the same biodiversity and carbon capturing potential as rural landscapes.

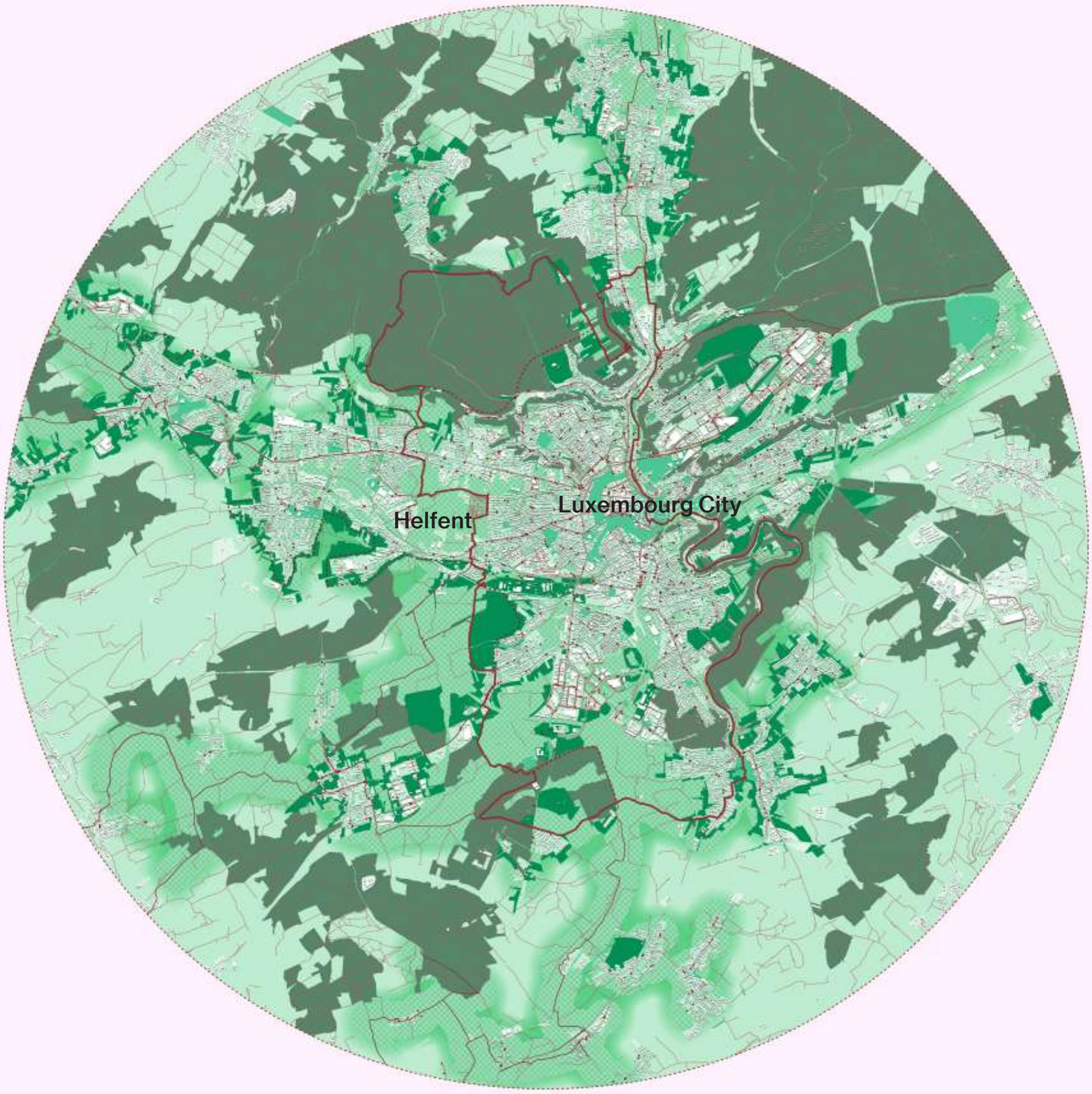
The ways to manage growth of cities can be framed as two contrasting approaches of ‘land sparing’ and ‘land sharing’. The former emphasizes reducing the spatial extension of urban land expansion, whereas the latter focuses on less intensive land uses, with the built areas being more spread out (Williams et al., 2018).

In an assessment of potential impacts of different land-use strategies on regional carbon stocks researchers concluded that land sparing scenarios offered a greater potential to conserve regional carbon stocks than all other strategies assessed.




**Afforestation and existing forest in transition**

# Luxembourg city leisure belt




Existing forest

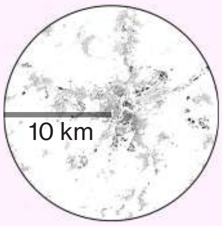
Existing public space

Search area new public forest catching development pressure

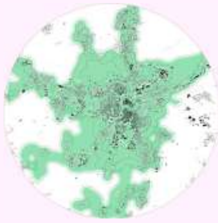
Existing recreational access

Search area new recreational access

Existing main national cycle route = main loop in leisure network




Outer Influence zone for metropolitan leisure accessibility



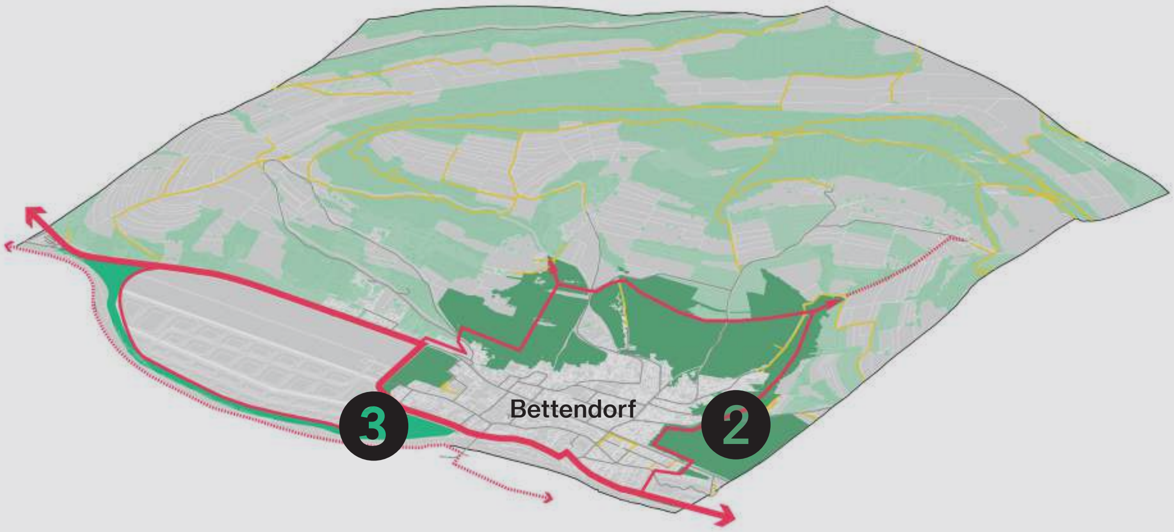
Highly accessible zone: within 300 meters of public transport stop or cycle way

# Land use accelerators and capturing high development pressure

The land-use accelerators put forward in next chapter offer an opportunity to transform agricultural lands into forests to maximize sequestration and diversify ecological habitat. If we concentrate these reforestation efforts on agricultural lands on urban fringes, public forests can be developed that capture high development pressure but also offer citizens places to meet and for outdoor experiences as an alternative to private gardens.

image 1: Afforestation agricultural land

# Leisure necklaces and public forests




- Existing bike path
- New bike path
- Leisure necklace access
- Existing paved
- Existing path
- Leisure necklace
- Existing forest
- Bordering wetland

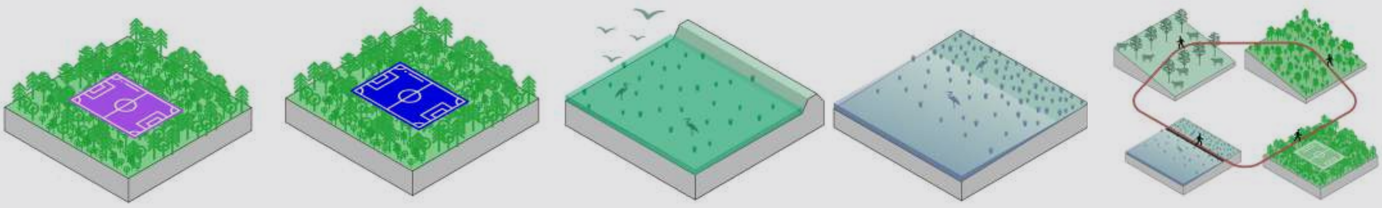

1 urban program

2

3 natural program

4

connectivity improvements



# Public forest as new commons

The urban fringe can be seen as 'planning's last frontier' arguing that areas abutting towns and cities have been largely neglected by land-use planning and by those agencies, public and private, with direct or indirect planning responsibilities (Gilhespy, 2020).

The rural-urban fringe is a diverse, dynamic, multifunctional region in terms of historical development, biodiversity, production, recreation, identity and landscape aesthetics It frequently consists of open and green spaces and alternative land uses, different from the densely built-up urban areas. Thus, it has the potential to be used for recreational and agricultural purposes of the citizens (Gündel and Kalonya, 2021).

The "common space" approach aims to repair the disconnection between natural, urban and rural zones, and it also aims for people to experience these areas with social activities. The term commons can be defined as the "tangible and intangible spaces of the public use and collective ownership that belong to society with free access"(Gündel and Kalonya, 2021).

image 2: Sportspark Genk by LOLA and LIST

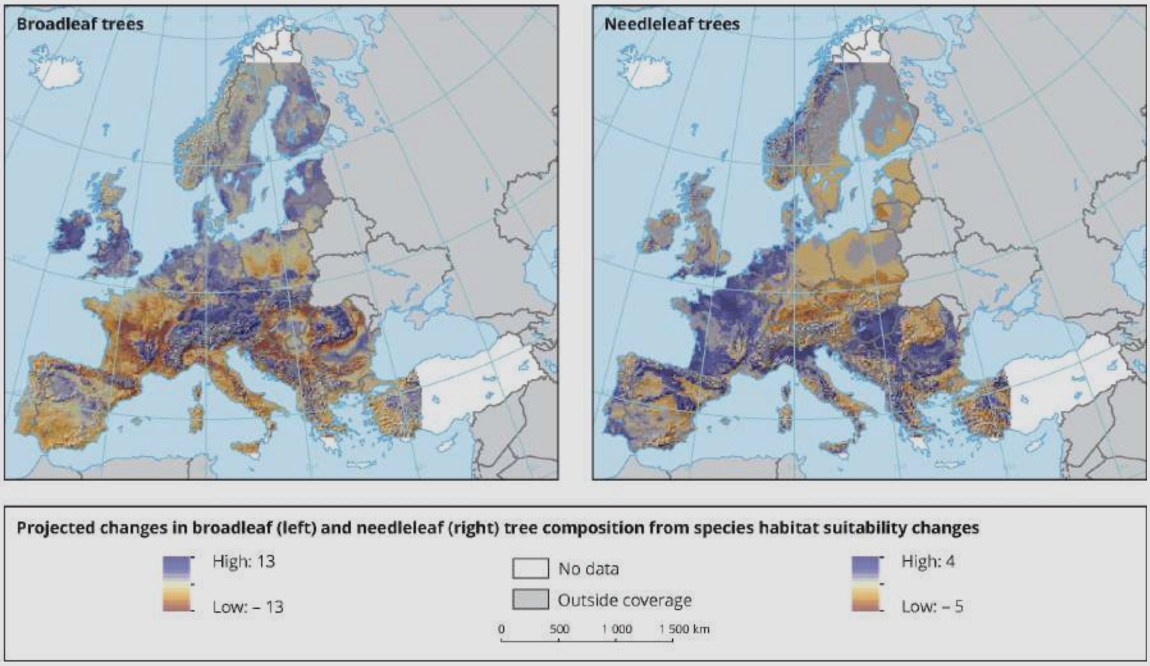



fig 1: projected changes in tree composition ranges.

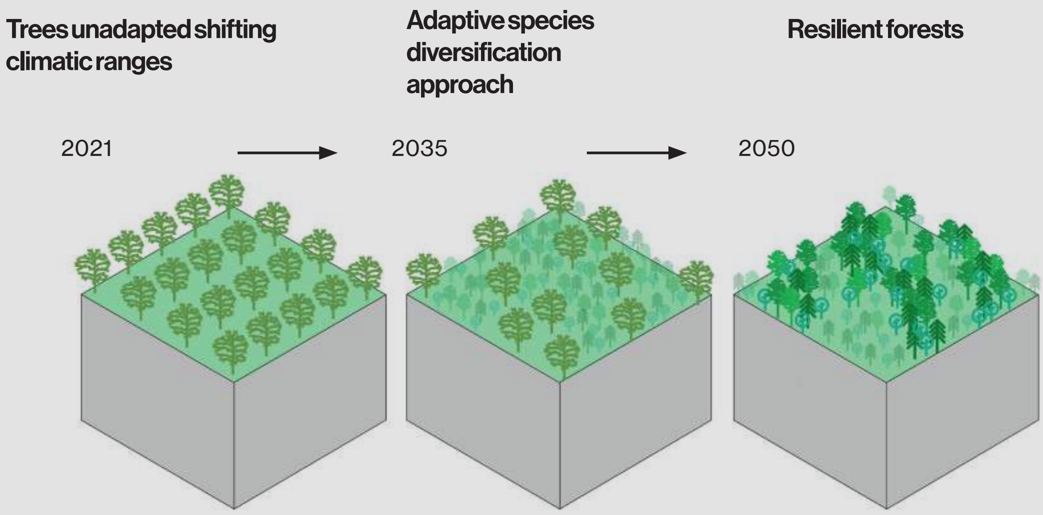



fig 2: timeline of projected changes in tree composition ranges.

# Multispecies resilient forest

Anthropogenic climate change, is proceeding at a magnitude and speed that is unprecedented in the history of human civilization, and forests will likely be out of phase with climate over the coming decades to centuries. This means that a pro-active, forward-looking approach is needed for managing forests with an adaptive species-diversification approach (Fitzgerald and Lindner, 2013).

In such a species-diversification approach Forest development types and site adapted species composition may include a variable amount of non-native or exotic species to promote the production function, or – increasingly important – to promote the resistance of forests to future stresses and disturbances (Bauhus et al., 2013).

The projected range shifts will affect the forest structure quite considerably. Such changes will also affect the functioning of forest ecosystems and the services these ecosystems could provide. Species such as beech (Fagus sylvatica), sycamore maple (Acer pseudoplatanus), lime (Tilia), elm (Ulmus) or silver fir (Abies alba) are likely to see further reductions in their ranges. Species from (sub-)Mediterranean regions such as holm oak (Quercus ilex), hop hornbeam (Ostrya carpinifolia) and cork oak (Quercus suber) are expected to extend their ranges to the north (Williams et al., 2018).

The focus should be on ecosystem stability, resilience against the predicted issues that are to become the most important disturbances in Europe, including climate change, wind storms, insect outbreaks and in particular bark beetles feeding in coniferous trees (Bauhus et al., 2013).

# Close to nature forestry (CTNFM) and microhaversting

Close-to-nature forestry is a low-intervention management method. The objective is to produce valuable timber while using the emulation of natural processes as a guiding principle. Biological legacies and natural biotopes, as well as habitat trees, are promoted inside the stand and should not be removed. The preferred method of regeneration is natural regeneration. Habitat and biodiversity protection are incorporated by selecting single and small groups of trees to be left in the stand (Duncker et al., 2012).

image 3: CTNFM as a manangement strategy between economics and ecology

# Economics of close to nature forestry

Practice of clear-felling, leads to reductions in soil organic matter content and should be avoided. opposed to clear-felling one aim of CTNFM is to produce and maintain valuable timber in harvestable dimensions continuously in every stand. In addition, the avoidance of clear-felling is associated with a reliance on natural regeneration and associated savings in planting costs.
Reliance on natural processes, aims to minimize management inputs. The reliance on is mainly focused on stages in which silvicultural activities are not producing revenues, such as regeneration and early stand development phases. Large-scale artificial regeneration through planting or sowing is generally avoided.

The focus lies on the development of individual trees. Harvesting decisions are made on a tree-by-tree basis to ensure that trees are cut as close to target diameters as possible. This ensures maximum value increment. Target diameters represent a tree's economic optimum or economic maturity, when the value increment culminates ending efforts to optimize diameter and quality development of individual trees often include frequent thinning operations during selected phases of tree and stand development. Thus, typical CNTFM operations may use tending blocks that comprise one fifth of management districts, resulting in five-yearly return intervals for tending and harvesting operations.

Mixed and uneven-aged, structurally diverse forest stands often have higher productivities than monocultures and they often offer greater economic and ecological stability (Bauhus, 2013).


fig 3: Delivery of goods and services should be highest in moderately managed

image 4

# Outtake 1 : Drought-tolerant fir can replace spruce

The majority of European forests are characterised by spruce. The Norway spruce is one of the most important commercial trees. Due to climate change droughts are expected to become more and more common and intense in Europe. However, not every plant species has adapted to this. Researchers of the University of Freiburg (Breisgau) and the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) investigated conifers in the Black Forest. They found that the indigenous Silver fir and the Douglas fir, introduced from Northern America, are more tolerant to droughts than the spruce (Drought-tolerant fir can replace spruce, 2021).

Cultivating these species instead of Norway spruce will contribute to maintaining a high level of productivity across many European forests under future climate change (Vitali et al., 2017).

*“Transparency and exposure for smaller supply and demand is key to the success of the timber value chain. We have developed a platform to showcase these, and be able to label and archive the tree supply of owners, so that local demand can detect their suitable targets for timber before harvest.”*

Johnny Brebel
Director
Luxinnovation

*“It is socially and politically very unpopular to export wood, but for local value chains to become successful & favorable, a lot of advocacy work needs to be done to adjust current procedures at the local, national and European level.”*

Stephan Kampelmann
Co-Founder & Managing Director
Sonian Wood Coop

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**Images**

image 1: Gambles, I. (2019, November 4). The Woodland Carbon Guarantee has now launched. Forestry Commission. https://forestrycommission.blog.gov.uk/2019/11/04/the-woodland-carbon-guarantee-has-now-launched/

image 2: LOLA ad LISR (2018). Sport Park. Genk. https://lola.land/project/sports-park-lola/

image 3: Pro Silva.( 2020). https://www.prosilva.org/

image 4: The decline of forests in Europe. Declinul Padurilor din Europa(2021, December 8). TehnoÈ-tiri. https://tehnostiri.ro/index.php/2021/12/10/declin-paduri-europa/

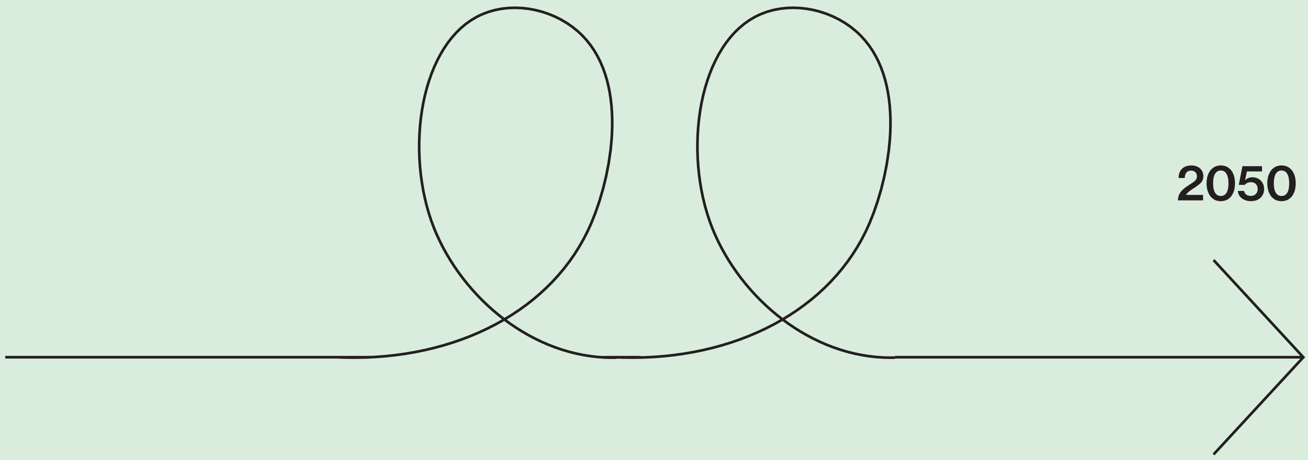
**Figures**

fig. 1: Projected changes in climatic suitability for broadleaf and needleleaf trees. (2016). European Environment Agency. https://www.eea.europa.eu/data-and-maps/figures/projected-change-in-climatic-suitability

fig. 2: Projected changes in climatic suitability for broadleaf and needleleaf trees. (2016). European Environment Agency. https://www.eea.europa.eu/data-and-maps/figures/projected-change-in-climatic-suitability

fig 3: Arroyo-Rodríguez, V., Fahrig, L., Tabarelli, M., Watling, J. I., Tischendorf, L., Benchimol, M., Cazetta, E., Faria, D., Leal, I. R., Melo, F. P. L., Morante-Filho, J. C., Santos, B. A., Arasa-Gisbert, R., Arce-Peña, N., Cervantes-López, M. J., Cudney-Valenzuela, S., Galá-Acedo, C., San-José, M., Vieira, I. C. G., . . . Tscharntke, T. (2020). Designing optimal human-modified landscapes for forest biodiversity conservation. Ecology Letters, 23(9), 1404–1420. https://doi.org/10.1111/ele.13535

# Carbon farming



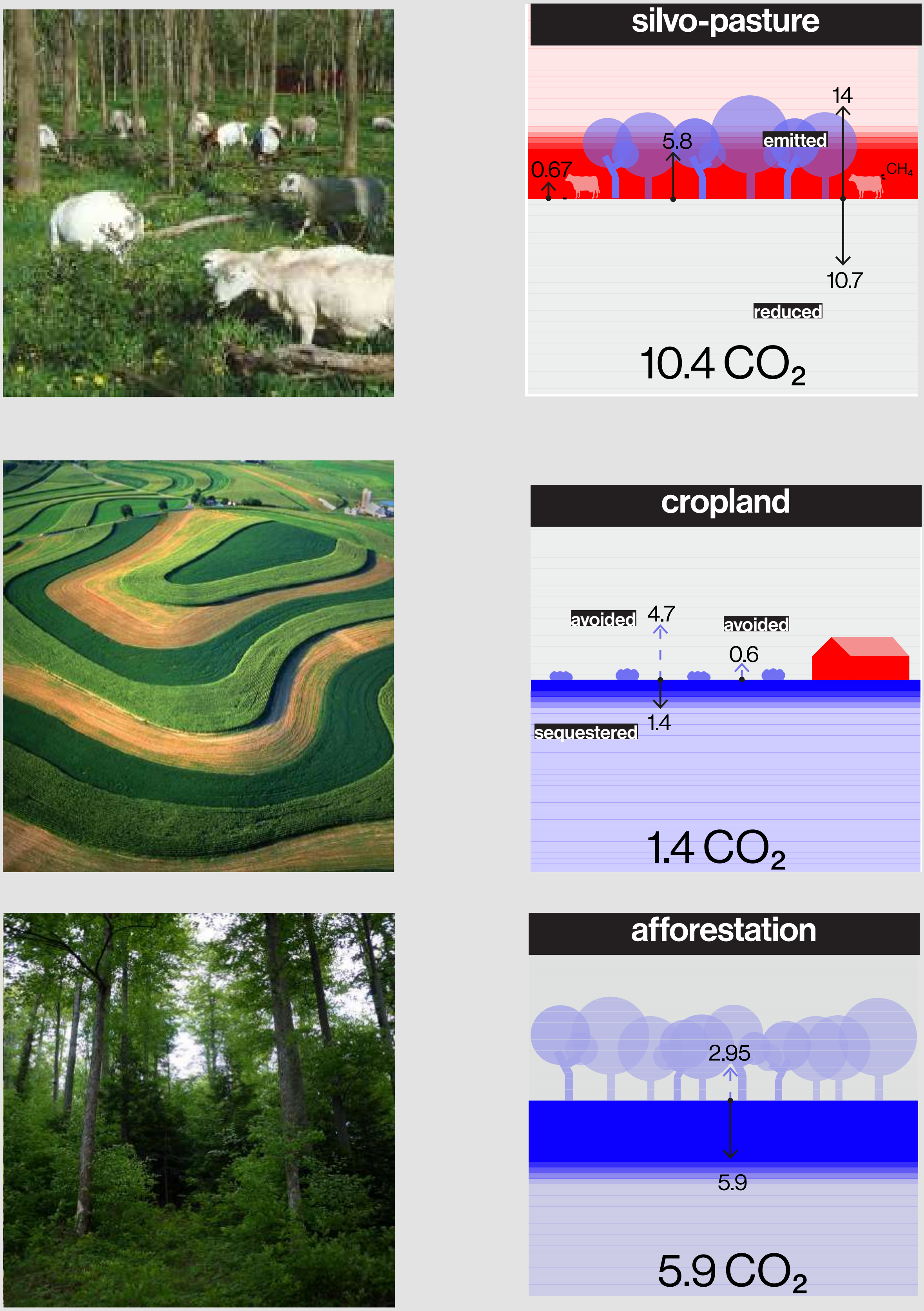



fig. 1: Total emissions/sequestration of 1 ha of land in cropland, silvo-pastures, pastures, reforestation, climax forest and afforestation.

# Carbon farming

Farming practices can play a crucial role in nature-based decarbonisation. As shown in the previous phases, practices such as silvo-pastures, afforestation and implementation of hedges on croplands and pastures are important sequestration tools able to mitigate carbon emissions. As an example, hedges reconstruction has two effects on SOC storage: local effect of SOC storage under the hedge itself and an anti-erosive effect locking SOC at the hillslope scale. Such practice has been implemented in Wallonia, who has declared to reconstruct 4000 km of hedges. Since the coalition agreement was concluded in 2019, 45 km of hedges, 1.7 km of undergrowth, 800 row trees and 1,900 fruit trees have already been planted (Region of Wallonia, 2019).

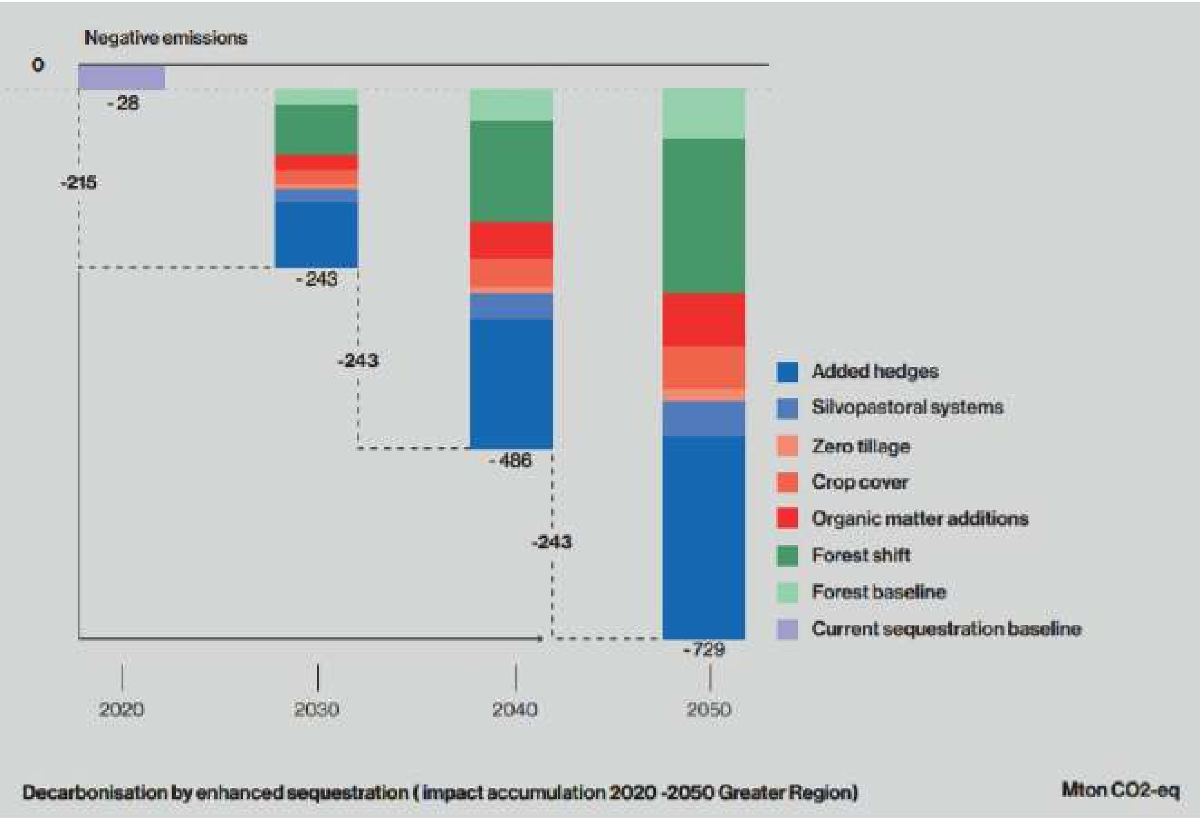
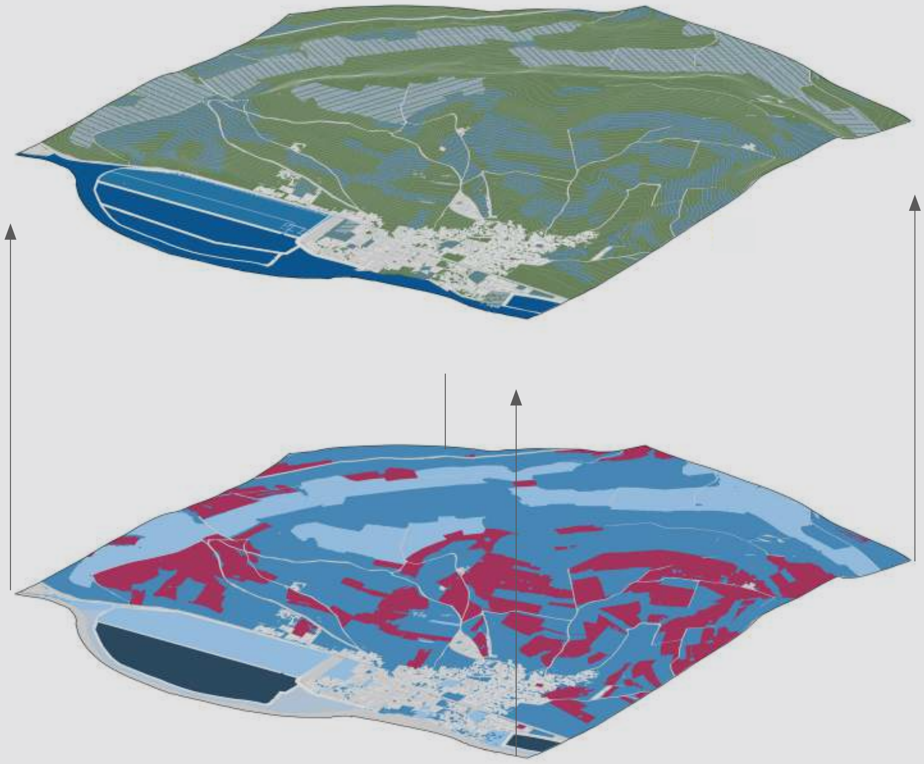



fig. 2: Decarbonisation by enhanced sequestration (impact accumulation 2020-2050 Greater Region). Mton CO2-eq.

## Bettendorf - Decarbonisation by 2050



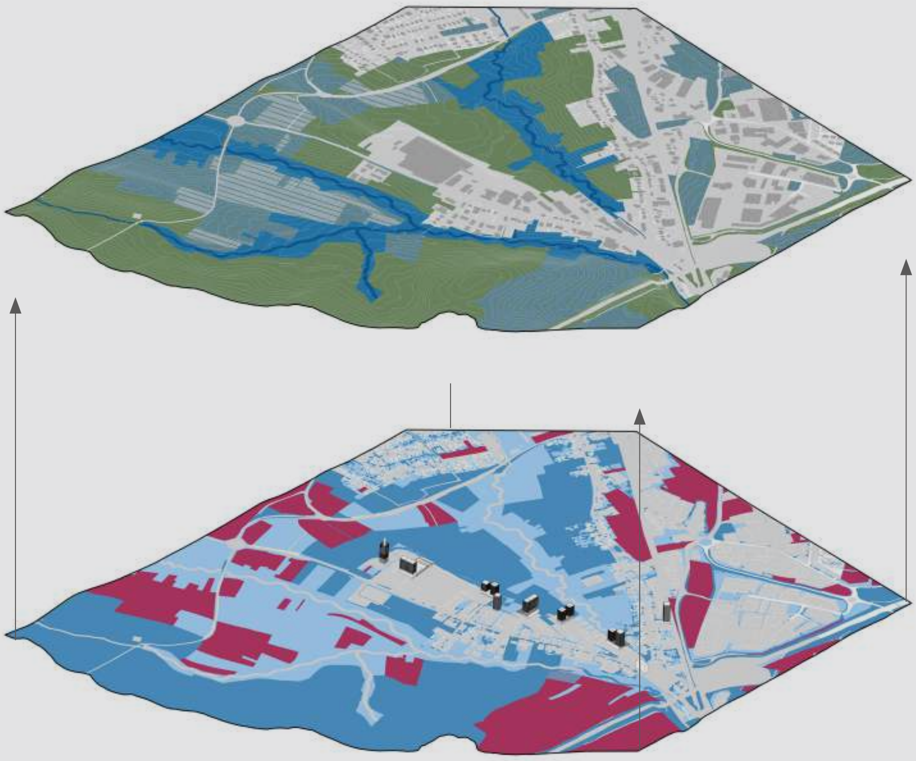
## Additional resilience by decarbonisation measures

- reduced run-off, increased infiltration, reduced high river levels and reduced (flash) floodrisk low located villages
- more space for the river to reduce the waterlevel of excess flows and avoid economical damage downstream due to large scale flooding
- HQ 10 & 100: high to medium flood probability
- HQ extreme: floods only during extreme event

- climate/drought & future disturbance resilient forests
- crop disease control, soil fertility increase, reduced erosion soil loss, increase soil water retention and availability
- climate/drought & future disturbance resilience trees, increase soil water retention and availability

- - 12,7 t CO2 eq./ha/yr
- + 20,47104 and - 10,0771 t CO2 eq./ha/yr
- - 1.4 t CO2 eq./ha/yr
- - 335 t CO2 eq./ha/yr

## Helfent - Decarbonisation by 2050



- reduced run-off, increased infiltration, reduced high river levels and reduced (flash) floodrisk low located villages
- more space for the river to reduce the waterlevel of excess flows and avoid economical damage downstream due to large scale flooding
- low to extreme flood probability

- climate/drought & future disturbance resilient forests
- crop disease control, soil fertility increase, reduced erosion soil loss, increase soil water retention and availability
- climate/drought & future disturbance resilience trees, increase soil water retention and availability

- - 12,7 t CO2 eq./ha/yr
- + 20,47104 and - 10,0771 t CO2 eq./ha/yr
- - 1.4 t CO2 eq./ha/yr
- - 335 t CO2 eq./ha/yr

# Can decarbonisation of our productive landscape be used as leverage for ecological and climate resilience?

In the resilience strategy ‘water as leverage’, water is used as leverage to adapt to a wider range of future challenges (Water as Leverage for Resilient Cities in Asia, 2019). With water as a building block for sustainable development water related challenges become a lever for an integrated approach to urban and landscape development (Ministerie van Buitelandse Zaken, 2020).

Decarbonisation measures in landscapes can be seen in a similar fashion, as leverage to incorporate integrated solutions that also tackle additional challenges that landscapes and societies face such as droughts, floods and biodiversity decline. Decarbonisation can be leverage for an integrated approach for future resilience of productive, urban and ecological landscapes

For example, If we add trees to pastures to cut their emission in half, how can they benefit ecological connectivity or reduce flooding? If we transition from industrial crop production to organic strip-cropping how can biodiversity corridors and water retention be integrated? These multifaceted aims of single interventions with a diversity of positive impacts also create positive feedback loops as more biodiversity corridors and water retention in arable land, for instance, will increase pollination but also groundwater availability to overcome drought periods.

image 1: Additional resilience and ecological impact of silvopastures beyond carbon

image 2: rebuilding connectivity in the matrix by using silvopasture

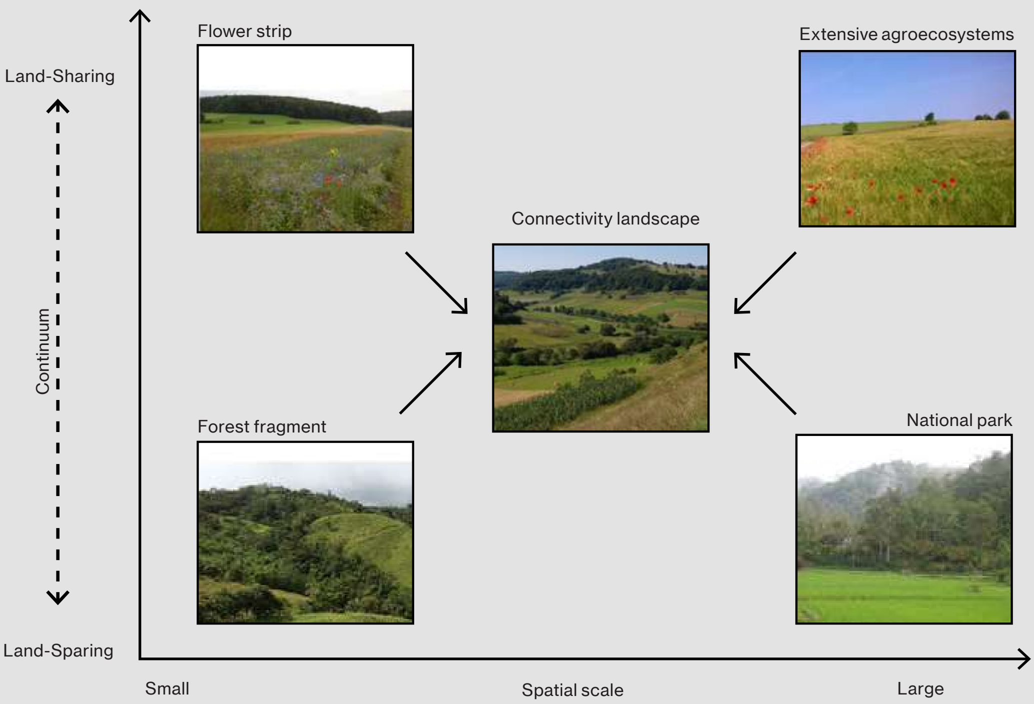



fig. 3: Land-sharing/-sparing connectivity landscapes.

# Potential of land sharing and agro-ecological intensification

This multifaceted approach described in previous chapter is premised on the idea of land sharing, whereby productive landscapes are interwoven with natural elements. This is achieved by adopting agro-ecological techniques, agroforestry and Silvo pastoral systems, cover cropping, crop rotation, intercropping, etc. All of these different approaches are part of what has been called 'ecological intensification' (PBL Netherlands Environmental Assessment Agency, 2020).

Saving the planet's biodiversity requires a combination of protected areas and the creation of a wider landscape that is sympathetic to nature (Sparing vs Sharing: The Great Debate Over How to Protect Nature, 2018).

Biodiversity-based techniques can be used to manage most human-modified lands. These can provide for human needs and maintain biodiversity not just for ecosystem services but also for maintenance and persistence of non-human species. Increasing the criticality of matrix connectivity to permit wide species distribution. Maintaining the diverse communities of organisms, from microbes to mammals, that contribute to producing food, materials, clean water, and healthy soils; sequestering greenhouse gases; and buffering extreme weather events, functions that are essential for all life on Earth. Aiming to support biodiversity while providing goods and services for humanity over the long term, assuring sustainability and resilience. Further, by maintaining the biodiversity that supplies critical ecosystem services within productive landscapes, these approaches ensure that the production of food, fibre, fuel, and timber can be sustained over the long run and be more resilient to extreme events, such as floods, droughts, hurricanes, and pest and disease outbreaks, which are becoming more frequent with climate change.

These shared ecological intensified landscapes often comprise of heterogeneous patch habitats, including novel communities made up of mixtures of native and non-native species, as well as remnants of natural or semi-natural habitats whose composition is more similar to that of a historical ecological community. Maintaining mosaic landscapes composed of different patch types provides opportunities to maximize diversity, resilience, and multifunctionality (Kremen and Merenlender, 2018).

# Potential of Land sharing and agro-ecological intensification

## Bettendorf

Increased matrix connectivity by ecological intensification agriculture (sharing)

Increased matrix connectivity by sustainable intensification to set agricultural land aside for afforestation (sparing)

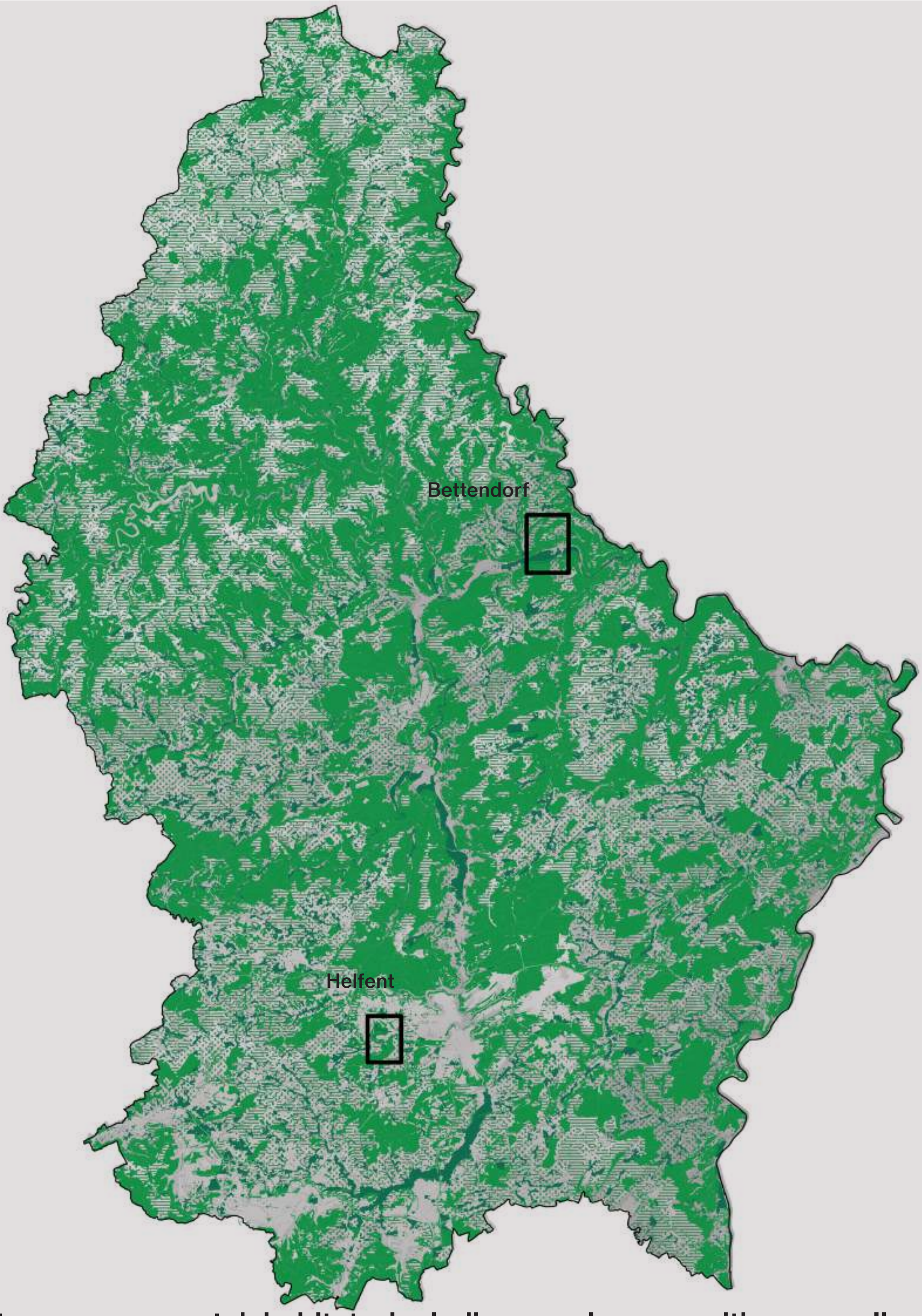
heterogeneous patch types: novel and remnant natural and semi-natural habitats

## Helfent

Increased matrix connectivity by ecological intensification agriculture (sharing)

Increased matrix connectivity by sustainable intensification to set agricultural land aside for afforestation/valley renaturalisation (sparing)

heterogeneous patch types: novel and remnant natural and semi-natural habitats




**Heterogeneous patch habitats, including novel communities, as well as remnants of natural or seminatural habitats, productive landscapes are interwoven with natural elements resulting in high matrix connectivity**

Forested ecosystems | Extensive agroecosystems | Wetland ecosystems

image 3: Retention

image 4: Stripcropping and ecological intensification

# Potential of land sharing and agro-ecological intensification

The alarming decline of biodiversity and increase in extreme weather means there's an urgent need to develop resilient crop production systems (WUR, 2018)

The advantage of various crops in strip cultivation is that strips of up to 6 meters help prevent the spread of diseases, "You can compare it with social distancing during the corona outbreak," The strips attract more crawling insects and spiders, and flying insects such as parasitic wasps and hoverflies (Meer natuur op akkers door strokenteelt, 2020).

Producing crops in strips running across the slope can greatly reduce the risk of erosion by cutting surface water runoff approximately in half. Using strips effectively shortens the slope length, thereby slowing runoff of surface water from sloping fields. Adding sod waterways in natural channels on hillsides and using no-till techniques to plant crops into the strips should almost eliminate erosion problems (University of Kentucky, 2020)

When strips of soil are strong enough to slow down water from moving through them, the weaker soil can't wash away like it normally would. Because of this, farmland stays fertile much longer. Resulting in slow runoff, increase soil water retention, improve soils, flood risk reduction and Increase infiltration/ groundwater recharge. Employing a crop rotation system down a slope in order to minimize runoff and rain velocity (European Commission, 2015).

But ultimately strip cultivation is a transitional technology, all techniques, machines and seeds are made for monocultures. Ultimately, we can move towards 'pixel farming', where crops are surrounded by other crops that suit them and where only mature crops are harvested and the rest are given time to ripen as well (Meer natuur op akkers door strokenteelt, 2020).

image 5: Contour cropping and water retention

image 6: Mature silvopasture with fruit trees as extra crop

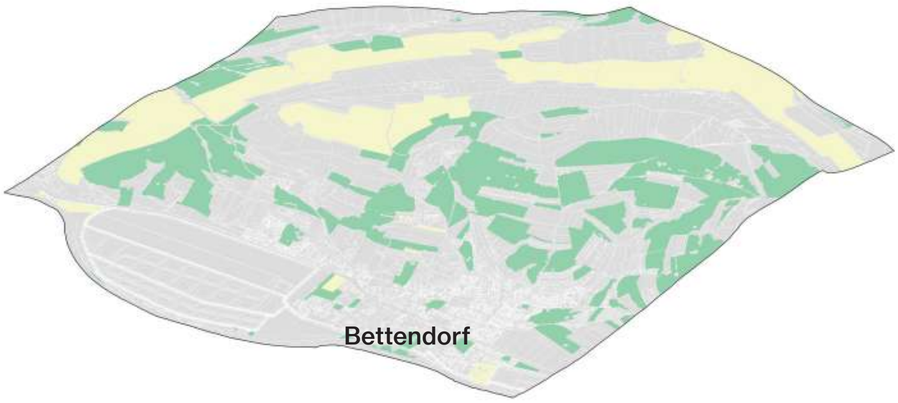
## Pastures transitions: silvopastures (SPS)

Well-managed SPS (silvopastoral systems) can improve overall productivity, while sequestering C, and potential additional economic benefit for livestock farmers. In these systems, tree roots generally explore deeper soil depths and can contribute to relatively large amounts of sequestered C compared with grass monocultures.

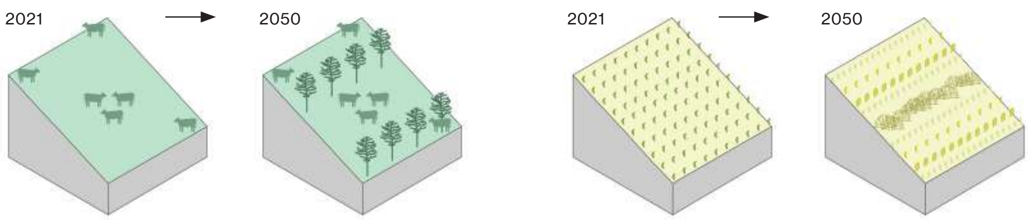
Results from several studies document the importance of SPS (e.g. pastures with high tree densities or multistrata live fences) for the conservation of biodiversity . The bundling of production activities with the marketing of environmental services could constitute a route to reconverting traditional cattle systems towards eco-friendly systems that integrate Silvo pastoral and agroforestry systems.

This could represent one of the best strategies for ecological restoration, C sequestration and conservation of water and biodiversity resources, while ensuring agricultural productivity. This linkage provides the farmer with the option of continuing to produce food, raw materials, and services and at the same time of providing benefits for society and the global environment (Ibrahim et al., 2011).

# Agroforestry transitions




Silvopastures
Stripcropping

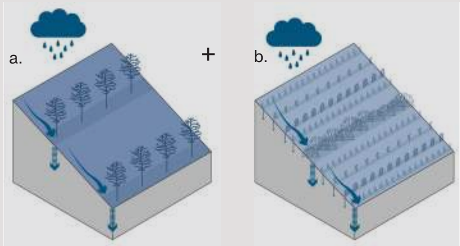


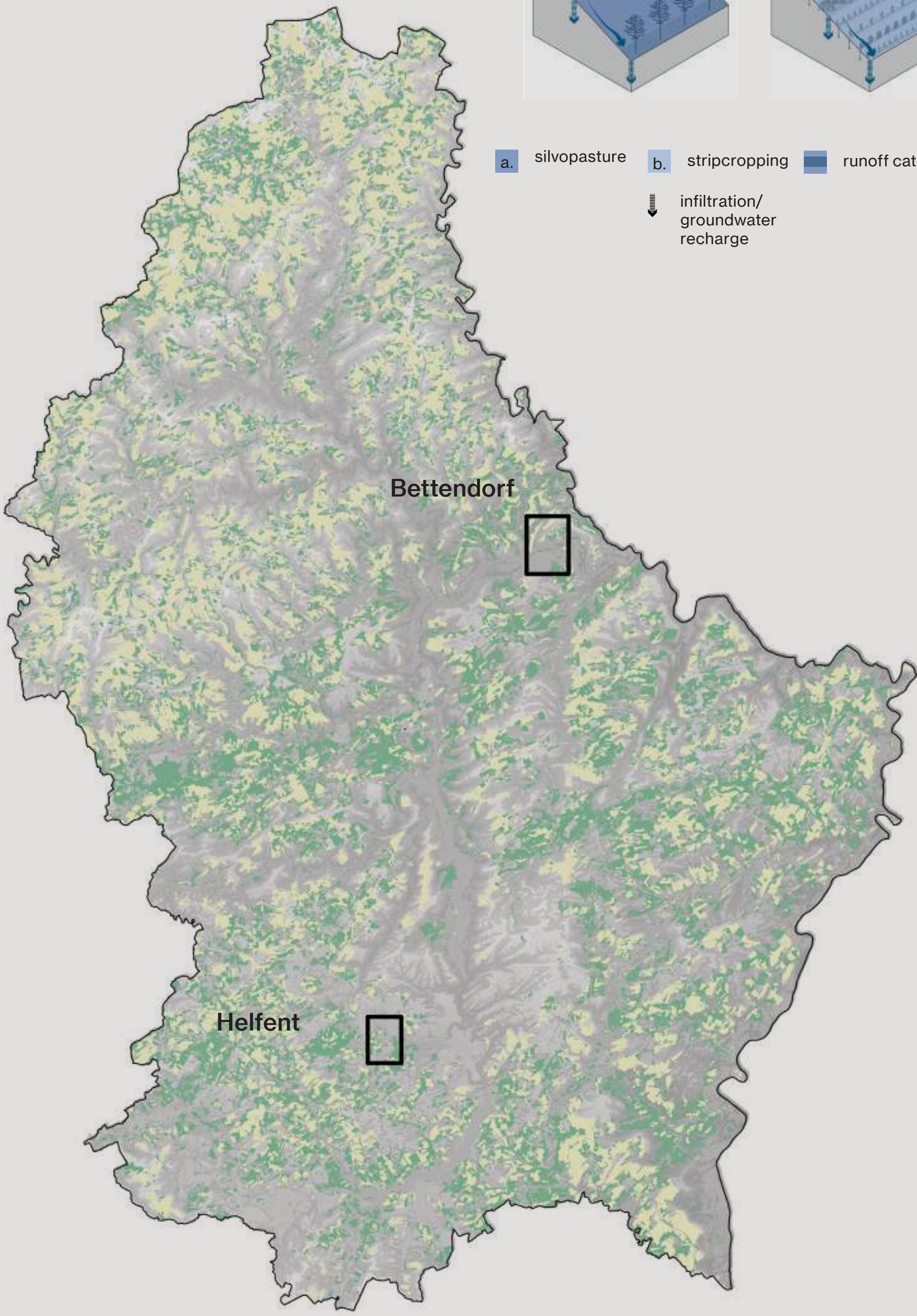

Cattle
Fruit/nuts

monoculture
polyculture
ecological strip


Silvopastures
Stripcropping

Additional resilience benefit: vertical (rain) flood relief




## The agro-ecological intensification footprint

Silvopastures

Stripcropping


image 8: Ferraris map 1770 and 1778 with original wet valleys in Bertrange/Helfent

image 9: Extensive grazing in combination with water storage

# Pastures transitions: renaturalisation of valleys and natural extensive grazing

Until the mid-19th century, few animals grazed the Luxembourg's outer fields and the wet and unproductive floodplain wastelands. In the second half of the 19th century, floodplain wastelands disappeared and were substituted by drained and so-called improved meadows and pastures.

After 1945 there was a greater emphasis on drainage and the maintenance of the corrections made to the river's course. The marshy character of the grassland during the vegetation period was lost and land use in the floodplain became increasingly homogeneous. Common grazing in the floodplains was phased out in the 1980s and some of the meadows were converted to paddock pastures.

The result of the measures undertaken in this period was the creation of a more uniform floodplain in terms of vegetation structures and site characteristics. Restored floodplain sections can provide indispensable ecosystem services in peri-urban landscapes, such as flood control, the retention of pollutants and nutrients, the provision of water resources – Gutland is experiencing falling groundwater levels – and biodiversity conservation.

In times of climate change such areas also provide 'new' functions such as the sequestration of carbon dioxide and the buffering of extreme peaks of flood events. Following restoration objectives of ecosystem functionality and biodiversity, restoration measures might, therefore, recreate hydrological functionality, reinforce river dynamics and implement a modern functional and self-sustaining management complex through low-intensity grazing to maintain the traditional semi-open landscape character and waterbuffering capacity (Schaich et al., 2012).


Natura 2000 Zone Welcomes Water Buffalo Herd to Syrtal

Published on Thursday, 01 Apr 2021 12:29 by SD

SHARE THIS ARTICLE: RATE THIS ITEM: | 3 votes

Water buffalo herd Credit: Philip Birget

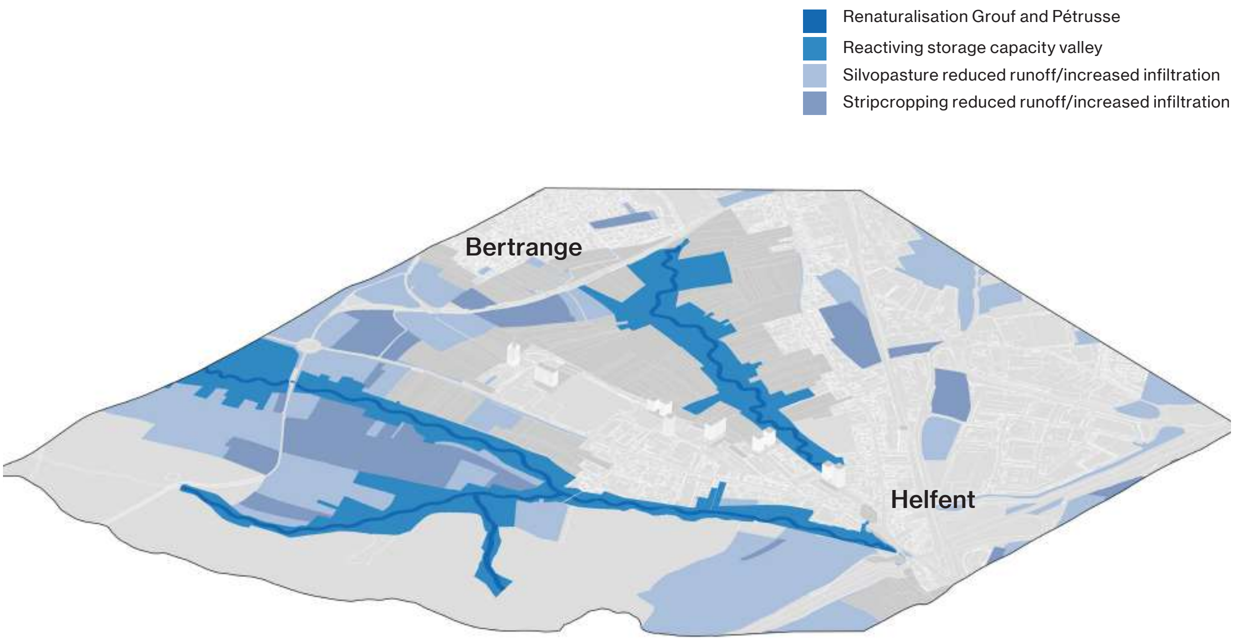
Luxembourg's Ministry of Environment, Climate and Sustainable Development has announced that, for a few days now, European water buffalo have been used in the "Schlammwiss-Brill" nature reserve in the large Natura 2000 zone of the upper Syrtal near Mensdorf to guarantee natural, extensive management of a wet pasture of around 25 hectares.

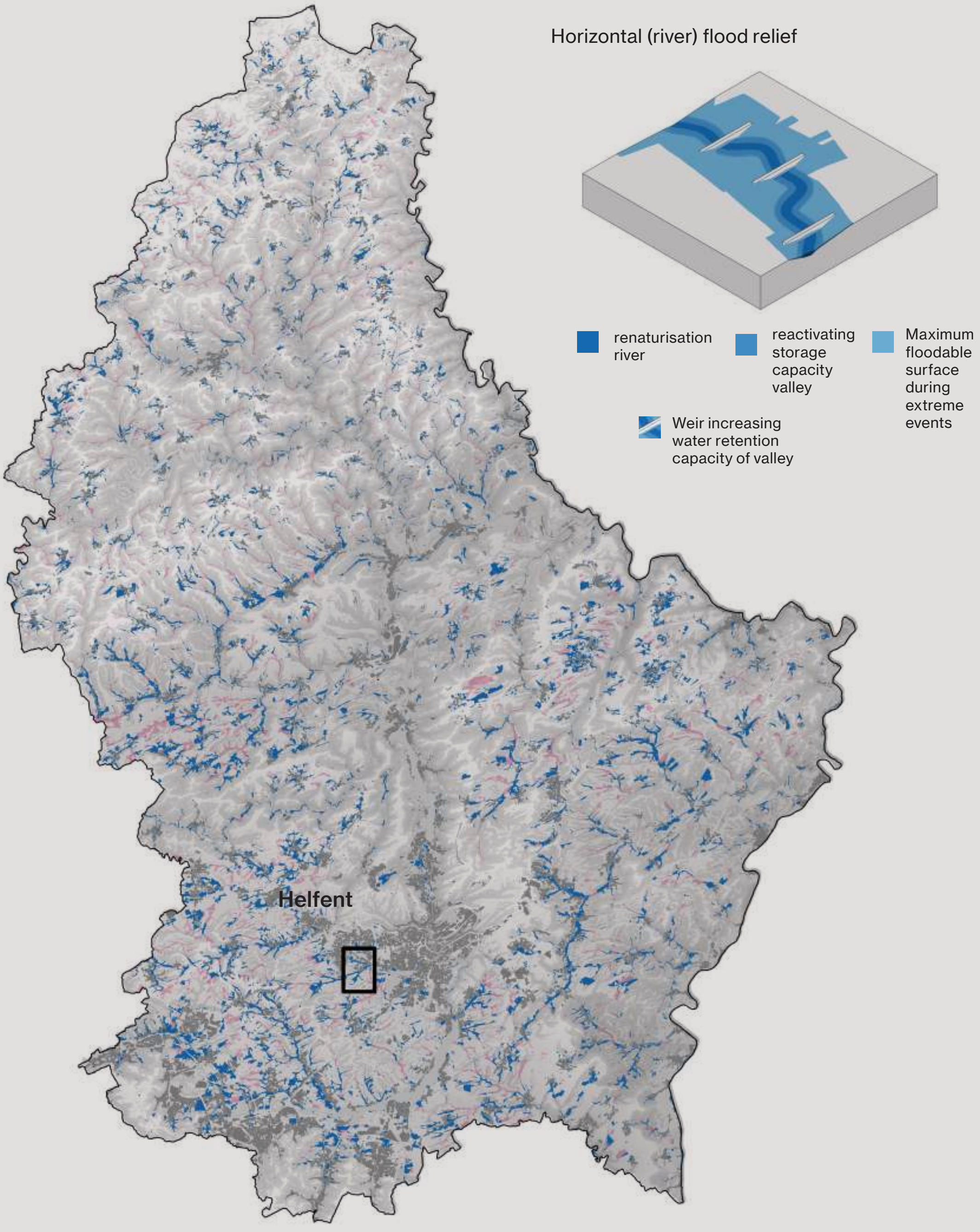
As the name suggests, the water buffalo are excellently adapted to humid habitats. The extensive grazing with these spectacular animals preserves the open land character of the area - ideal for the white stork, a target species of the area - but with a wealth of structural diversity. Due to the feeding behaviour of the water buffalo, the dense, matted vegetation of the area is

image 7: Existing extensive grazing practices in Luxembourg

# Pastures transitions: renaturalisation

image 10: Weir increasing the buffering capacity of valley






## Renaturalisation of valleys and natural extensive grazing

- High potential: high water storage capacity and close to urbanisation
- Low potential: low water storage capacity and far from urbanisation
- Urbanisation

# Productive landscapes

mean annual merchantable = 8 m3/ha/yr with close to nature forestry management

Silvopasture: 0.01 to 0.23 tons/ merchantable/protein/ha/yr

Stripcropping 1.8 tons/ merchantable/protein/ha/yr

Aquaculture algae for food: 13 tons/ merchantable/protein/ha/yr

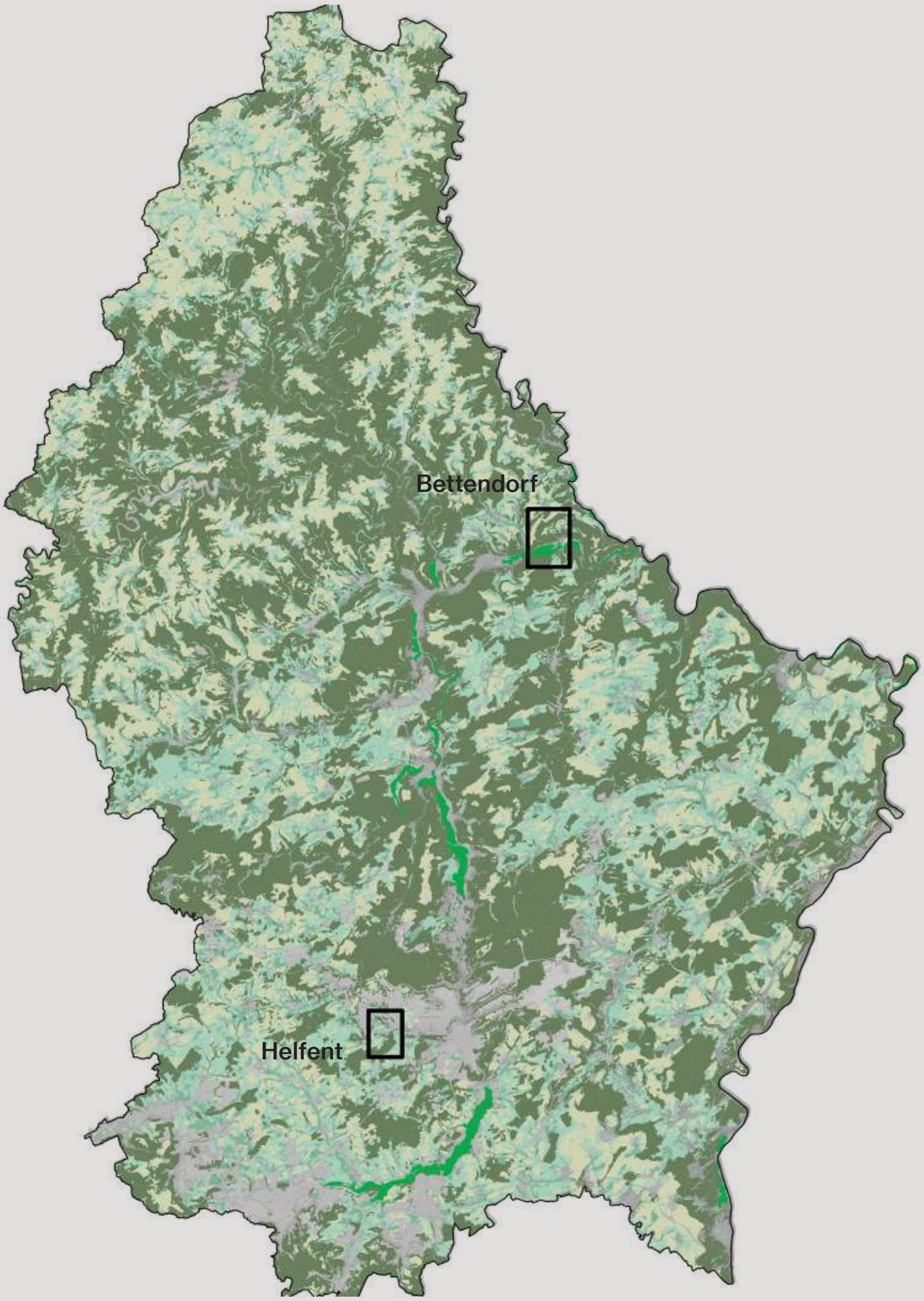
Aquaculture algae for fertilizer: 150 to 300 tons/ merchantable/biomass/ ha/yr

mean annual increment merchantable of 8 m3/ha/yr close to nature forestry managment

Silvopasture: 0.01 to 0.23 tons/ merchantable/protein/ha/yr

Stripcropping 1.8 tons/ merchantable/protein/ha/yr

Vertical farm: 3500 tons fruits and vegetables/ha/yr




## Productive landscapes

Forestry (CTNF) Silvopasture Stripcropping Aquaculture

*"We need the possibility to define and label agricultural land parcels specifically for regenerative forms of agriculture such as agroforestry  such that environmental protection on such parcels can be adapted, in a way that it does not block regenerative transformation. Today, planting trees (or hedges), can potentially directly impact the value of land if protected species settle there such that it falls under the most restricted preservation status. This is why we need a new land use label for agroforestry to avoid the current conflict between productive and protected land, once trees are planted. This will open up an immense capacity for regenerative transformation in agricultural practice."*

Ariane König
Sr Research Scientist
University of Luxembourg

image 12: Robotisation of monitoring and production

# Outtake 1
# Robotisation of monitoring and production

Automation is advancing in agriculture. The number of innovative processes and methods for creating an efficient and resource-friendly farming is constantly increasing. One example is precision agriculture - a farming management concept that allows for real-time monitoring of crops, fields, and farming environments. Precision agriculture makes use of new technologies to increase crop yields and profitability while lowering the levels of traditional inputs needed to grow crops, e.g. land, water, and fertilizer. Together with smart methods, such as hydroponics, precision agriculture will be vital to ensure a safe supply of food in Europe. The ultimate goal of these technologies is to develop technology that contribute to a more efficient and resource-friendly farming. It aims to demonstrate the potential for reducing the environmental impact of farming in terms of carbon footprint, eutrophication, and excessive use of pesticides and feed (Advancing monitoring in precision agriculture, 2021).


image 11: Monitoring

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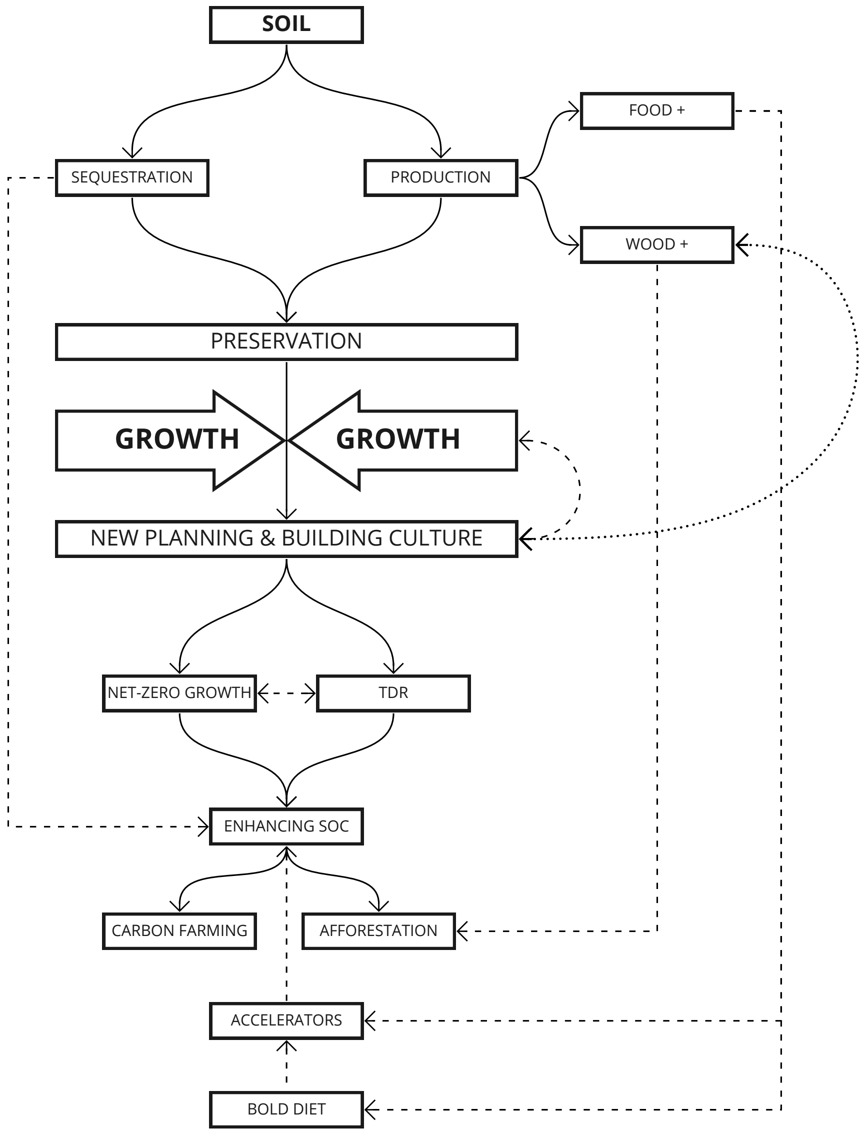
# Net Zero Growth

# Where and how, now!
# On transforming cultures of planning & construction.

In order to allow the development of the region and promote smart demographic and economic growth  while activating the soil's capacity for carbon sequestration and optimized production, current cultures of planning and construction will need to be transformed (US EPA, 2021) (GGDL, 2020).

If the question of where we build is paramount, how we build will have major implications on the carbon footprint of our buildings and our construction industry, on (r)urban resiliencies (Mariani, 2018)  and might potentially lead to the advent of new regional economic value-chains.

The current planning culture, as an operational expression of the political silo system, still promotes the fragmentation of the territory into zones of specialized i.e. sectoral activities, leading to the sprawling of our towns and cities at a high investment

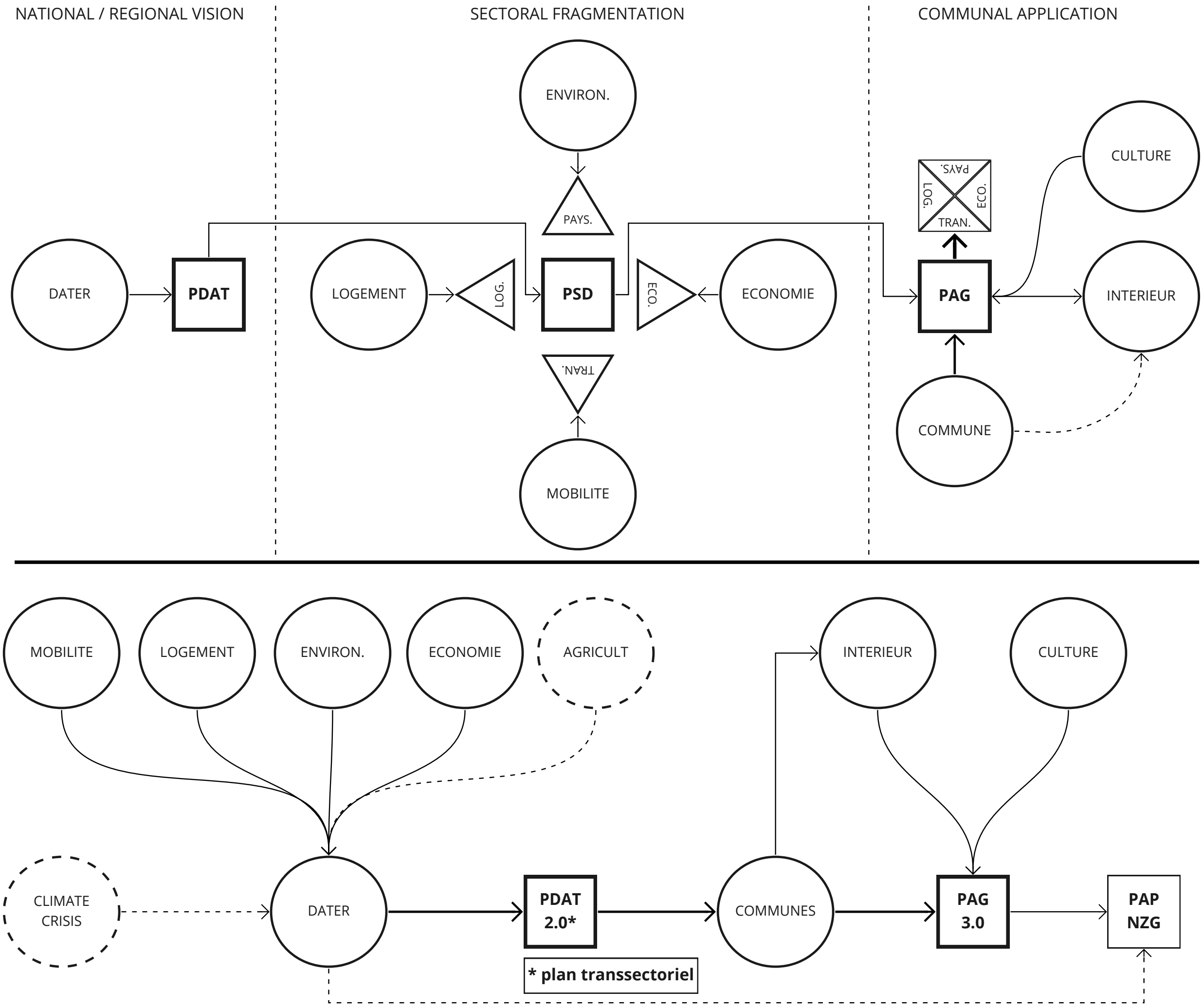


and maintenance cost of public infrastructure (Coubray, 2021).

The dissemination of the single-family home, of the activity zone hangar, of the business park building (...), collaterally provoke the weakening of social coherences and communities within villages and/or neighbourhoods and ultimately lead to the loss of (r)urban and landscape identities.

image 1: Ingeldor, fragmented landtake with reminiscences of agriculture.

## Territory: disassembled through sectoral thinking



Speed and scale of post-war development and growth could seemingly only be met with standardised spasms, from landtake planning to construction methods and products.
These were held together by the least common denominator: the gabarit.

A politically mute and socially acceptable average promoting a complicit horizontal spreading over contextual intensification and public debate.

An imperative re-evaluating of where and how we build, holistically anticipating as much the climate crisis as socio-economic shifts, is therefore not a reactionary but rather a prospective stance aiming for more liveable, durable, context-specific and hence desirable outcomes.

**All you can eat territory**
Luxembourg has the 4th highest landtake rate in Europe (EEA,2019) which represents a land consumption of 0,5 ha per day. (Fourmann and Tholl, 2019) If the built footprint grew from 1,63% to 1,74%, roads and parking spaces flourished at the

***Space requirement according to building type / gabarit: 100m wide strips accommodating 200 inhabitants in 50 apartments respectively single family houses.***

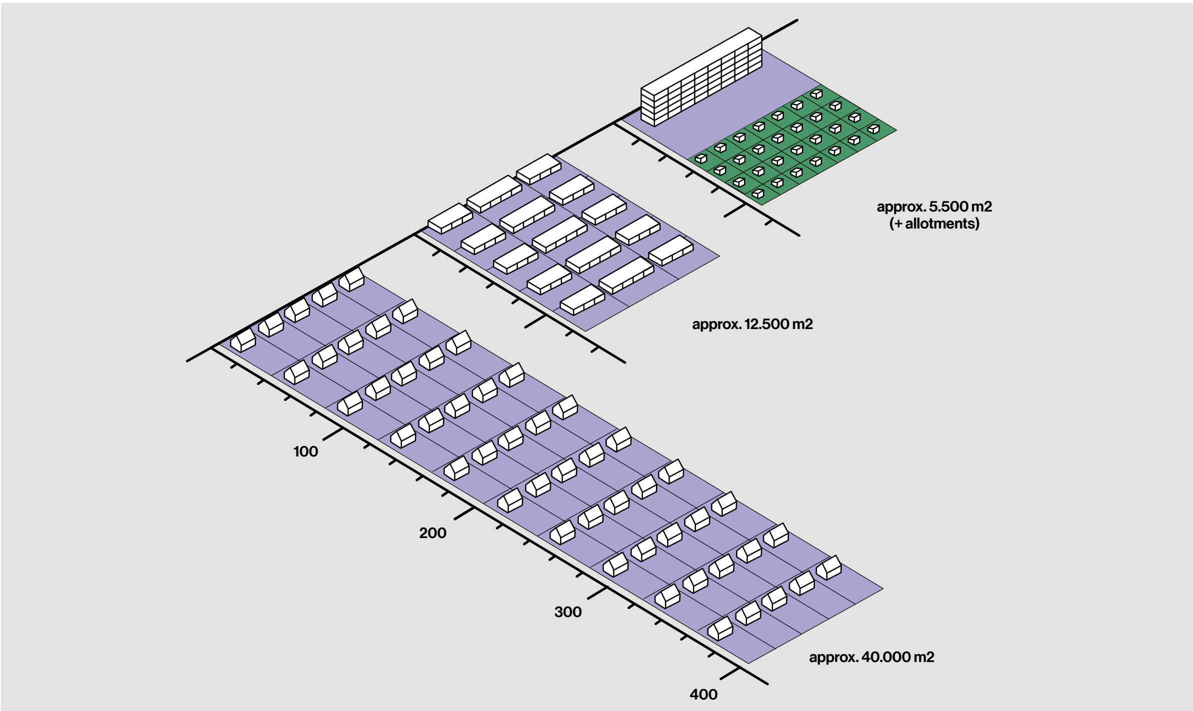



fig. 1: Space requirement according to building type / gabarit

same time from 5,73% to 6,24% of the territory (LISER, 2013), making Luxembourg the most fragmented landscape of the Greater-Region.
By 2020, built surface and infrastructure accounted for 15% of the national territory, up from 8% in 1990.At this rate, the country would be fully covered within the next 350 years. (Fourmann and Tholl, 2019)

**Perimeter Plague**
If over the last fifty years collective housing has steadily grown into becoming the dominant building typology, in 2018 single family houses still accounted for 28% of all buildings , materializing landscape fragmentation and suburbanization(STATEC, 2018). If this housing typology still accounts for 1/3 of buildings, it is because zoning plans, building perimeters and communal politics still promote its dissemination.

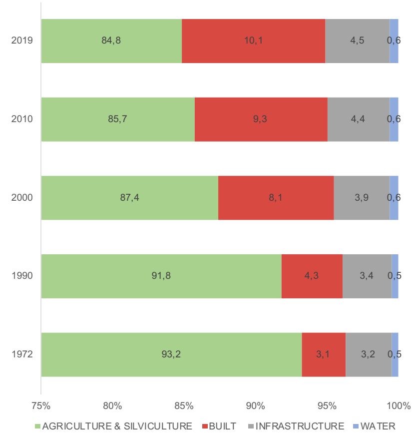


fig. 2

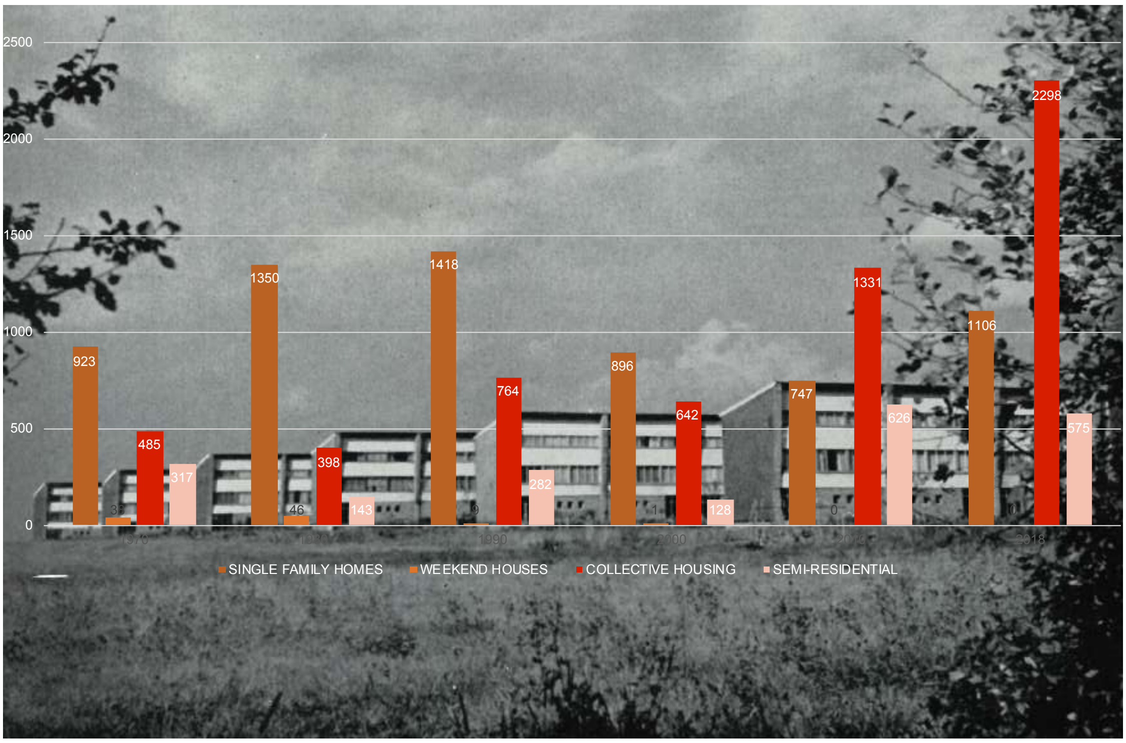


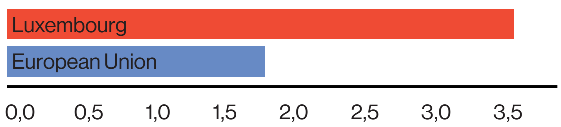
fig. 3: Housing Typologies. Habitations ouvrieres a Esch-sur-Alzette, Cite Eugene Reichling, Architectes Jemp Michels et Robert Lentz

## *Based on what criteria do we choose our buildings' materials and heights?*

**Collateral damage**
Apart from losing the capacity of sequestration (up to 7,5tCO2/ha/year) (Brown et al., 1996) , landtake comes at a high collateral price both for private households as much as for the public realm: The spreading of built tissue imposes the construction and maintenance of infrastructure, from roads to sewer systems. A built heritage which is becoming a structural burden for generations ahead:

In 2016, Luxembourg topped EU government expenditure on transport with 3.7 % of GDP (Eurostat, 2016), while private household expenditure on personal mobility went up from 16,7% in 1999 to 19,2% in 2008 of total spending (EEA, 2011) .
The latter indicates an additional phenomenon: suburbanization and the loss of centrality is followed by the exodus of amenities from rural villages into specialized clusters or more urban areas.
The single-family home thus makes its inhabitants more dependant from mobility and turns village communities into dormitories. It is therefore paramount to revise our communal building codes and zoning plans.

Where villages could once cope with 20 meter high silos or flour mills and the related tractor activity, 4 to 5 floors buildings with activated socles on sealed land could reanimate town centres, both economically and socially.




a fragmented territory demands mobility:
expenditure on transport % GDP

image 2: a tale of 2 scales. Zettinger Mill, Bettendorf.

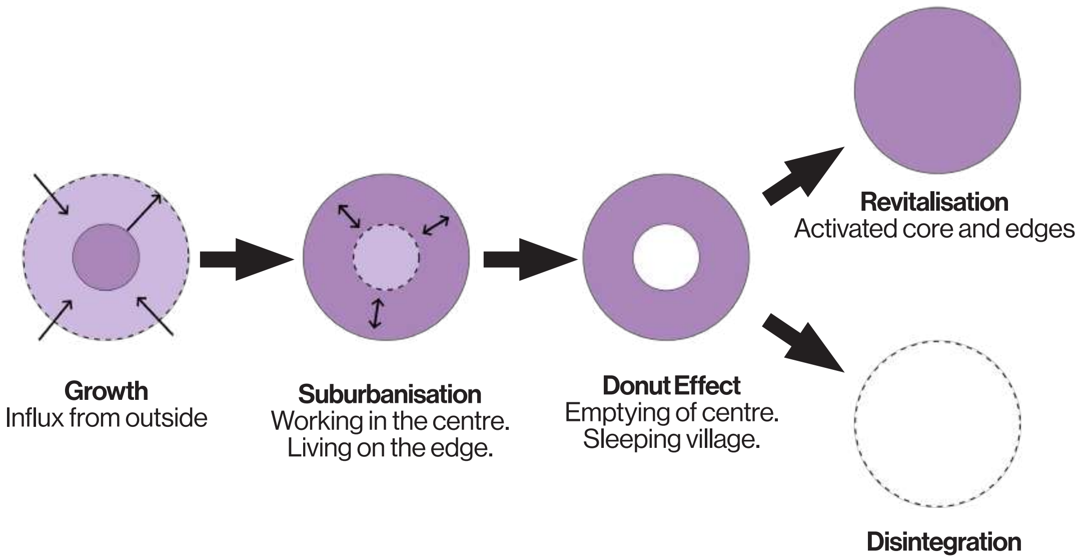
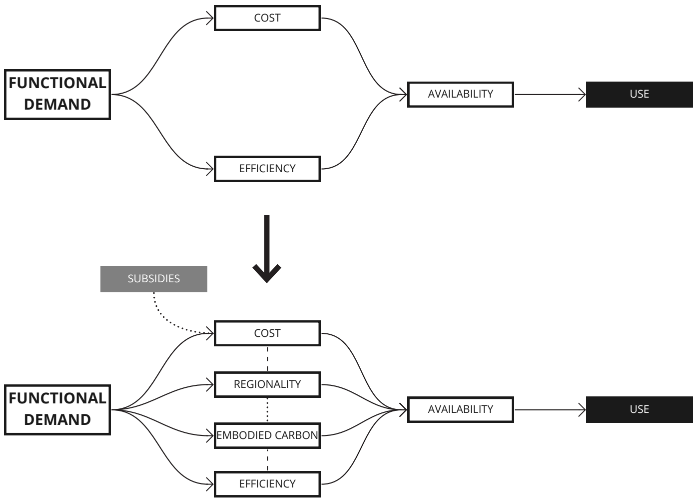



fig. 4: The Donut Effect

**Low-to-no CCC**
If today material components are chosen by efficiency, cost and availability, embodied carbon and regionality must play a role in tomorrow's choices: on a mere 230m2 façade, the choice of insulation can make a difference of up to 14t of CO2.
In fine, these new factors will not only support the fight for carbon neutrality, but also promote regional value-chains and thus the socio-economic resilience of the territory.
In order to kickstart the production, processing and distribution of low-to-no carbon construction components, government funding is however required in a transition phase.




New considerations in the decision making process will promote regional low-to-no carbon components.

**Re-transition**
From garrisons for soldiers over mass housing for industry workers to massive development of office space for the finance sector, Luxembourg has a past of pragmatically answering the challenges at hand, both with speed and scale.

Beyond the quantitative challenge of the current housing crisis, transition and the looming climate crisis should therefore serve as qualitative benchmark to redefine our planning and building culture, as a key to overcome the status quo of our habits and the burden of our tastes.

image 3: Terres-rouges: heavy industry, social housing, infrastructure & productive gardens in a single space.

# Structural change:
# From local stones to concrete blocks and back.

Exploiting what the land could offer, pre-industrial buildings in Luxembourg were traditionally made from local stone. The masonry, its size and colour, would hence depend on the regional soil specificities: from the reddish Minette sandstone to the Gutland beige limestone to the Oesling black slate (Restauration Sites et monuments nationaux Luxembourg, 2016).
With the industrialisation and demographic growth came a transition to concrete bricks then blocks. The latter is today still the prevailing material of choice for structural work.

« making steel and concrete, two of the most common building materials, generates around 8% of the world's anthropogenic carbon-dioxide emissions. If cities are to expand and become greener at the same time, they will have to be made from something else » (The Economist, 2021).

If cement production, one of the few remaining industrial activities in Luxembourg, is currently investing in remedies against its disastrous carbon footprint, market ready adaptations and solutions might not be ready soon enough.

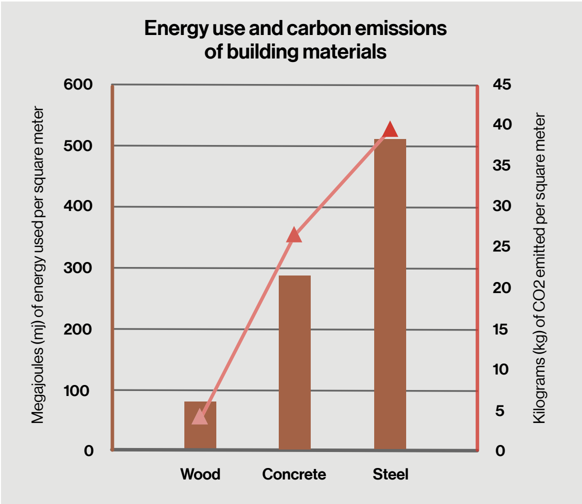
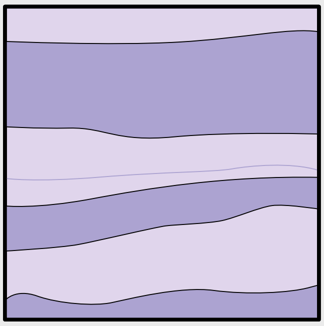


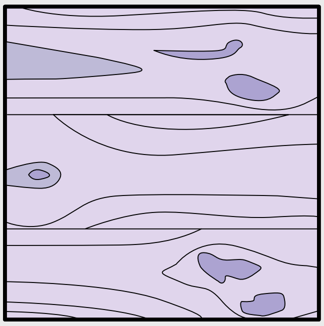

fig. 5: Energy use and carbon emission of building materials

image 4: Looking at 2 resources CIMALUX Rumelange, 2019

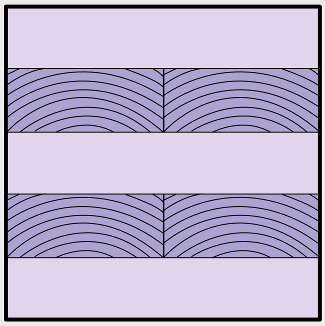
## The relative carbon emissions of different materials



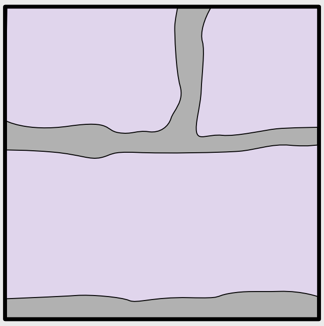
**Rammed Earth**
48 kgCO2e/m3
Ranges from 40 to 170 kgCO2e/m3



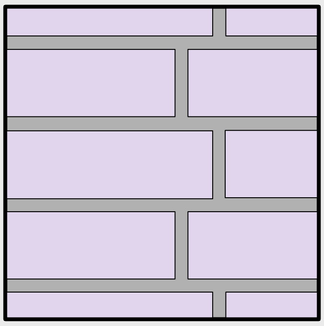
**Softwood Timber**
110 kgCO2e/m3
Ranges from 1 to 480 kgCO2e/m3



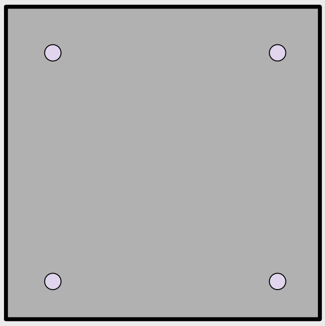
**CLT**
219 kgCO2e/m3
Ranges from 160 to1,370 kgCO2e/m3



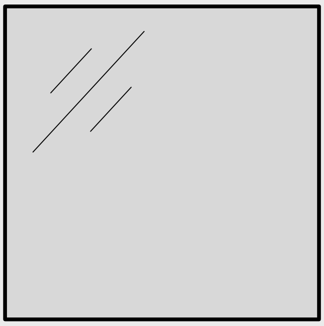
**Stone - 1950's**
237 kgCO2e/m3
Ranges from 60 to 2,100 kgCO2e/m3



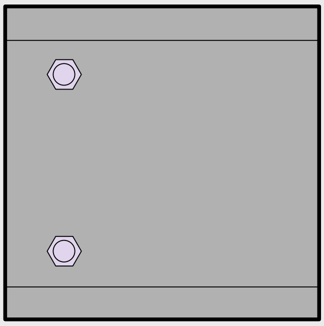
**Clay Brick Wall 1950's - 1970's**
345 kgCO2e/m3
Ranges from 260 to 1,100 kgCO2e/m3



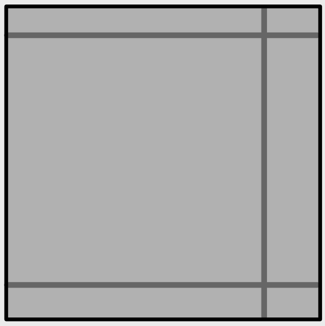
**Reinforced Concrete 1970's - now**
635 kgCO2e/m3
Ranges from 120 to1,370 kgCO2e/m3



**Glass**
3,600 kgCO2e/m3
Ranges from 2,300 to 5,100 kgCO2e/m3



**Steel Section**
12,090 kgCO2e/m3
Ranges from 7,600 to 28,000 kgCO2e/m3



**Aluminium**
18,009 kgCO2e/m3
Ranges from 2,400 to 58,000 kgCO2e/m3

fig. 5

Estimations have shown that regional forest capacity could provide the necessary harvests of timber for the current building demand (of housing).

Furthermore, local building typologies, which are rather low- to mid-rise, could easily be built from engineered timber.

However, this implies massive investment in value-chains and especially regional and local processing of wood, a sector still under-developed in Luxembourg.
A parallel lead are soil-based materials.

image 5: upgrading a 1970's concrete building with a wood construction, 2001.

***« A family-sized apartment requires about 30 cubic metres of timber, and Dr Ramage estimates Europe's sustainable forests alone grow that amount every seven seconds ». (The Economist, 2021)***

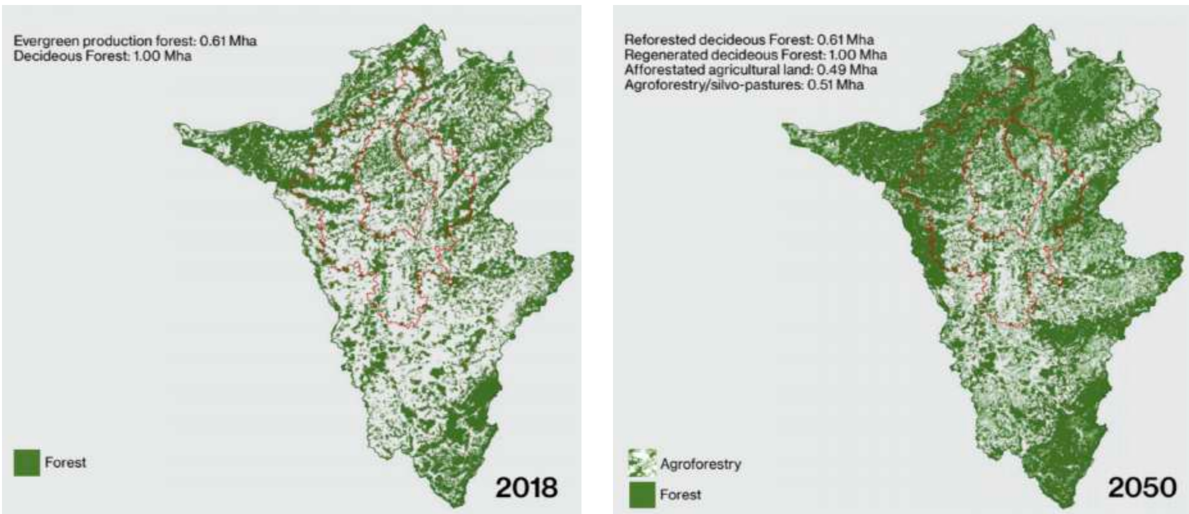



fig. 6

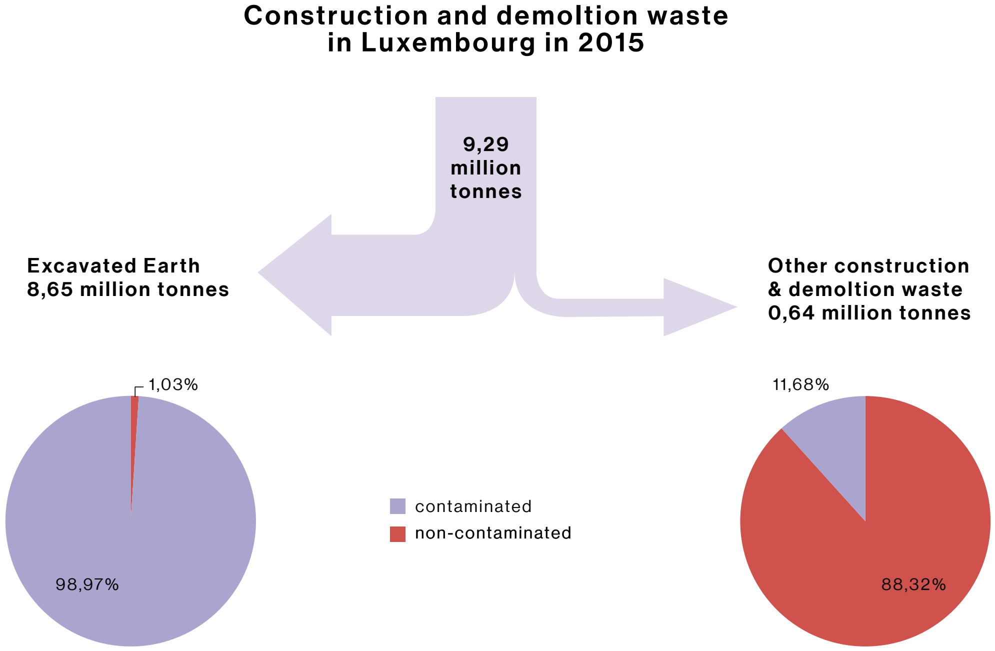



fig. 7: Construction and demolition waste form the biggest part of the overall waste.
Re-using excavated earth and demolition waste is not only valuable for the environment but also for the economy.

Facing a lack of national landfill sites, earthworks for underground spaces and even foundations have become costly and generate massive truck traffic (Construction: Le Luxembourg manque de décharges pour déchets inertes, 2020). These soils can however be locally processed into construction-ready bricks and blocks, by compressing the excavated earth into moulds (images 6,7,8).

images 6,7,8: Geobloc

# Flesh & skin of architecture.
# Back to material and immaterial heritage.

Regional building culture, marked by successive waves of migration and hence by a shifting influx of various know-hows, thrived nonetheless on a tradition of the “crépis”: the outside application of a protective mineral layer on the structural masonry.

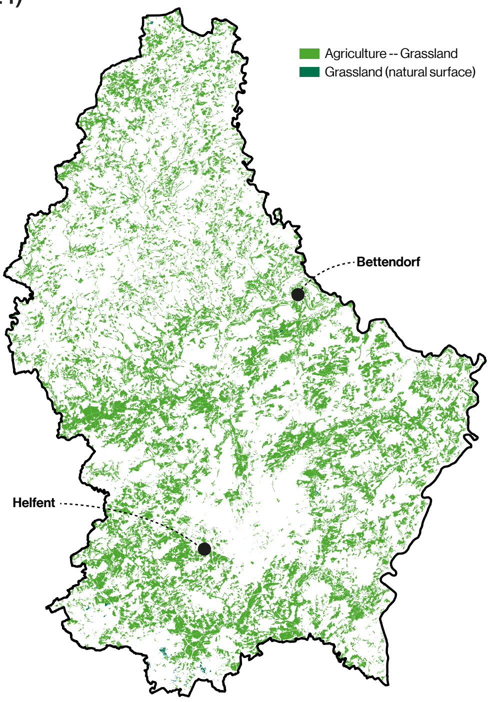
If before industrialization these renders were, just as the structural masonry of local stones, soil based and thus mostly site specific, the applied products became ever more standardized and generic and eventually induced the loss of techniques and so of this heritage itself.

For the last 40 years the industrialized products dominated both the market and architectural expression, for economic reasons but above-all lack of available alternatives.
The appearance, then ageing, maintenance, repair and eventually replacement of these products and insulating systems start to raise questions however (F.A.S., 2014) .

If structural elements will in the future mainly be soured from the forestry sector, insulation could become a key by-product of agriculture.

**new flesh: grass insulation**

Trading cows for a light industrial process of harvesting, drying, compressing and cutting insulating panels from grass, Luxembourg’s dominating landscape characteristic of pastures could fully be exploited. (Gramitherm, 2021)
A second agricultural by-product could be the planting and processing of hemp on fields, replacing animal fodder.  (Vicarius Canna, 2021)



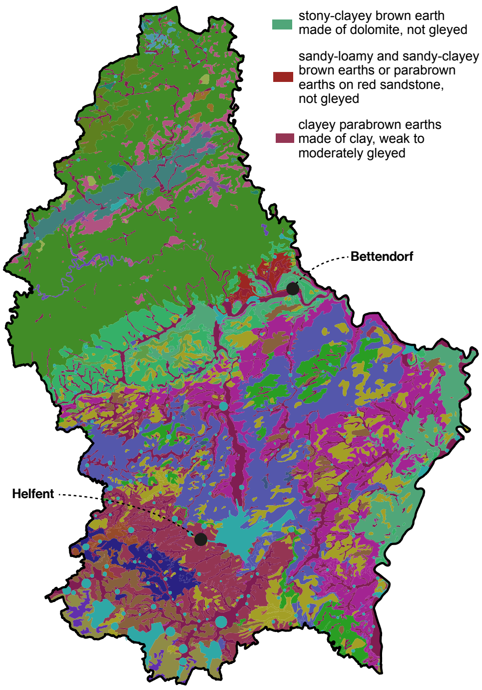

Grassland map of Luxembourg: growing thermal insulation

image 9: pasture to insulation

image 10: pasture to construction

**new skin: soil based render**

The outside protective layer for the insulation could then come directly from the construction site itself, by upcycling the earthworks into external plaster (BC materials, 2021), ultimately providing each building with a plot specific expression.

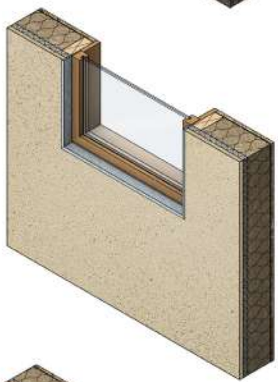



Soil map of Luxembourg: diversity underground

image 11: original facade of listed house on the Moselle

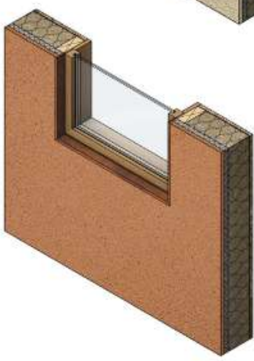
**Eislek**

**Sauer**



**Minett**

images 12, 13,14.



# Toward common grounds: Grand shared landscapes over mediocre private gardens.

The traditional Luxembourgish conception of housing implies an intimate link to the ground on which it is erected.

Only recently concepts like long lease or emphyteusis, uncoupling property of the built from its ground, have become more popular and applied (Thomas, 2020). Nevertheless, private outside space remained until today a lifestyle expectation for many citizens.

In order to preserve unsealed land and yet be able to accommodate a growing population, less land-intensive building typologies are needed:
studies have shown that 4-5 level buildings liberate proportionally the biggest surface.

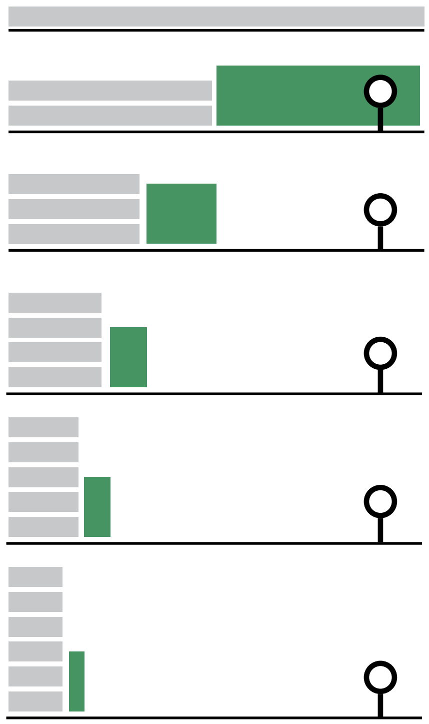
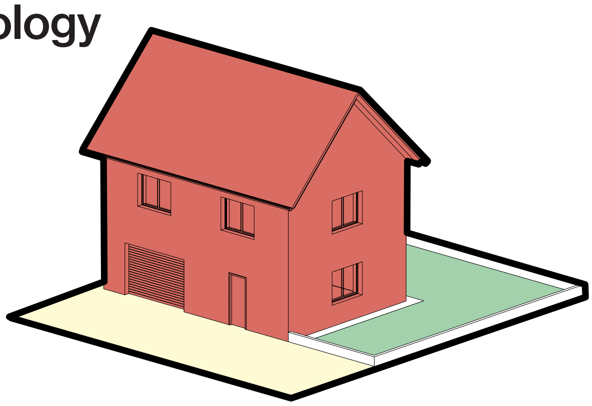


fig.8: Built typologies and additional outside space.

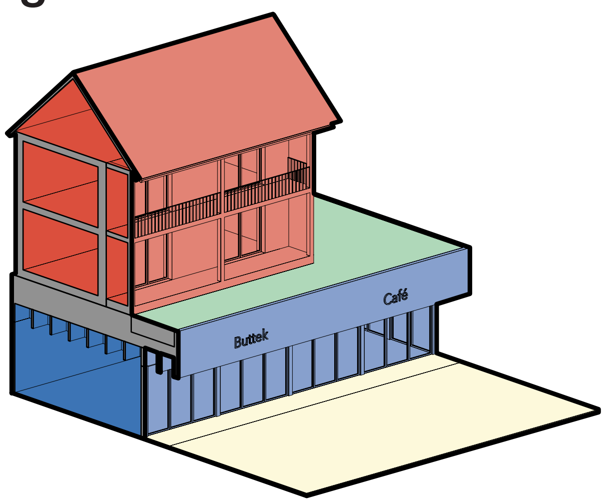
## Single-family House Typology

1106 units built in 2019
typical requirements:
-≥6meter width
-setback front & sides
- front yard ≥ 6meter, fully or ≤50% sealed
-≤2,8 floors
-≤ 1 household
-exclusively housing

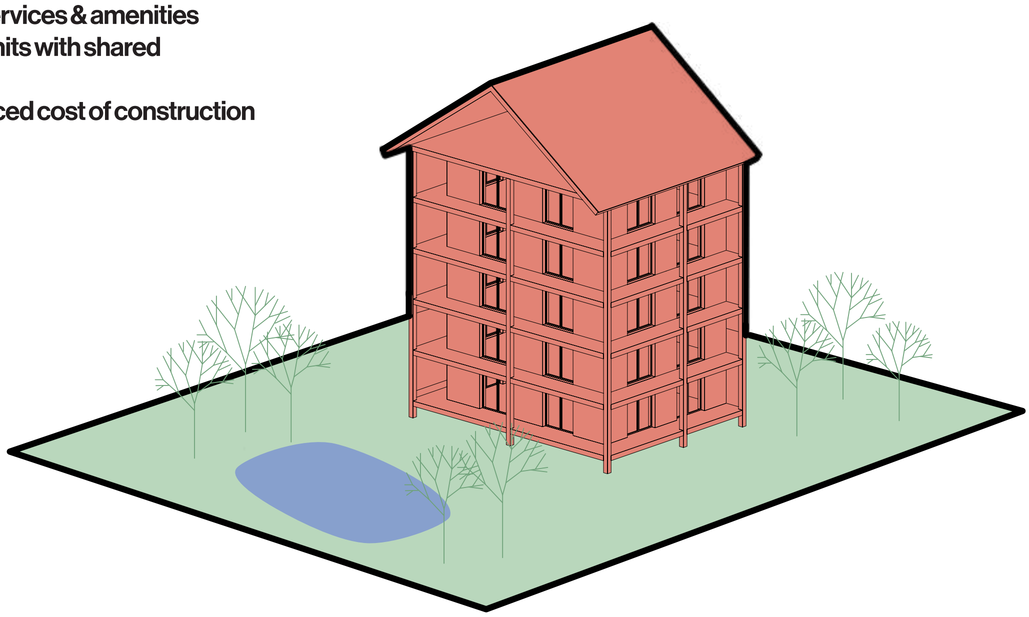


## Resilient Rurality© Typologies

to replace barns & sealed surfaces:
-Mixed use
- economic / light industrial / agro-forestry processing in socle
- 2-3 floors housing on deck/roof




4-5 floors collective housing
- critical mass for services & amenities
- smaller housing units with shared amenities
- affordability: reduced cost of construction & maintenance




With the rise of millennials as new residents, space rather than commodities will need to be facilitated for behavioural shifts like the advent of the sharing economy;

"(...) the focus lies on the sharing of underutilised assets, regardless of whether such assets are monetised or not or whether they are mediated through a platform or not. This concept is therefore closely linked to the wider aims of 'resource efficiency', 'sustainability' and 'community'." (Fink et al., 2018)

This resource efficient attitude permits punctual densification while thoroughly safeguarding unbuilt landscape. These spaces, which will come to be understood as a common good in their role of carbon sequestration, food production, channels for urban cooling or social platforms, will play a key role in village and neighbourhood structures of tomorrow.

The historical right of gleaning* can potentially merge with this new understanding and highlight its importance for social resilience of tomorrow's towns.

***"In the Sharing Economy, the redistribution of product usage means extracting higher value from fewer resources. This leads to an increase in aggregate efficiency and productivity. (...)***

*The Sharing Economy is changing the way we organize economic life, offering the possibility of dramatically narrowing the income divide, democratizing the global economy, and creating a more ecologically sustainable society. ” (Rifkin, 2015)*


fig. 9: Generational will to share and image 15: The  Gleaners

*Gleaning is the act of collecting leftover crops from farmers’ fields after they have been commercially harvested or on fields where it is not economically profitable to harvest. It is a practice described in the Hebrew Bible that became a legally enforced entitlement of the poor in a number of Christian kingdoms.  (Wikipedia)

# The fat of the land*
# A prospect for new local economic and material value-chains.

One of the transitions our civilization will witness is the socio-economic shift of labour induced by AI, robotics and automation (European Union, 2017).

New economic sectors and activities, associated and anchored with local resources, demands and needs, must therefore be developed.
Furthermore, the current cost of labour imbalance which is preventing for instance more vegetable planting and harvesting, could today already be addressed as a sector of social inclusion: by training (climate) refugees and offering relevant jobs, a transitory win-win situation can be developed in the shape of contributory territories:

**“The digital is a ‘pharmakon’ which, in order to become therapeutic for a territory instead of toxic, requires that new knowledges and new dynamics are cultivated there. In this regard, the attraction a territory holds for investors is increasingly related to what Amartya Sen calls the capacitation of its inhabitants, their sharing of values and mutual support, all of which constitutes a reflective social milieu, which is to say a critical space, much more than a ‘smart city” (Crogan, 2014).**

The shifts of planning and building culture required to face the climate crisis, will reinforce the agro-forestry sector while necessitating new economic setups and material value-chains.
While regional landscape capacities suffice both for feeding a growing population, capable of adapting its diet, and producing the necessary material for building this population’s housing, the industrial complex necessary for processing these resources is however underdeveloped.
If for new high-protein crops like soy the region is lacking any roasting facility, the wood cluster is in dire need for saw mills, laminating or fibre processing plants.

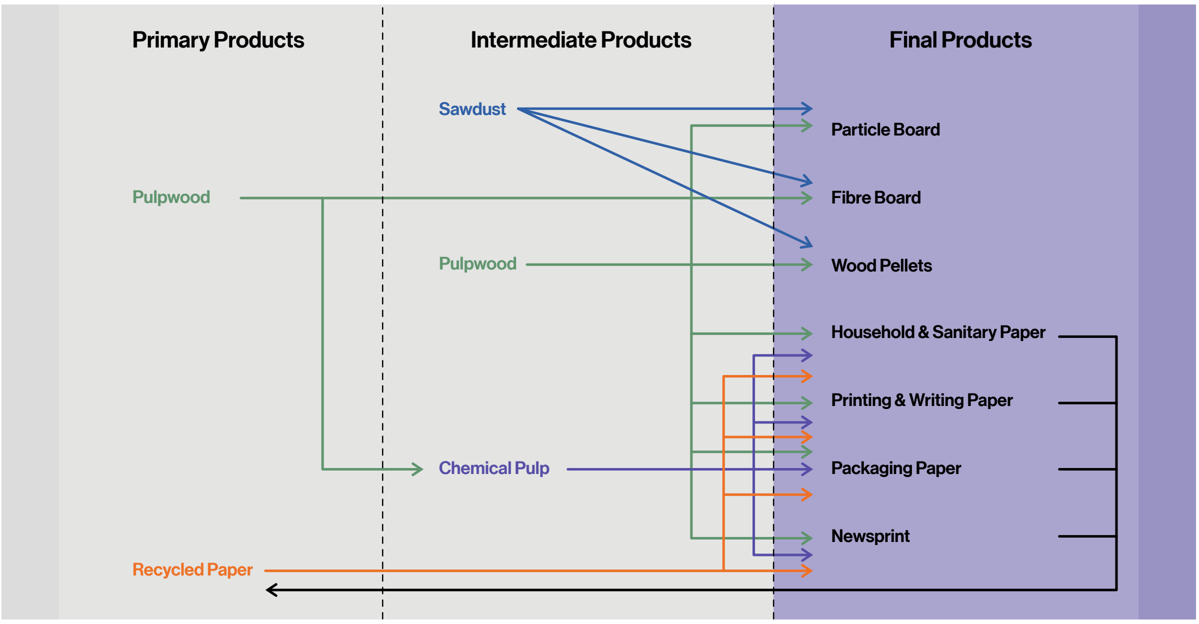



fig. 10: Towards a Timber Bonanza
*Genesis (45:18)

***"The current industrial revolution will change many things, as is already happening. But the qualitative difference this time is that it is not simply physical work that is being replaced by machines, some of the 'intellectual' work in the service sector is being replaced by artificial intelligence too."***

Mady Delvaux-Stehres, (Touchy about Technology: Jobs and the Challenge for the Left, 2019)

Hundred years ago, Minette could be extracted and locally processed into iron. It would ultimately lead to the region's wealth.

Today the same region needs to develop the networks and infrastructure to process its renewable resources and insure future abundance.

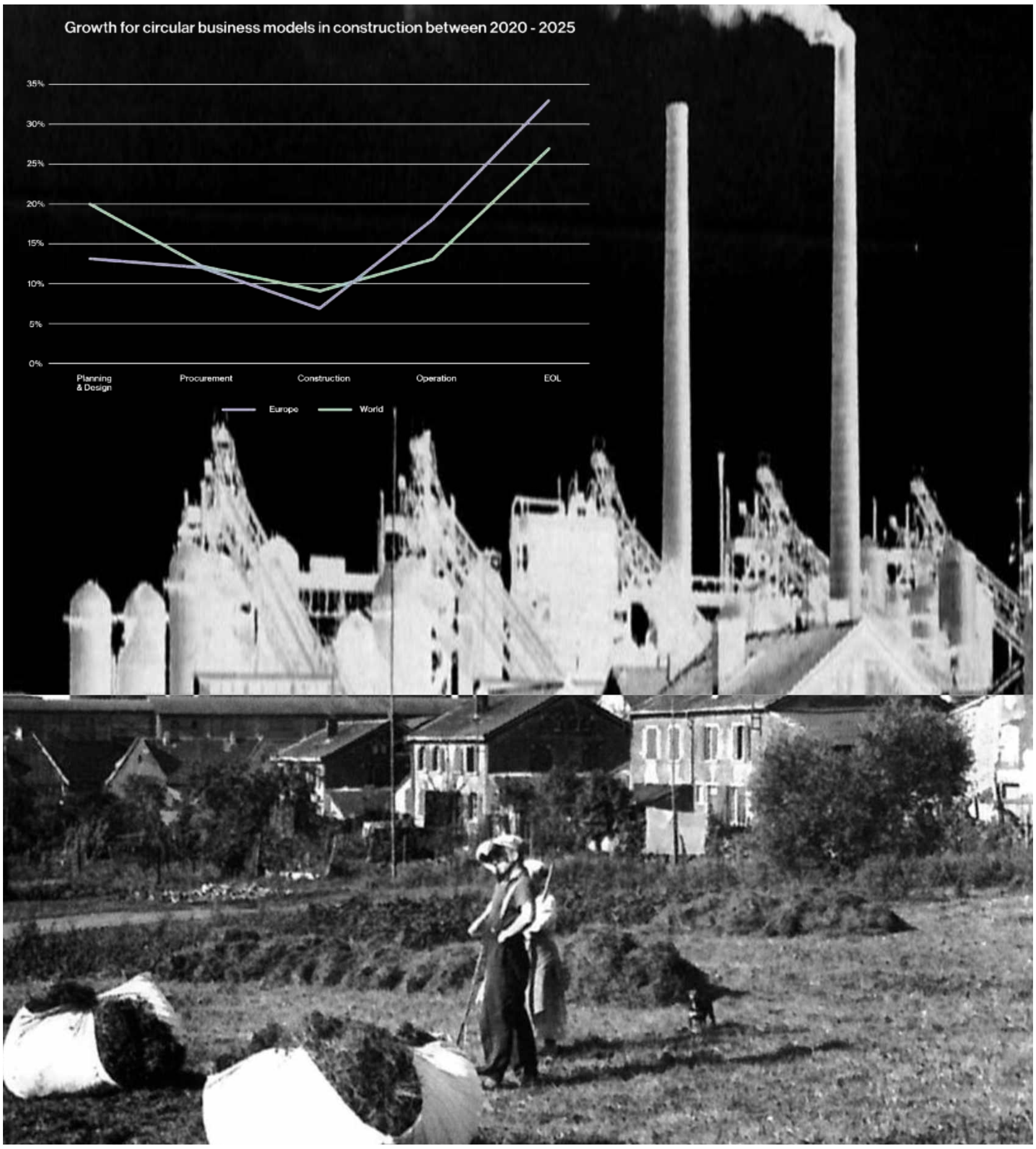



fig. 11 and image 16: Back to the future: reverse transition
picture of Terres-Rouges, Esch-Alzette, from: Archives Nationales, Histoire de la sidérurgie

# Found in Transition
# How the imperatives of the transition can foster (r)urban identities.

**Overcoming the status-quo**

Protecting unsealed land in order to exploit its full sequestration and/or production potential can help to overcome the current status-quo of average planning and building reflexes which are in fine dissolving urban structures at the cost of communities.

The objective of zero landtake imposes the development of daring yet appropriate planning approaches resulting in specific built applications.

Three studies (LISER, 2021) recently revealed that “there is enough potential land for accommodation in Luxembourg”(Heindrichs, 2021). To solve the equation, underused capacities of already sealed land need to be identified, mobilized and activated, in a transitory time by tools like Transferable Development Rights, TDR.

These neglected potentials sit either within urban tissues, where they are already being monitored by Baulücken programmes (GGDL, 2016), or also and foremost in suburban / peripheral and rural contexts (LISER, 2021).

In the latter two, by overcoming sectoral specialization and fragmentation, underused spatial potential can become a key asset in strengthening and/or fostering (r)urban identities.

2 case studies serve as epitomes symptomatic for the region beyond its small-city urban conditions:

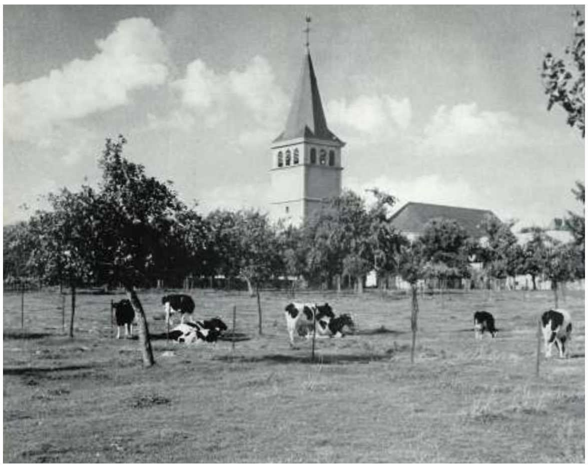
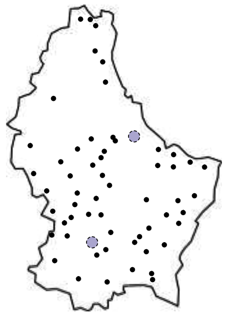
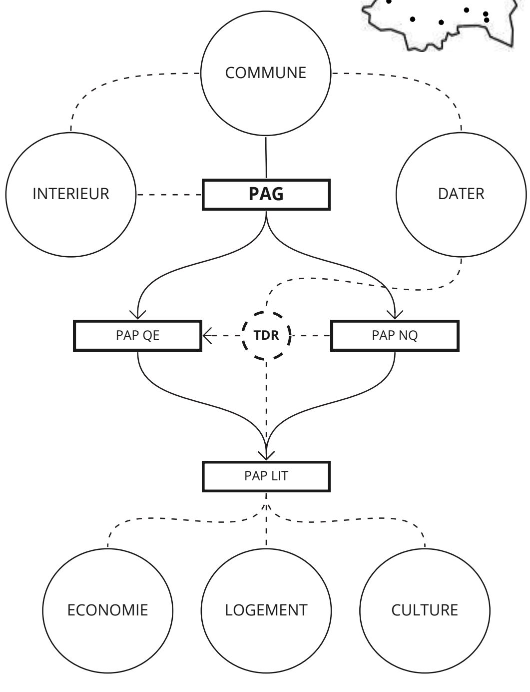


image 17: Berdorf after WWII: hybrid function of the church and water tower. Silvopastures with cattle in the foreground.

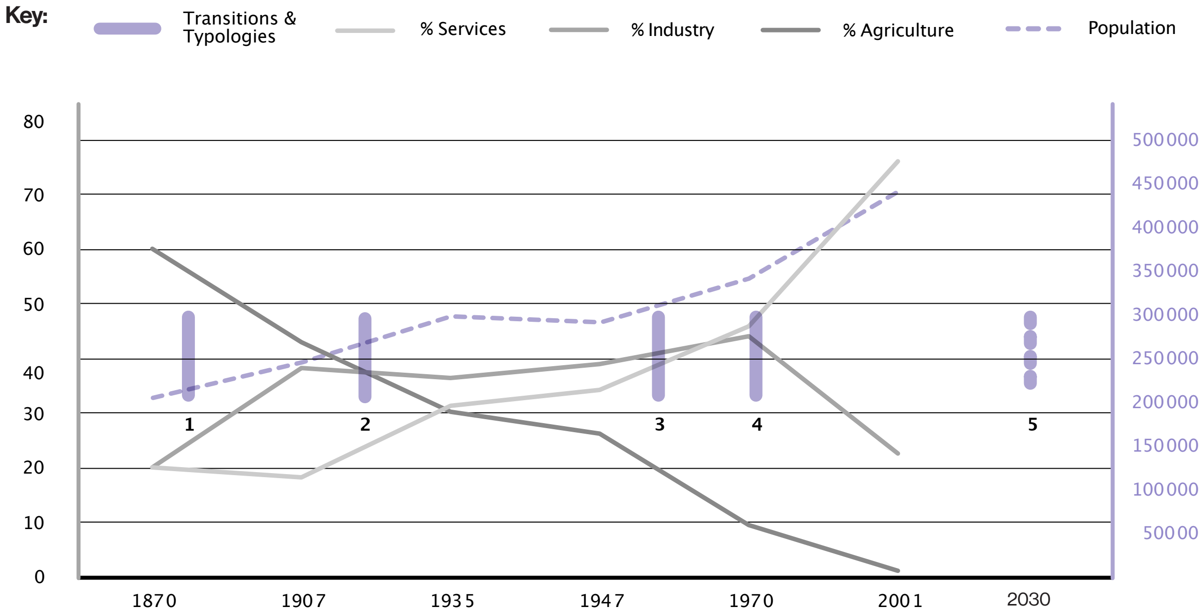






Flowchart showing the transition from the current PAG and PAP to TDR and the LiT PAP.

# A brief history of typological transitions

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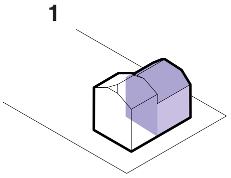

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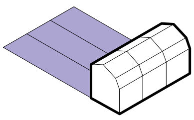

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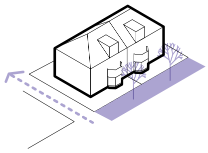

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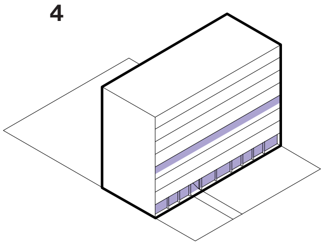

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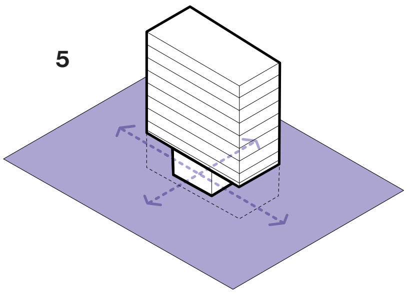


1
late 19th ct.

Farmhouse & barn as local processing & storing architecture

2
early 20th ct.

Workers' houses with private gardens

3
Post WWII

Detached family houses

4
1970s

Collective housing & apartments

5
2050

Minimal footprint collective housing: augmented housing experiences through compression of private dwelling surfaces compensated by upgraded shared amenities and available facilities

# Sampling: Suburbia

Helfent, an area of the Bertrange commune on the fringe of an approaching Luxembourg-city, is an epitome for peripheral, suburban conditions, neatly collaging drive-in nine-to-five big-box economic zones and suburban housing along inter-modal infrastructure and onto residual landscapes composed by fragments of agriculture and leisure.

It is in areas like these, that the stigmata of sectoral planning are blatantly unveiled: zones framed by water management ditches or similar infrastructure become oases of mono-functional purity.

If the single-floor hall surrounded by surface parking dominates economic and activity zones and the two to three level single- or bi-family house most of the dwelling zones, both follow the planning principle of grabbing land from agriculture or leisure landscapes.
Yet both the presence of dense networks of inter-modal infrastructure and the proximity to major urban centres as much as to lush landscapes could turn areas like Helfent into well connected and lively neighbourhoods. In fine, these peripheral satellites would compose a living necklace of housing, production and leisure landscapes.
Rather than fragmenting the territory in specialized zones, transition thinking shall serve as mediator and platform to foster cross-sectoral political alliances and functional synergies, turning the monofunctional archipelago islands into diverse 24/7 15' neighbourhoods.

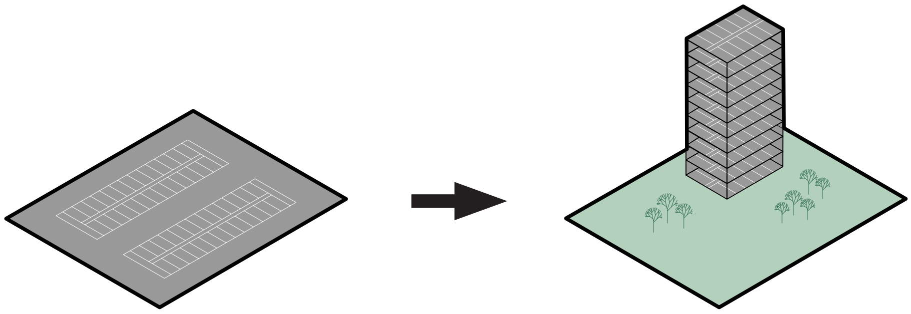
**Reclaiming sealed surfaces**

Surface parking will be freed by compacting vehicles into vertical, retrofittable structures. The reclaimed sealed land can thus be developed: mid-rise engineered timber towers will provide diverse dwelling types benefiting from views over- and immediate access to- the safeguarded landscape.
Various socle conditions can fuse housing, economic and industrial activity with landscape interaction.

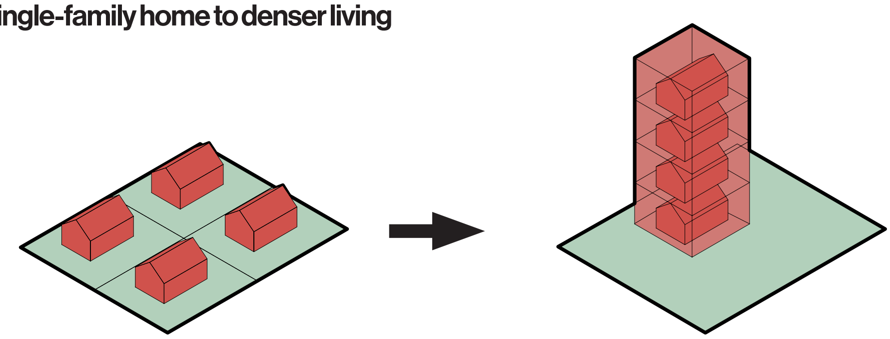
***approx. 1.792 ha of Helfent epitomes can be found across Luxembourg***

image 18: infrastructure, environment,economy: political and spatial fragments

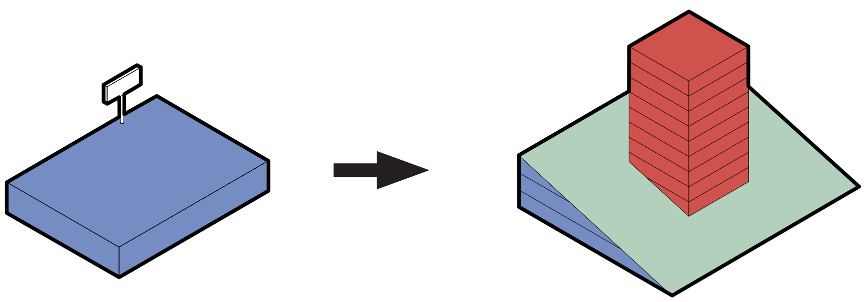
1. **Reclaiming sealed surfaces**



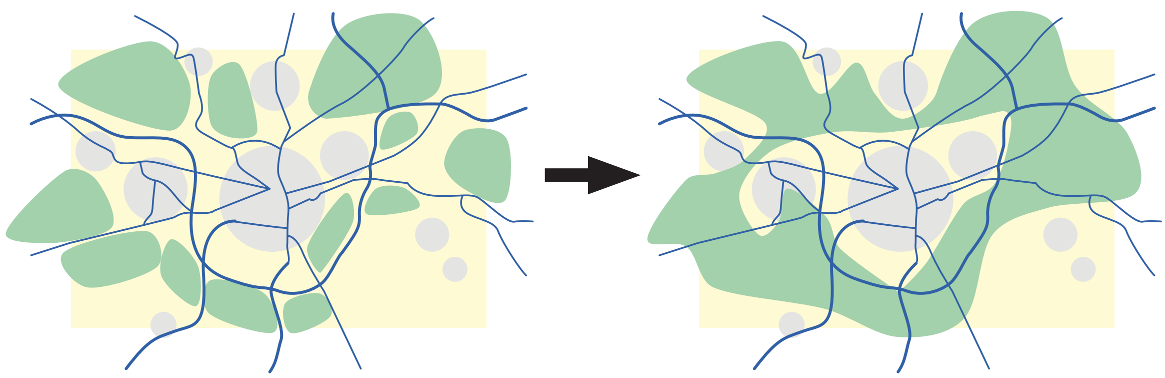
2. **From the single-family home to denser living**



3. **From a monofunctional archipelago to a cross-sectoral neighbourhood**



4. **A living necklace of housing, production and leisure landscapes**



# Sampling: Ruralia

Representative for a majority of the regional territory, Bettendorf highlights several dilemmas and challenges which rural towns are chronically facing: economic and social shifts following the decline of small to medium farms and local craftsmanship, the explosion of a concentric village structure into diffuse suburban developments, the loss of services, social structures and ultimately identity.

“In the EU, the share of the agriculture, forestry and fishery sector in rural regions’ employment went from 21% to 12%. between 2000 and 2018.The share of industry and construction remained practically unchanged, while the share of services increased by almost 10 percentage points (pp”)(European Commission, 2021).

Nevertheless, by identifying an existential need for productive landscapes and progressive agro-forestry in order to cope with the climate crisis, the transition holds the potential to strengthen rural village structures and infuse new economic and social potential into the vernacular.

This mindset will promote the compaction and intensification of concentric village structures, beneficial and crucial for community life.
Rural village centres are increasingly marked by abandoned farms, leftover plots and out-of-use barns.

“Over the last 30 years, the national agriculture sector has shrunk significantly, with almost half of all businesses having disappeared since the 1990s” (Agriculture: Farmers organisation laments shrinking of the sector, 2021).
Beyond historic preservation and restoration, specifically barns represent a spatial capacity for re-development through their big sealed footprint.

Hybrids made of productive groundfloors integrating agro-forestry processing and/or services and housing on top will provide space for emerging industries as much as for generous dwelling conditions, and will intensify rural communities.

Moving from 1,5 to 4 level buildings will not only compensate the theoretical PAG development rights, but will strengthen the vernacular-built substance through a resolutely contemporary yet context-specific architecture. These new typologies will thus generate the critical mass and proximity of citizens necessary to maintain a village community, to be clients, patients, entrepreneurs.

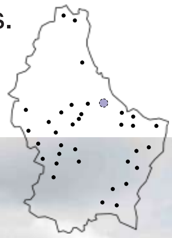
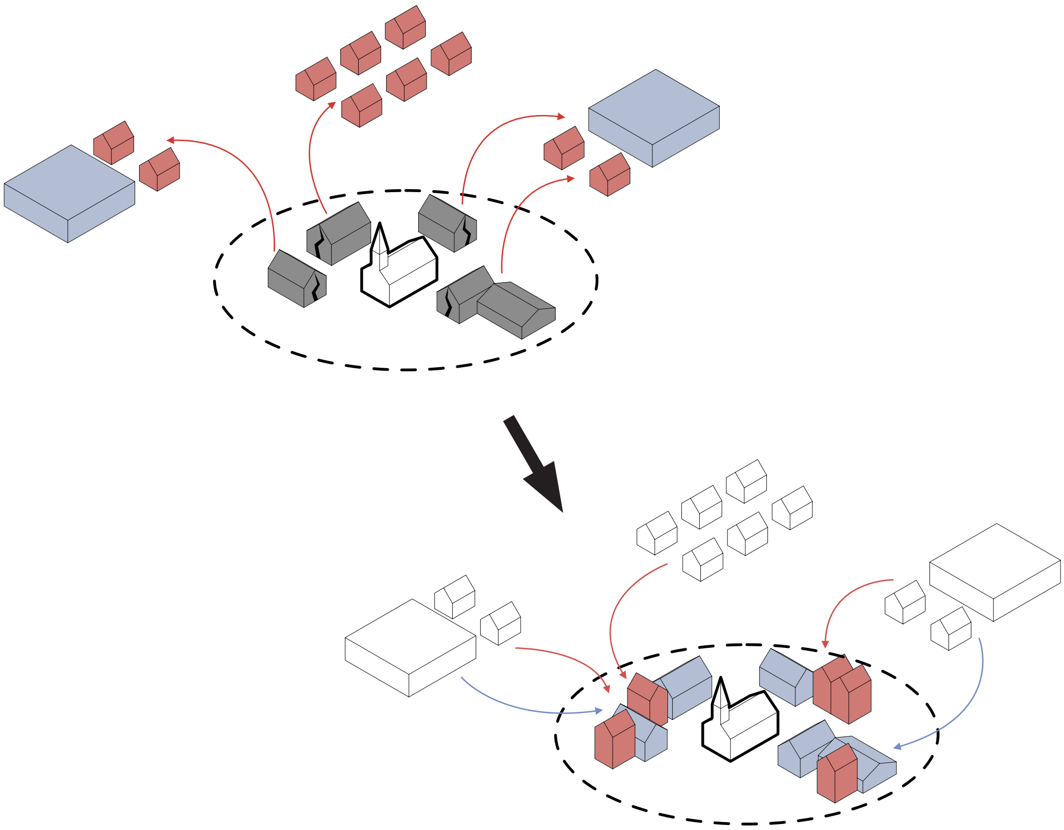


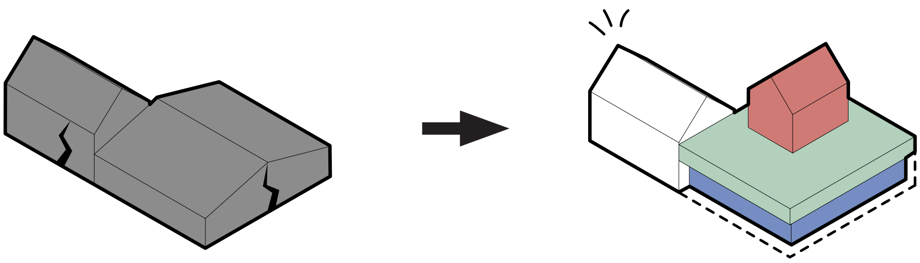
image 19: the village slowly eating up farm land, the church leaves town

# *approx. 2.619 ha of Bettendorf epitomes can be found across Luxembourg*

**1. From diffuse suburban developments to a concentric village structure**



**2. Transitioning towards a new identity by respecting the local context**



*“Within the construction sector, In contrast to our clear targets for reducing the emissions by 2030, we have very little data on our current emissions, including indirect emissions arising from material and component production. The first step is to define a systematic standard approach in collecting and measuring data across public and private efforts.”*

Paul Schosseler
Director Sustainable Construction and Ci
Ministry of Energy and Spatial Planning, Lu

ircular Economy
uxembourg

# Outtake 1:
# Transitioning to more sustainable economies.

## Europe's cost reduction by 2030: Moving to a circular economy.

*Annual total cost of producing and using primary resources, EU-27, € trillion*

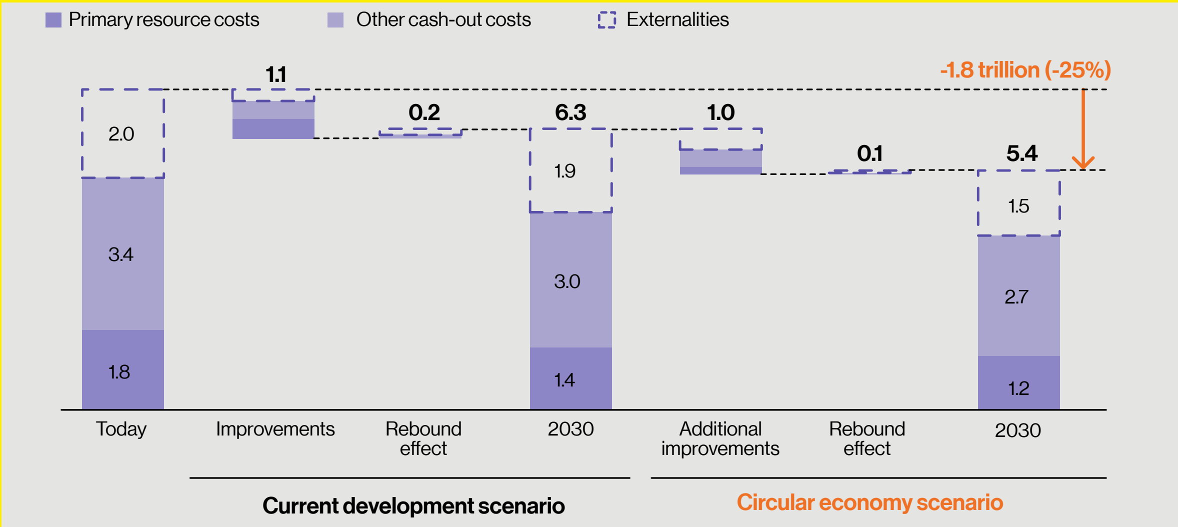



fig. 12

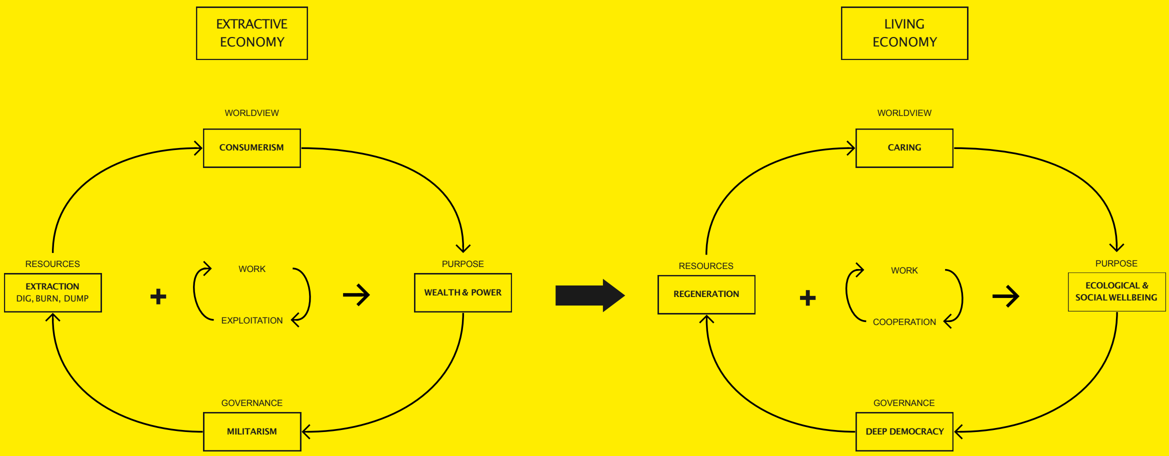



fig. 13: Just Transition Diagram: How to transition in a fair way from an extractive to a living economy.

**500.000**

***new jobs could be created in the UK through the transition to a more resource efficient circular economy.***

(ACAN,2021: 33)

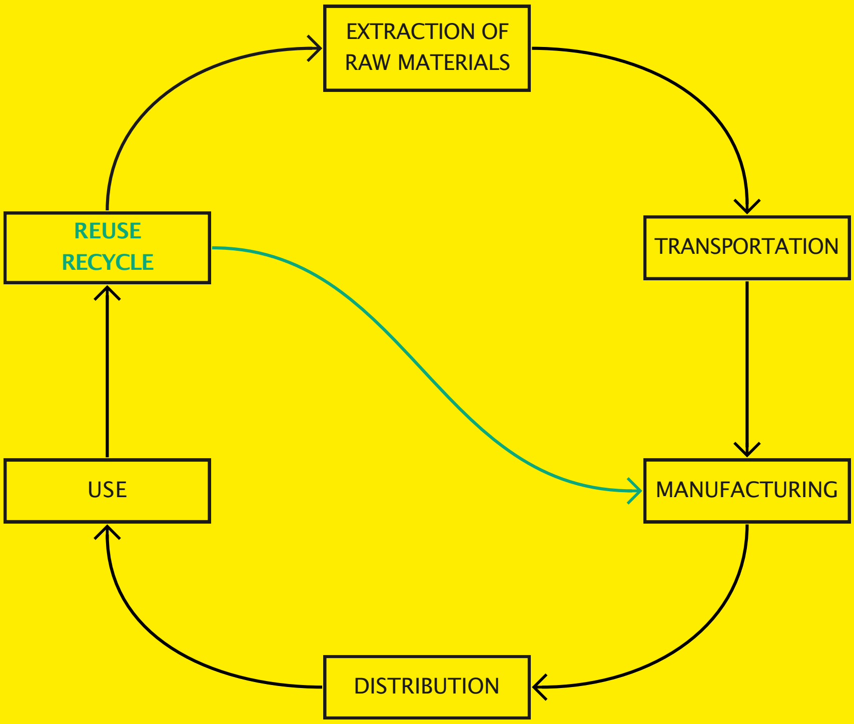



fig. 14: Cradle to cradle diagram.

***“Whole new industries will be created and existing industries transformed as we move towards a low carbon, more resource efficient economy***

UK Government: Industrial Strategy. (2017). Reed Business Education.

# Outtake 2: Carbon emissions in construction.

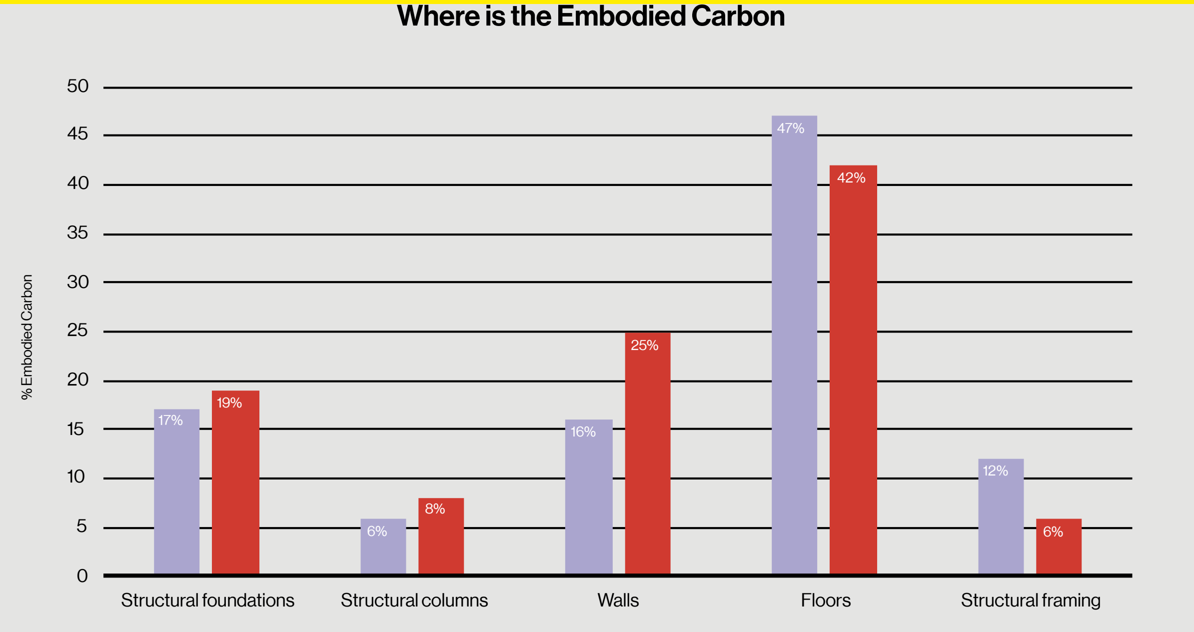



fig. 15: Independent of the type of building, the floors are always responsible for the highest embodied carbon.

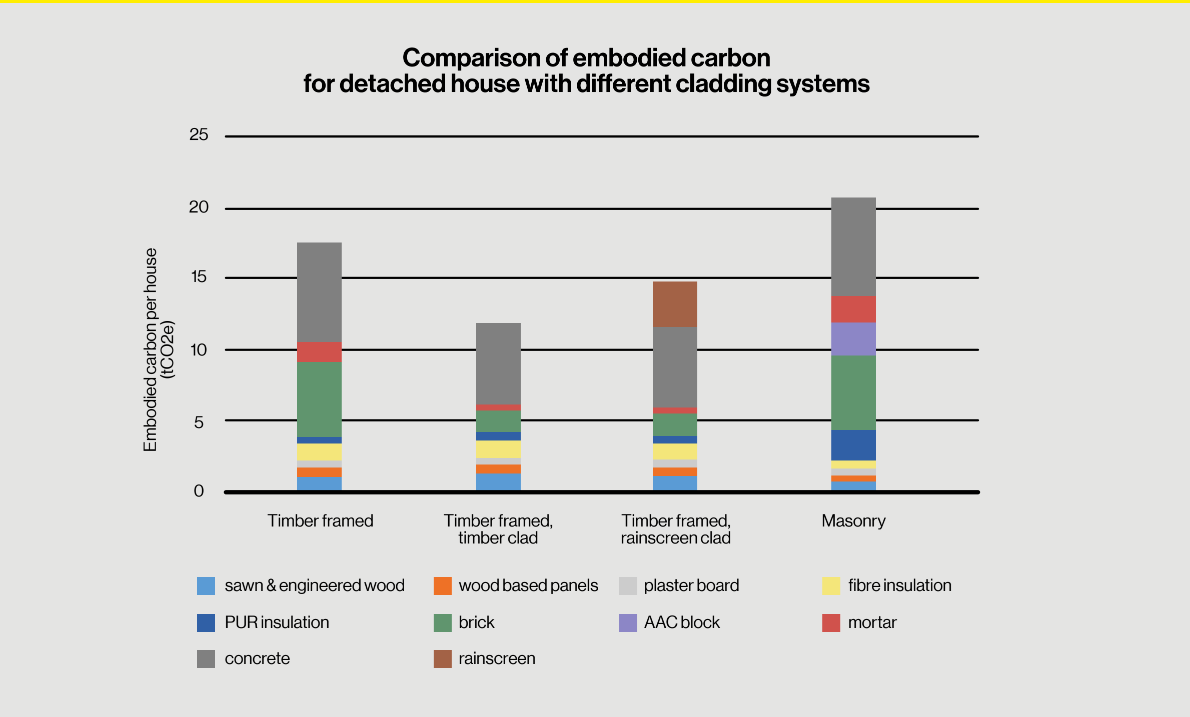



fig. 16: The increase of embodied carbon is usually directly linked to the use of concrete and brick.

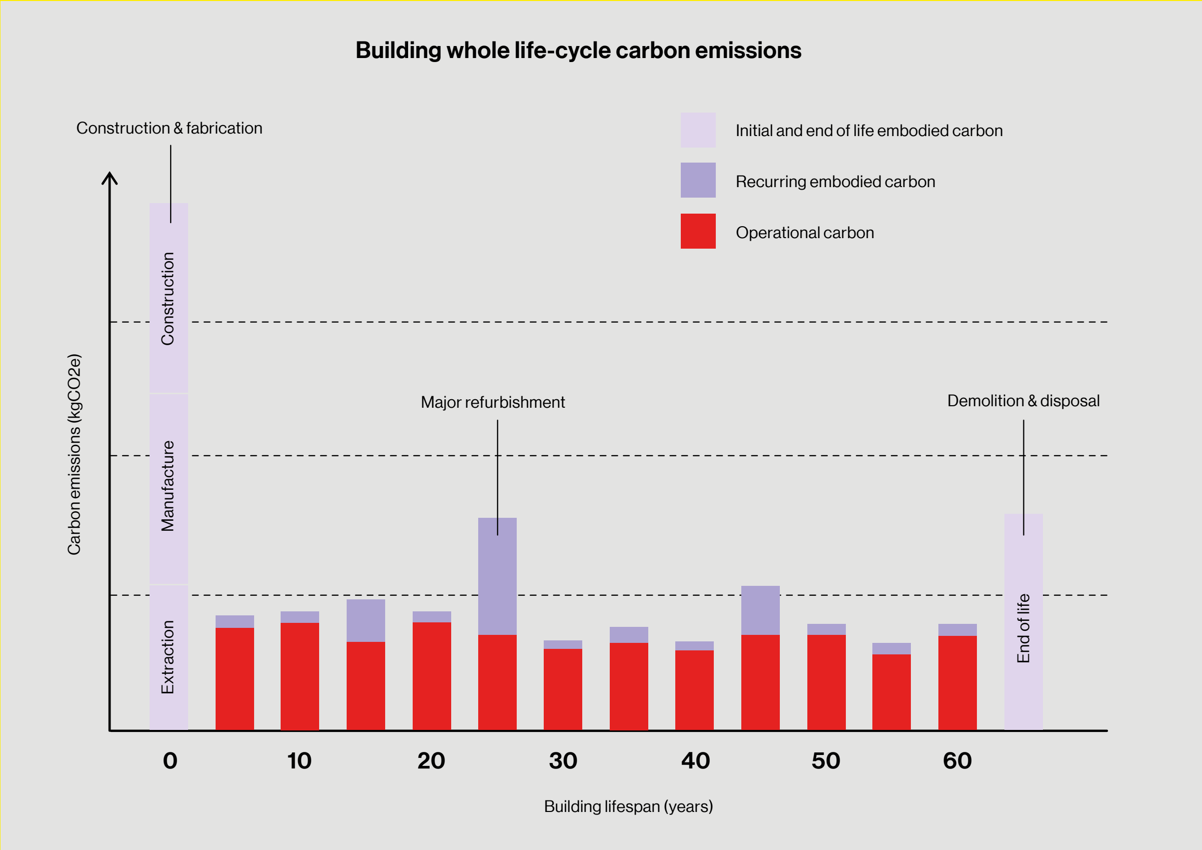



fig. 17: building whole life-cycle carbon emissions

***In most buildings we build between now and 2050, embodied carbon emissions will be more significant than those emissions released through energy use.***

(ACAN, 2021)

# Outtake 2:
# Carbon emissions in construction.

***Within manufacturing, the transition to a zero carbon economy will require, in the simplest terms, "material substitution from high-embodied-carbon to low embodied carbon materials."***

ACAN. (2021, February). The Carbon Footprint of Construction.

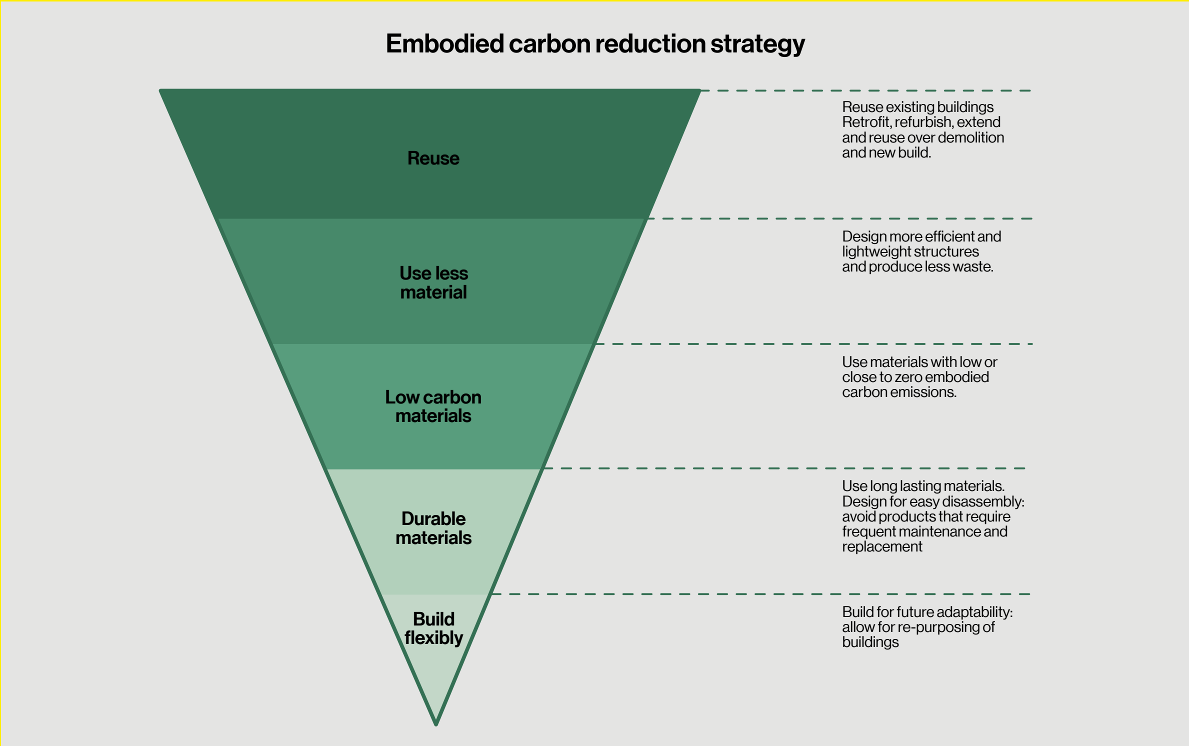



fig. 18: Embodied carbon reduction strategy.

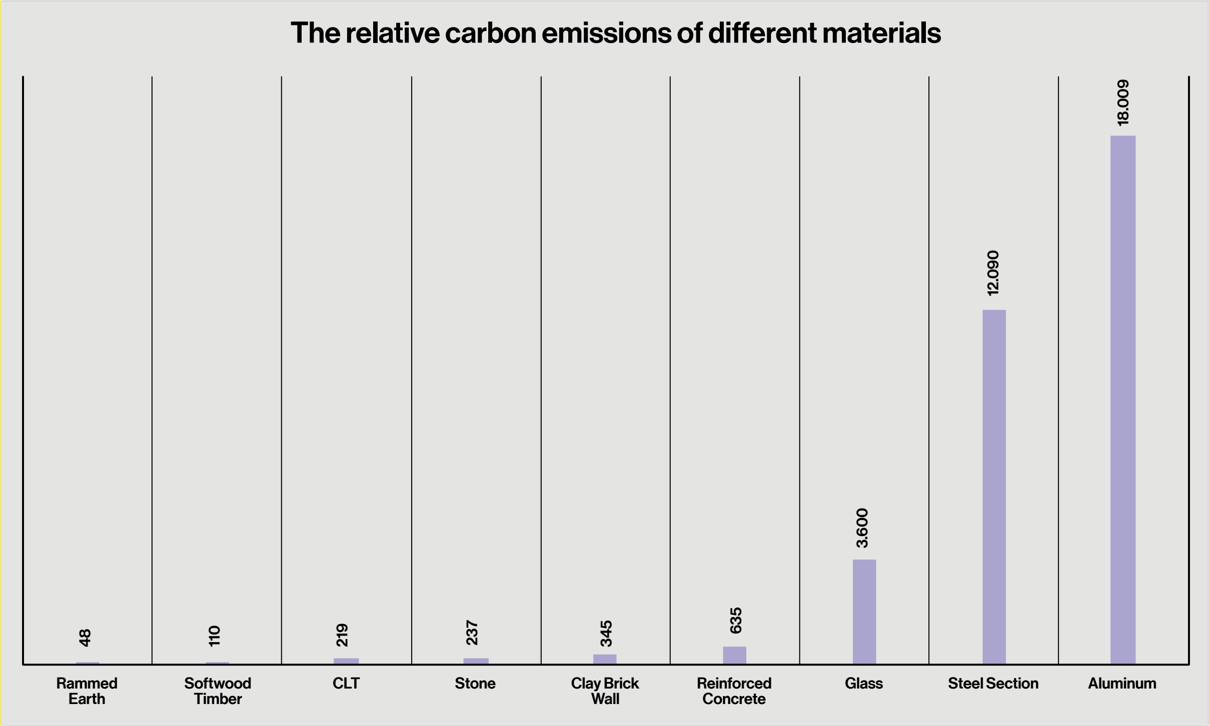



fig. 19: The relative carbon emissions of different materials

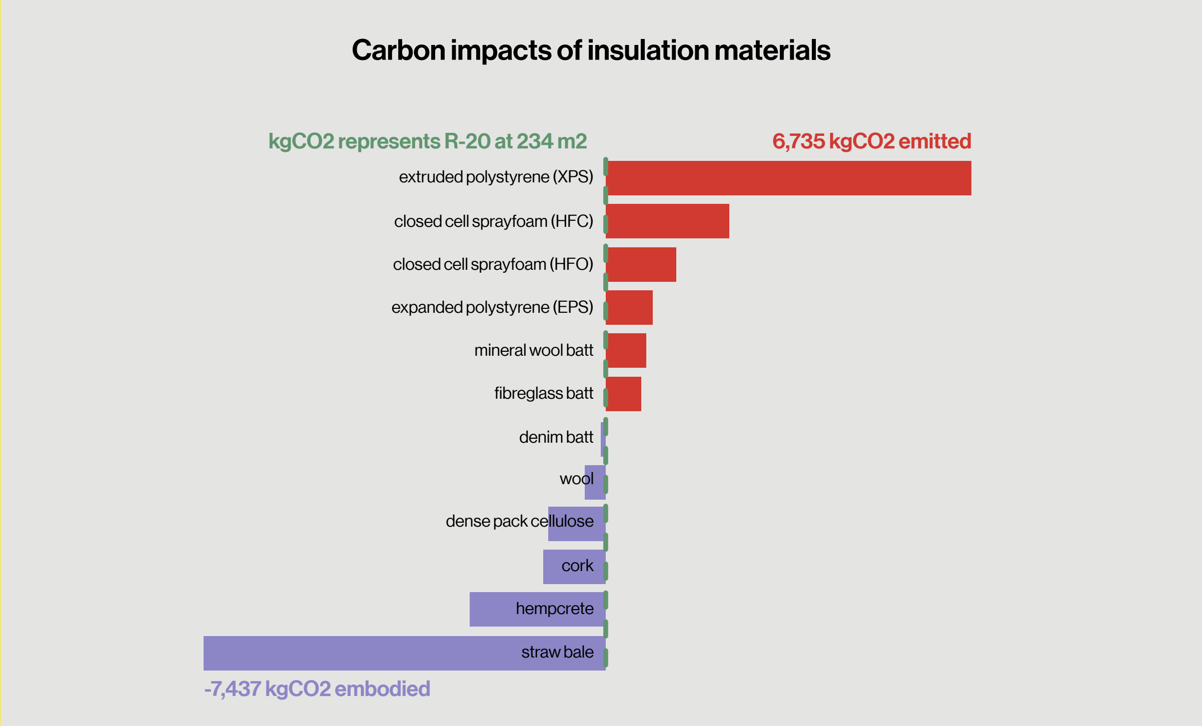



fig. 20: The content of natural materials in the insulation layer has a big impact on the CO2 emissions.

# Outtake 3:
# Building with wood.

## 1
## Building in wood = caring about our climate

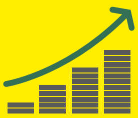
- renewable resource
- capture 1t of CO2 per m3
- the taller the building
  the more CO2 is captured

## 2
## Wood = efficient, fast & predictable

- high strength-to-weight ratio
- prefabrication is easy
- quick assembly on site
- reduced construction time and weather dependence
- suited for disassembly at the end of life cycle

## 3
## Wood = growing market

- by 2050, 70% of all humans will live in urban areas
- this requires a lot of additional housing
- wood is perfect for new constructions and renovations
- wood is perfect for the heightening of existing buildings du to it’s low weight

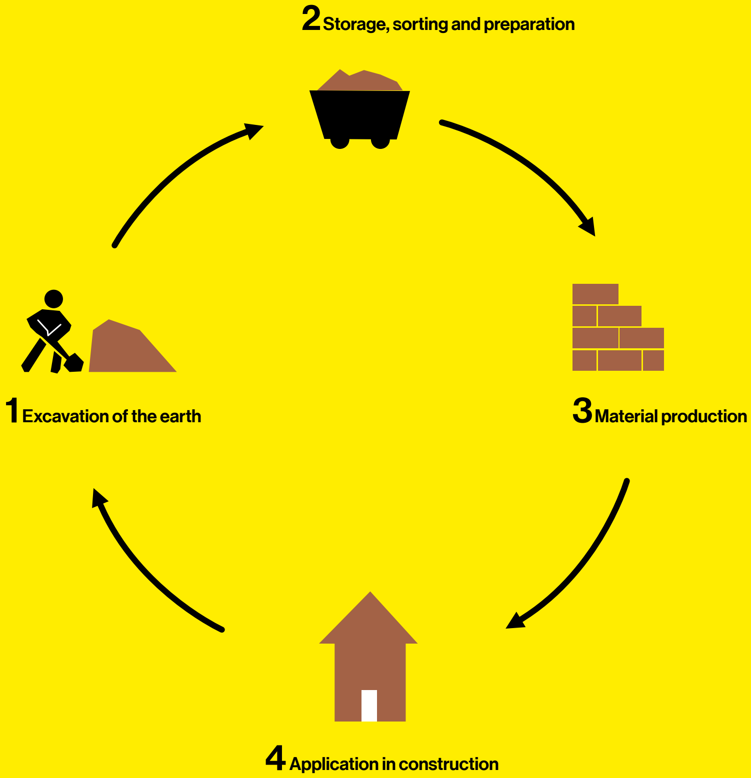


## 4
## Wood = healthy

- breathable and maintains a healthy indoor climate
- positive psychological and physical effect
- calming effect
- rooted in our past: connection to security and home

fig. 21: Why is wood key? by Build in Wood

# Outtake 3:
# Building with excavated earth.




- 100% natural & recyclable
- use locally excavated material - reduced transportation
- cool summers & warm winters
- 55% humidity - good for respiratory health
- tactile surfaces
- good acoustic properties

fig. 22The circular use of excavated earth.

# Outtake 4: The Monte Carasso case

The  experiences of the last 50 years by the Swiss village of Monte-Carasso, injecting modern architecture in order to strengthen vernacular tissues, can serve here as reference:

“Small towns are a significant component of the landscape in Europe and a key element of its cultural heritage. Currently, they face socio-economic crisis and spatial disintegration.

Against this background, the spatial transformation of the Swiss town of Monte Carasso is of particular interest. It was initiated in the 1970s as a design intervention made by the architect Luigi Snozzi and eventually constituted a local spatial policy with a scope to maintain or even restore town urbanity and identity. (...)

The positive results of this project paved the path for the formulation of a comprehensive concept of the whole of Monte Carasso’s spatial policy.

Its main goal was to restore the traditional character of a small town with its local identity.

Critical for its “urbanity”, the initiators of the re-urbanization process in Monte Carasso assumed that the social, cultural, and economic processes could be stimulated by creating urban conditions in a purely physical (morphological) dimension (Pedrycz, 2021).


image 23: a tale of 2 towns: Monte-Carasso densified, while the neighboring village spread

1.
**Any intervention must come to terms with the structure of the place.**

2.
**Three local structure experts must be nominated for a commission that will examine all projects.**

3.
**There is no rule defining the architectural language.**

4.
**Elimination of all distances from roads and between neighbours.**

5.
**Maximum height for any building is three stories.
Extra height can be granted for roof terraces.**

6.
**The Floor Area Ratio was raised from 0.3 to 1.**

7.
**Walls 2.5 meters high must be built along the road, reduced by the local council to 1.2 meters (for those built before 1940)**

image 24: 2 houses instead of 1:  an exercise of compaction

# Outtake 5: on the relationship between densification and construction waste

According to the European Environmental Agency (2020), Luxembourg is good at managing construction waste: 70% are recycled, 29% are backfilled and <1% is landfilled.
However, 1) recycling is most often downcycling (e.g. use in road constructions), and 2) reuse should be prioritized, which is not covered by this statistic.

Reuse of concrete construction elements has only 4% of the greenhouse gas emissions of in-situ concrete per $m^3$ from cradle to gate. (Asam, 2007).

Thus, we propose the following decision tree to guide relevant policies. Market opportunities arise for reusing disassembled construction elements, such as concrete walls. If demolition cannot be avoided, the proper recovery of concrete crushed to sand and rubble can be recycled. Within current blending limits, which should be increased to 100% recycling like in Switzerland), 0.15 $m^2$ of gravel pits can be avoided per $m^3$ of recycled concrete

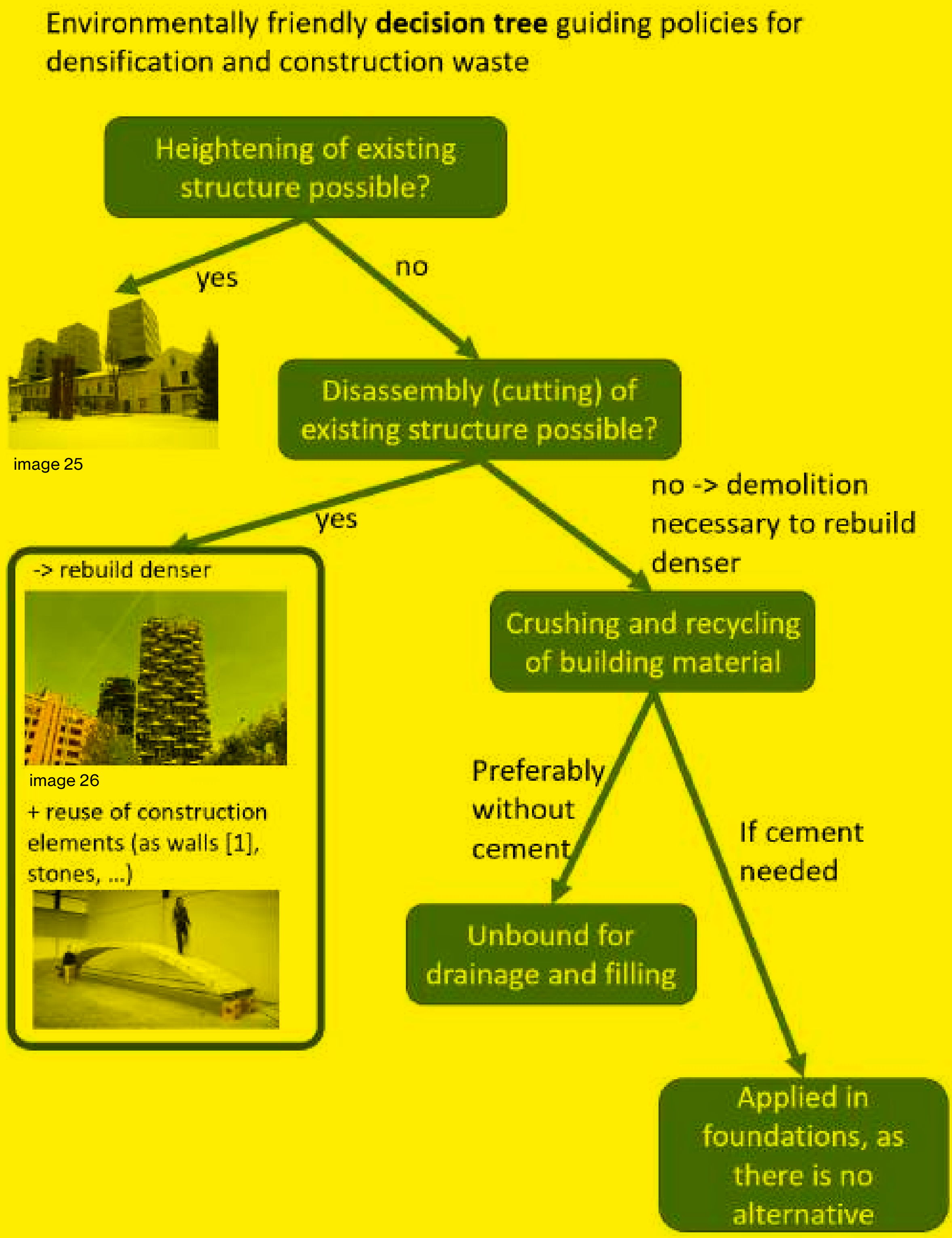


image 25
image 26
image 27

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**Images**

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image 3: Estate Bernd and Hilla Becher, represented by Max Becher; courtesy Die Photographische Sammlung/SK Stiftung Kultur - Bernd and Hilla Becher Archive, Cologne

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# Transferable Development Rights (TDR)

# *Every hectare sealed, is up to 1M tCO2 unsequestered.*

image 1

# Every hectare matters.

Natural landscapes are shrinking at a rapid rate in the region. Luxembourg for example has the 4th highest landtake rates among the EEA-39 countries (EEA, 2019).
Protecting natural land, means protecting the capacity of our soils for carbon sequestration and in itself can be seen as a decarbonising tool.
By protecting the landscape we will be able to enhance biodiversity, sequester carbon optimally and guarantee the region's food security in a turbulent 2050 climate.

***Between 2007 and 2015, the rate of landtake in Luxembourg has been 0.5 ha per day.***

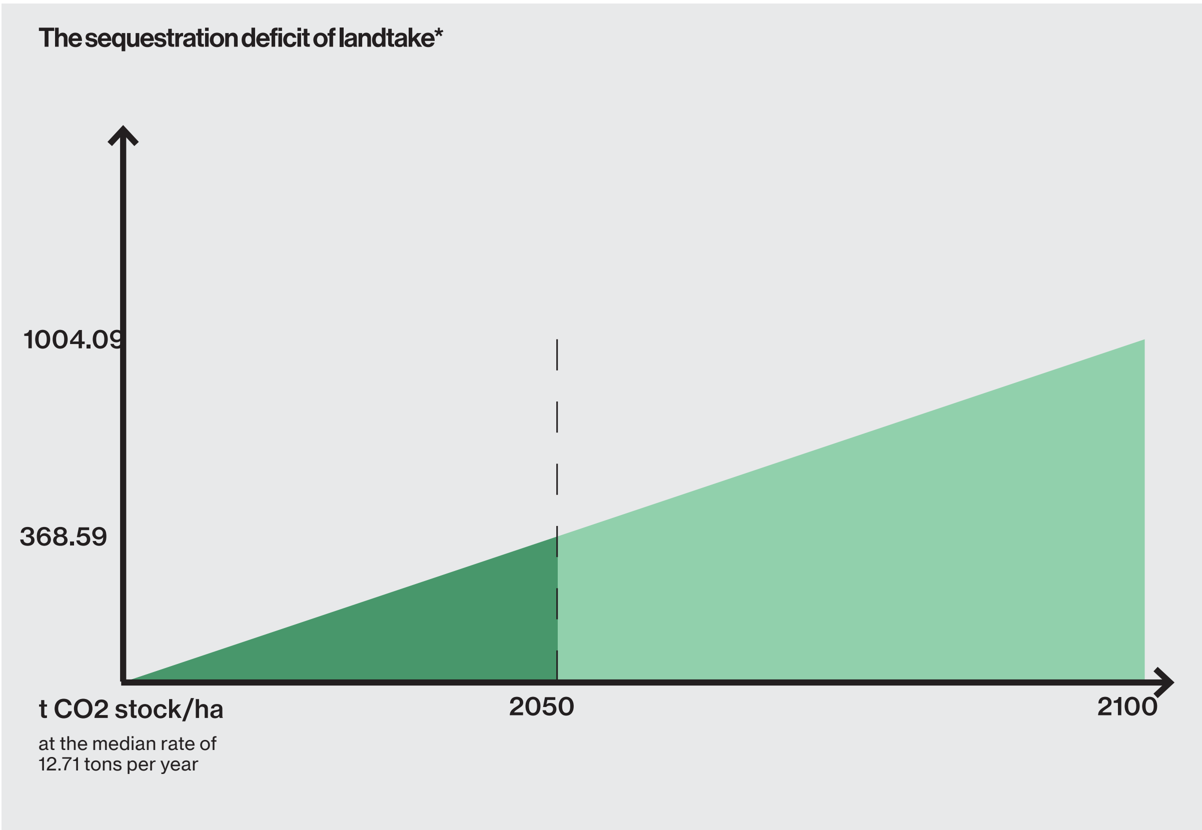
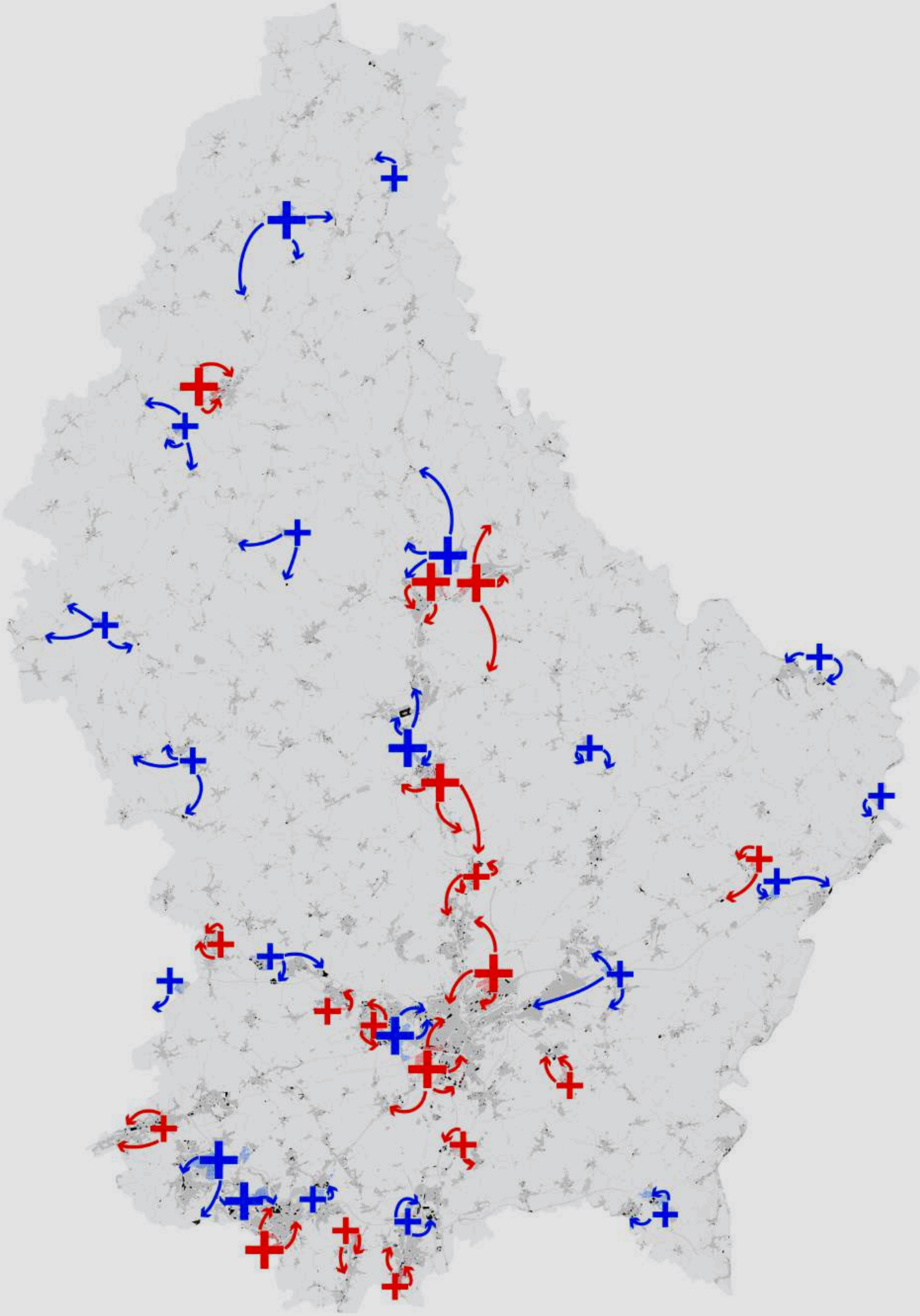



fig. 1: The sequestration deficit of landtake.
* for the purpose of this calculation, we have assumed the maximum sequestration capacity of 1 ha by considering it transformed into a forest.



# Battle of Luxembourg

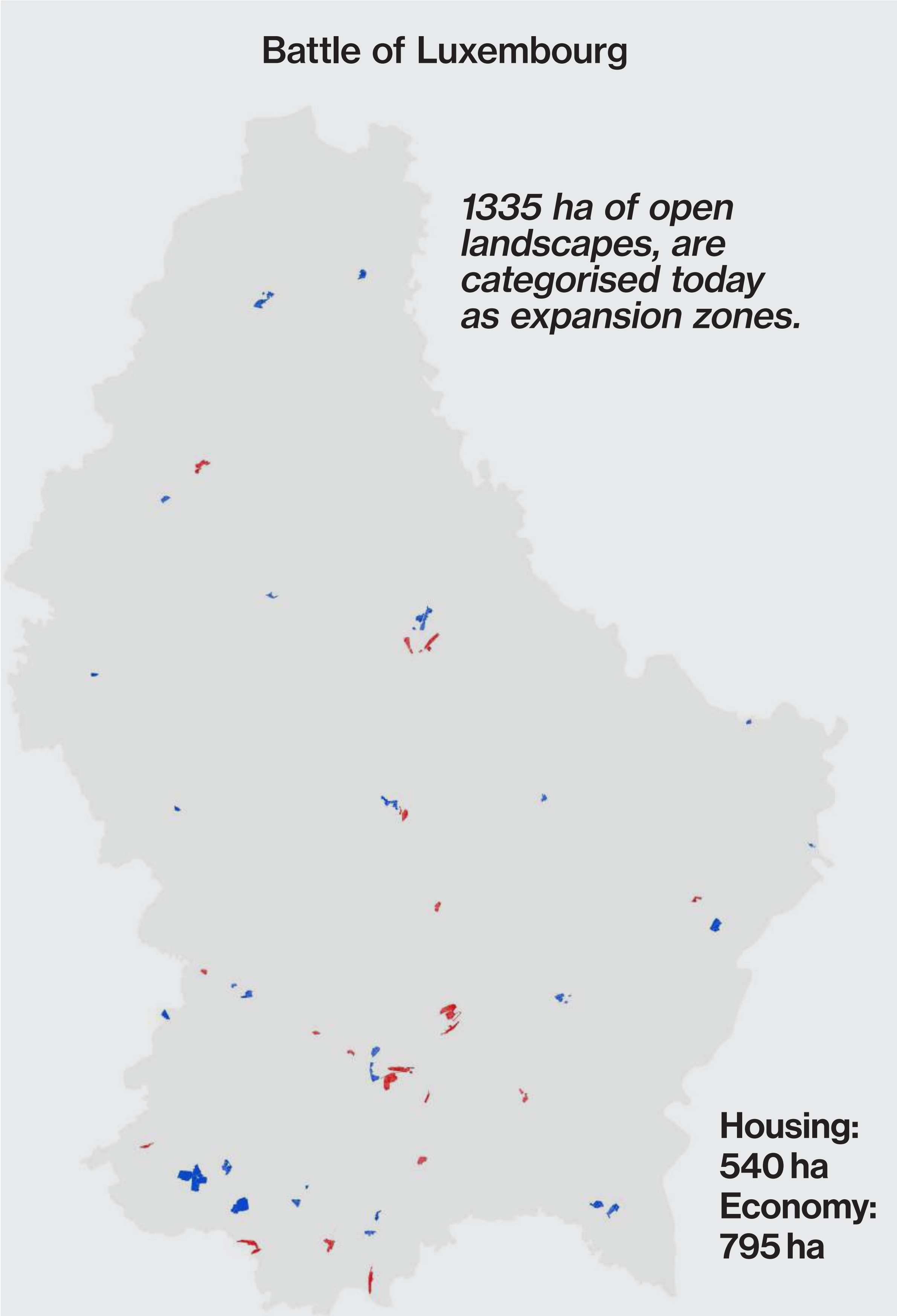
"Battle of Luxembourg" showcases the territorial spread of landtake. Housing expansion zones are presented in red crosses, and economic expansion zones in blue crosses, as foreseen in the sectoral plans. The arrows suggest a redistribution of expansion zones by prioritising underutilised land, such as brownfields and large open-air parking lots. To meet the net zero landtake ambition of the territory, property rights and land management needs to be rethought.

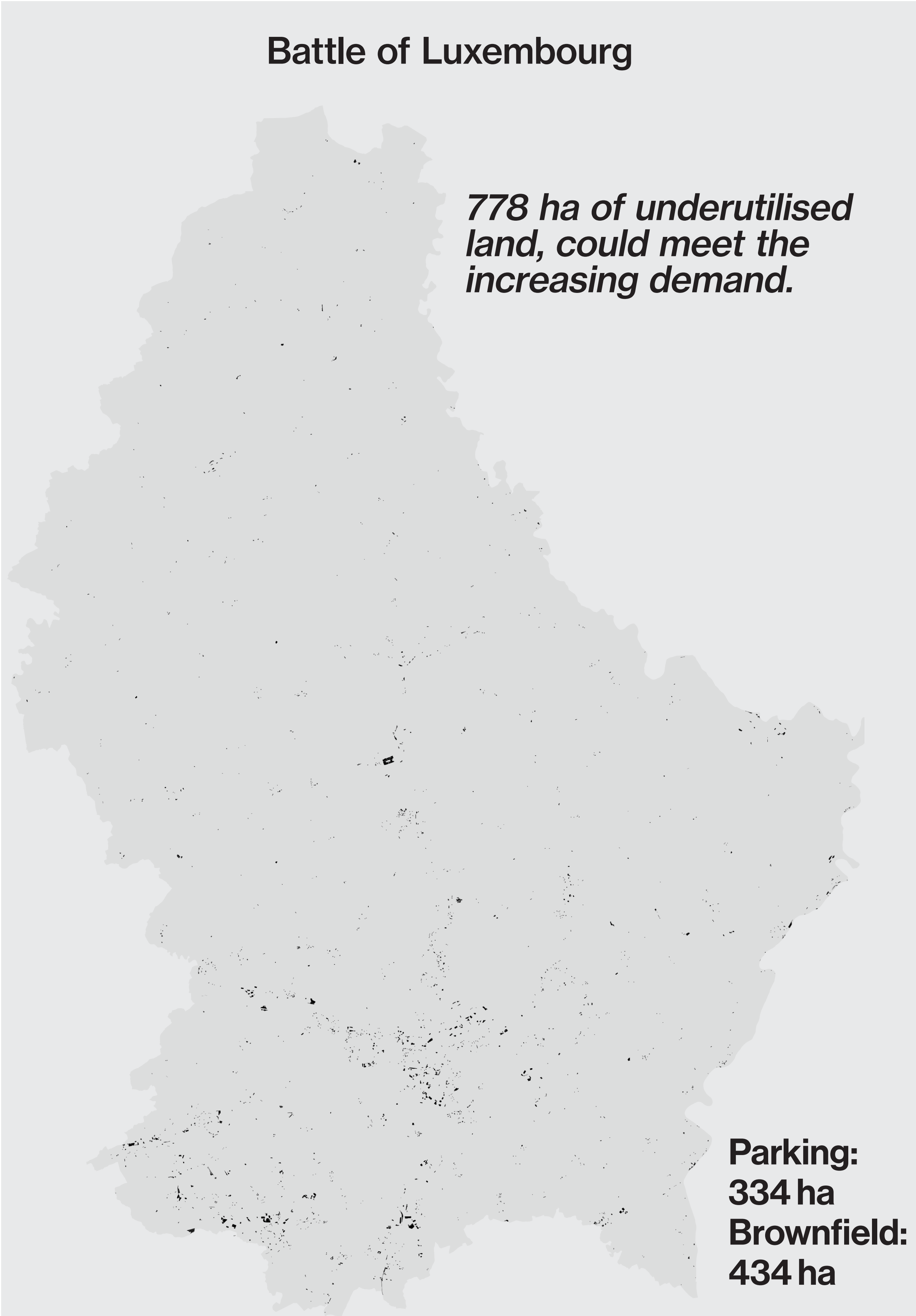
***Of the sealed surfaces in Luxembourg, 43,8 % are due to residential buildings.***

**(Fourmann and Tholl, 2019)**

image 2

image 3


Battle of Luxembourg
*1335 ha of open landscapes, are categorised today as expansion zones.*
Housing:
540 ha
Economy:
795 ha


Battle of Luxembourg
778 ha of underutilised land, could meet the increasing demand.
Parking: 334 ha
Brownfield: 434 ha

***Economic and environmental interest are at conflict with each other unless we see property as a bundle of rights which can be addressed independently from each other.***

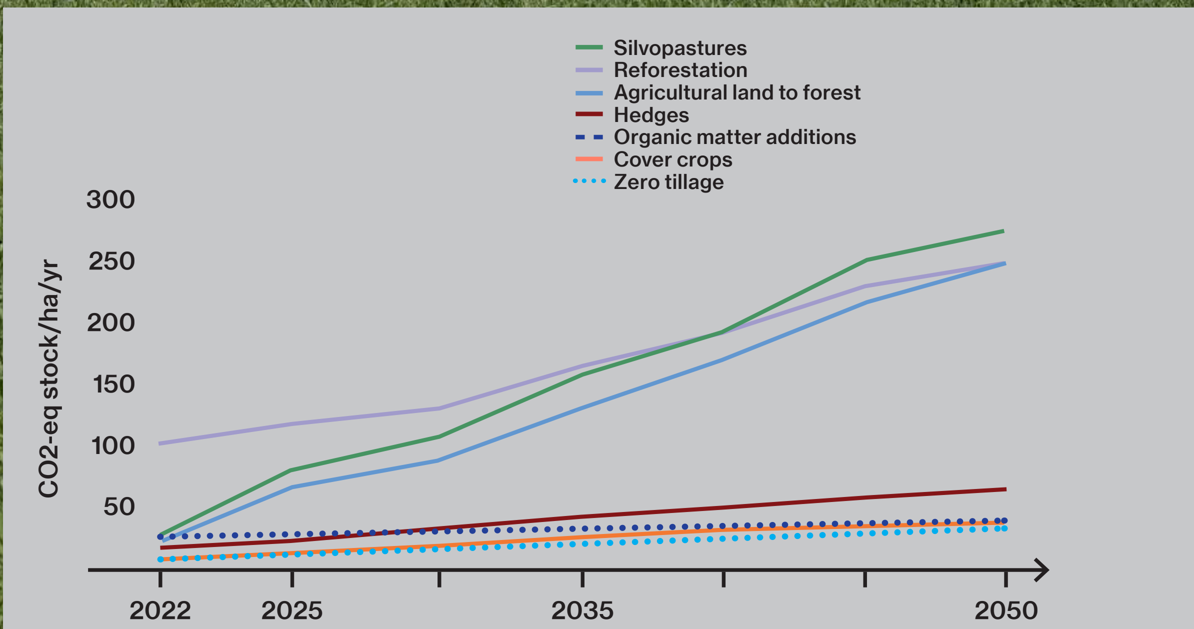



fig. 2: The carbon cost of one hectare.

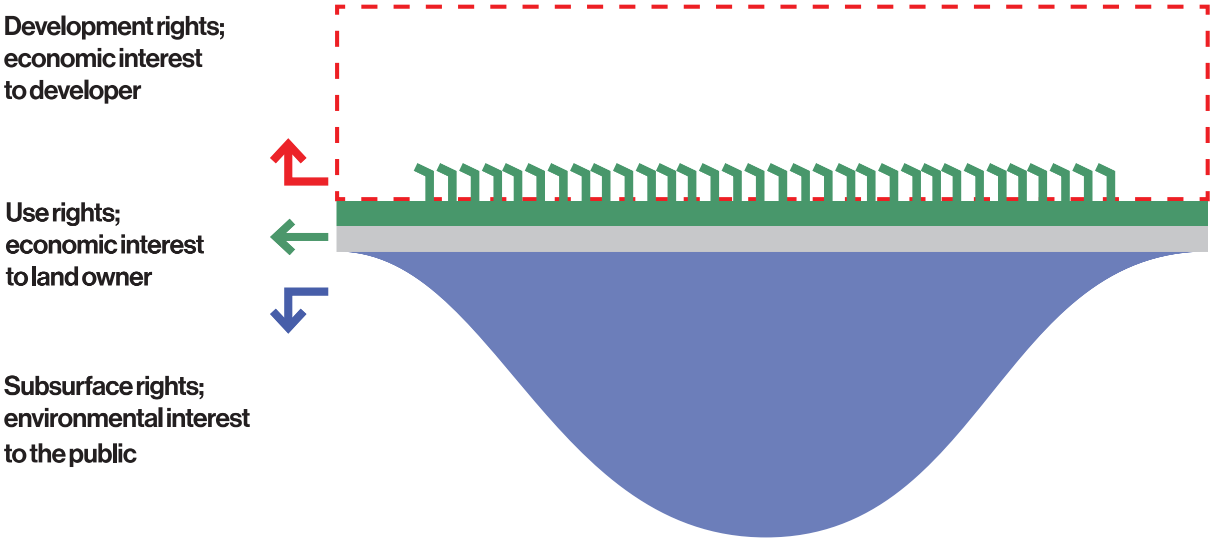
image 4

# Net Zero Landtake

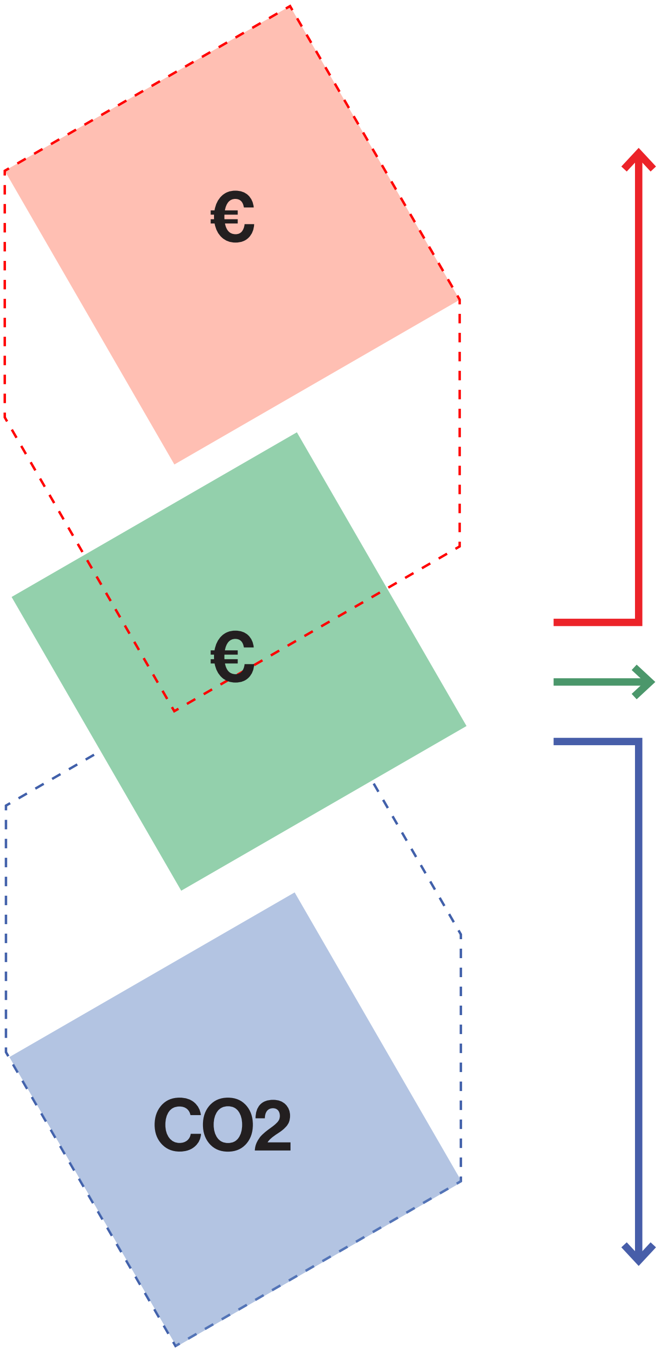
The ambition of net zero landtake for the territory, brings about the question of sustaining growth on the existing sealed land footprint. Under every hectare of soil that is sealed, there is a quantifiable sequestration deficit to be accounted for.

Conventional zoning has failed to prevent, and is often the cause of, suburban and rural sprawl. It has become clear that conventional planning has stood as an obstacle to the goals of many communities resulting in highly valued areas of forest or farmland being zoned for low-density residential development. Furthermore, current zoning often does not allow for density levels appropriate to a vibrant commercial or mixed-use district. Traditional planning techniques to address these situations, such as large land acquisitions in open space areas, whole-sale rezoning of downtown centres, or down-zoning of agricultural areas, are politically sensitive, costly, and often impractical as they reduce the development potential of a landowner's property.

When residential or economic expansion is planned over arable lands, we are often faced with two pathways. One is to follow the economic drivers which prefer low-density development over large parcels of arable land. And second to act upon the environmental interest, which would lead to preservation of natural land cover. Economic and environmental interests are at conflict with each other unless we see property as a bundle of rights. This will allow us to address these drivers independently from each other.



# Property as a bundle of rights




## Development right

Developer's interest;
profit from end product (as anticipated in the PAP table) minus land value and building cost.

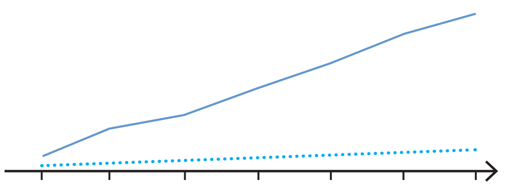
| | | | |
|---|---|---|---|
| COS | 0.24 | CUS | 0.84 |
| CSS | 0.5 | DL | 66 |

## Ownership right

Landowner's interest;
increased value of land due to development rights

## Subsurface right

Public interest;
capacity of soil for natural decarbonisation (as anticipated in the negative emission timeline of the parcel)



# TDR principles

In the law of the medieval Roman empire, whoever owned soil, the ownership extended up to the heavens and down to hell. In this way land ownership was attached to what sat below and above it. In the 20th century, TDR was born to protect values of public interest against increasing land values while still allowing for private interest to benefit from speculative development. With this tool, development rights and speculation could be detached from the land, designated for preservation, by purchasing the right of building from the owner. That right could then be transferred to another site, assigned as a receiving zone.

For such transactions to happen, reaching a consensus over the selection criteria of sending and receiving zones is paramount. To do so we need to understand what our common values are for preservation of land. As maximising negative emissions and net zero landtake has been our goal, we have identified sending zones as current expansion zones identified in PAG documents. And as for receiving zones we see all sealed surfaces and underutilised structures as destinations for such transfers.

For natural landscapes under threat from landtake, which we categorised as our sending zones, we need to consider three categories of rights; Ownership and use rights which are assigned to the landowner. Development rights above ground which are of economic interest to the land owner and developer. And finally the subsurface rights beneath the soil, which are of environmental interest to the society and the planet. The TDR mechanism allows for the land owner and developer to retain their speculated financial gain while allowing for natural landscapes to be preserved and play their essential role in decarbonisation of the territory (Commonweath of Massachusetts, 2020).

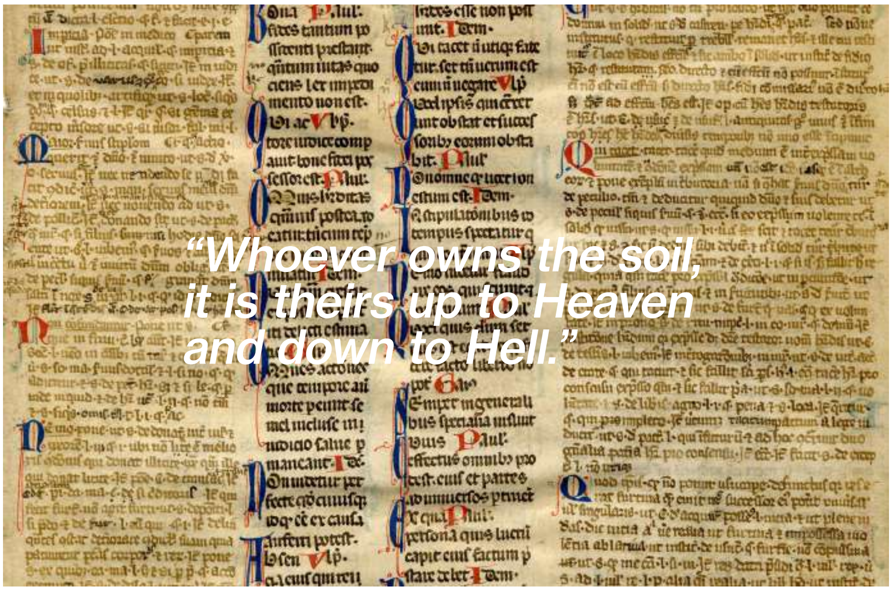



image 5: Justinian, Corpus iuris civilis. (1275).

# Sending & Receiving zones

For Transferable Development Rights to function, we need to identify two types of parcels. The sending parcels which are the zones that have been assigned for preservation, and the receiving parcels which are the zones where there is capacity for growth.

The criteria by which these zones are selected should be determined by local communities and authorities. For example, in the City of Davis, citizens have a right to vote against any new projects that would annex arable land for new developments. This in turn, can make that land eligible as a sending parcel. The same principle can also apply for Receiving areas whereby citizens would be able to vet the selection of receiving zones. Collective awareness of the environmental and economic impact of these decisions are necessary preconditions for such decisions, as much as consensus around common values around preservation is. Based on the studied cases, sending and receiving zones have mostly been assigned in proximity of each other, or within the same municipalities. However the procedure could allow for distant transfers as well, across municipalities and regions(Ingram and Hong, 2009).

This act of rezoning can act as a medium to negotiate public and private interests. As an example, when the landowner of the sending parcel sells its development right, the landowner will sign a deed for a predetermined time frame (e.g. 30 years), which freezes the use of the site and limits it to carbon farming practices. While on the

image 6: an illustration of district density transfers by SITU Studio

receiving site, the developer would combine the newly purchased rights with the existing ones, to achieve a larger development on the same footprint. These transferable development rights can be implemented as an additional right, without enforcement. However, transfers can be encouraged and facilitated by municipalities. Developers will have much higher incentive to use this instrument, if the receiving sites' planning procedures are simplified. In London, such simplification was done for the Small Sites developments whereby the Mayor of London listed the collection of publicly owned irregular sites which were previously less desirable to develop. Growth and transfers can be further guided by form-based codes, location-efficient mortgages, which make certain locations more preferable financially, and tax credits.

By 2010 TDR programs had been responsible for preserving over 400,000 acres of land in over 200 jurisdictions in the US. (Pelletier et al, 2010)

As noted by Donald Krueckeberg: "Property is not just the object of possession or capital in isolation, but a set of relationships between the owner of a thing and everyone else's claim to the same thing.
Rights to personal use of property are fundamental to individual and social wellbeing: rights to profit from property, in contrast, have always been subject to reasonable constraints for the benefits of the entire community and society.

\Attempts to establish a contrary case by appealing to natural rights, market necessity, liberty, social utility, or just desert all fail to withstand scrutiny...These concepts of use rights and profit rights in property are at the heart of the planning question." (Krueckeberg, 1995).


image 7: Example of the data bank Mayor of London has made of the irregular sites which were previously less desirable to develop.

## 2022

the decision for new zoning of the two exemplary sites below, is driven today by conventional planning regulations and economic interest. We foresee a pathway were without compensating the economic interest we can meet the environmental ambitions of Luxembourg in Transition.

## 2050

conventional plannin
result in economic pr
involved, and it come
environmental health
community.

Sending site; arable land

| | |
|---|---|
| 0.3 | 0.7 |
| 0.5 | 40 |

Transferrable De

Receiving site; parking

| | |
|---|---|
| 0.5 | 1.1 |
| 0.8 | 45 |

current PAP

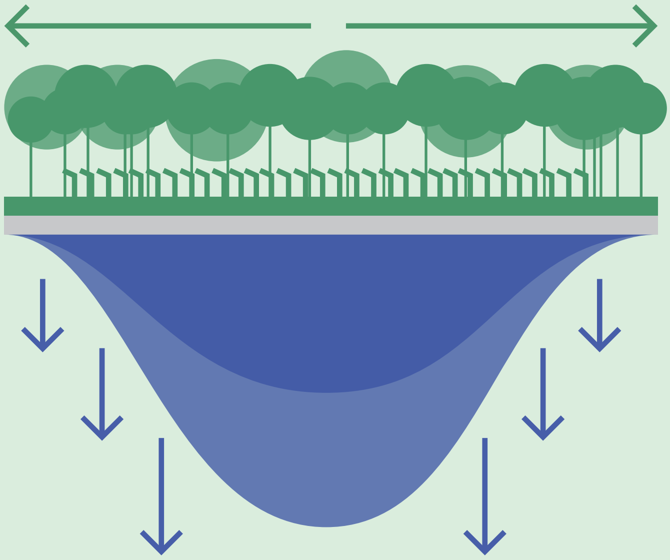
## ) BAU

g of these 2 sites will
ofit for the parties
s at the cost of
and interest of the

## 2050 LIT

with TDR, the economic profit of the parties involved will remain intact, while the environmental score of the interventions will be preserved and enhanced.

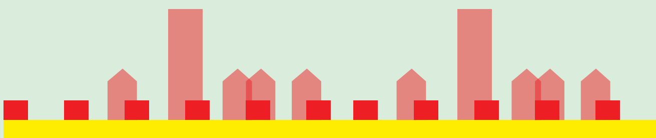
| | |
|---|---|
| 0.0 | 0.0 |
| 0.0 | 0.0 |

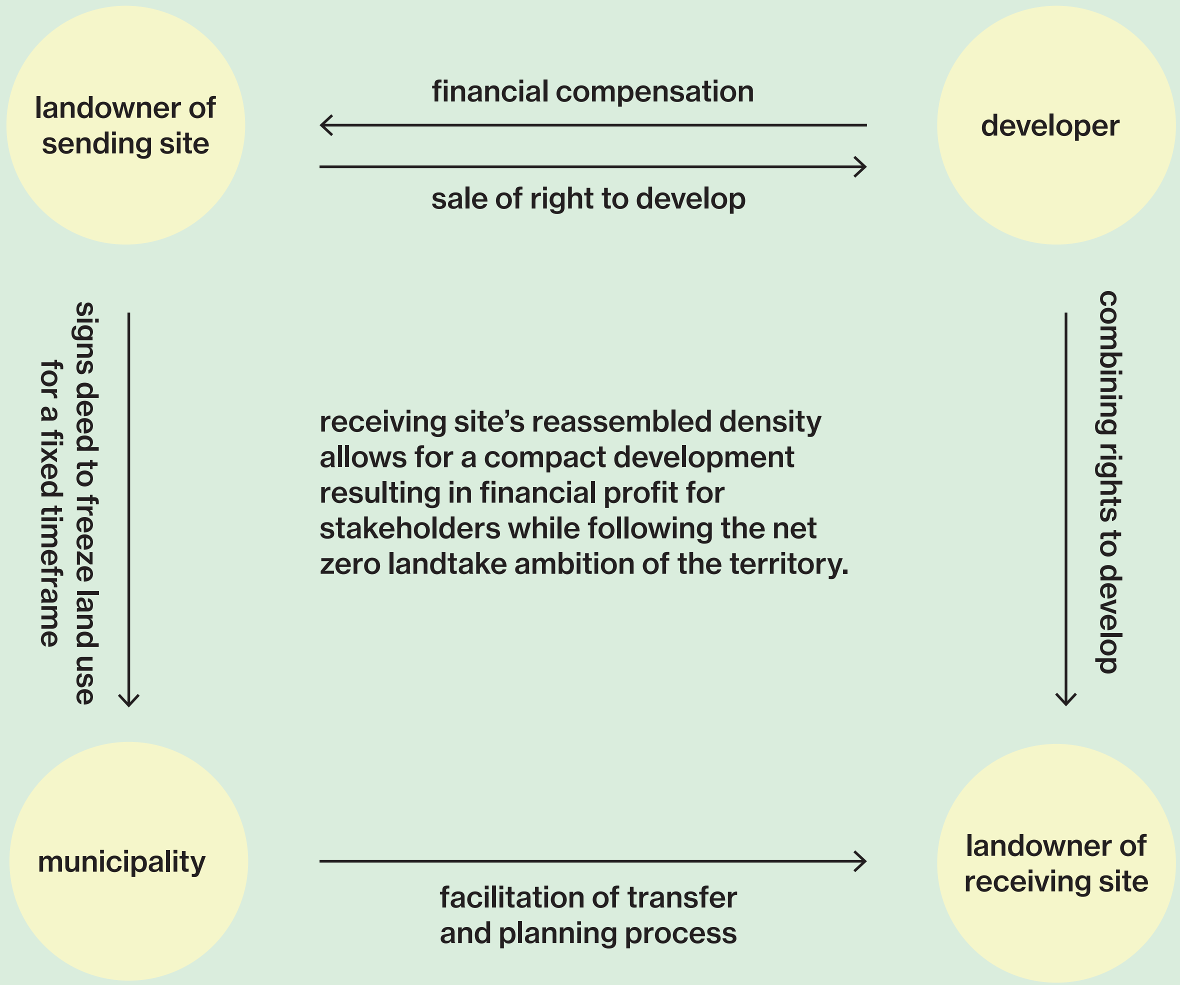


velopment Rights

| | |
|---|---|
| 0.1 | 1.3 |
| 0.1 | 91 |

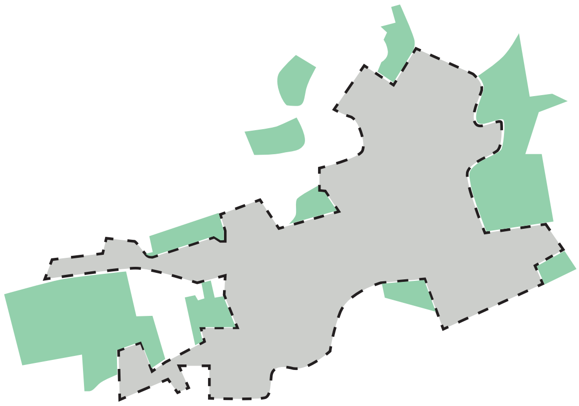
new PAP



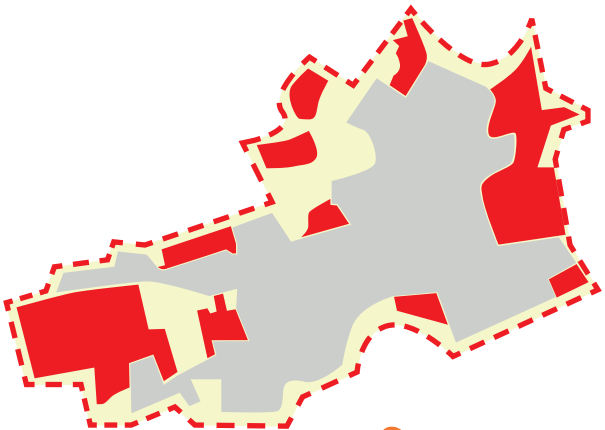

landowner of sending site
financial compensation
sale of right to develop
developer
signs deed to freeze land use for a fixed timeframe
receiving site's reassembled density allows for a compact development resulting in financial profit for stakeholders while following the net zero landtake ambition of the territory.
combining rights to develop
municipality
facilitation of transfer and planning process
landowner of receiving site

## Overview of transaction

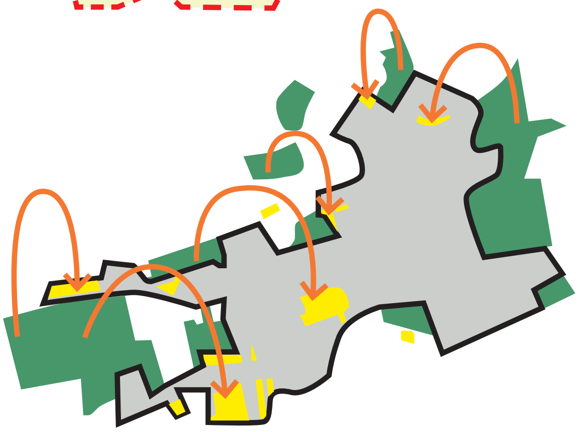
**1 Peripheral arable lands under pressure from landtake**



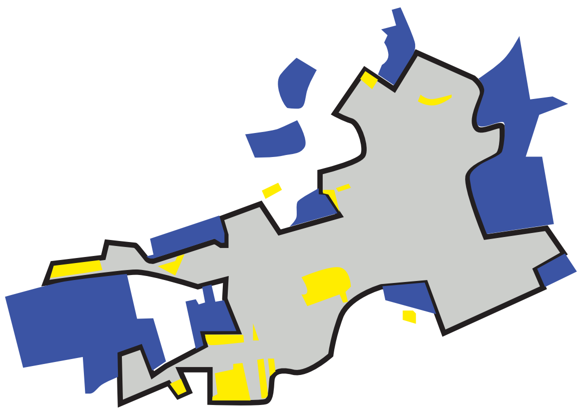
**2 Expansion of building perimeter in PAG to release pressure and Introduction of development rights to arable lands resulting in landtake**



**3 Transfer of development rights from arable sending sites to sealed receiving sites**



**4 Achieving economic return from receiving sites, and natural decarbonisation on sending sites**



*“Landowners today, have much better understanding of environmental values. Raising awareness among landowners on capacity of soil for decarbonisation is key to meet Net Zero Landtake ambitions. Hence, if the landowners reach a common understanding, TDR can be put into practice much more swiftly.”*

Shaaf Milani-Nia
Head of Urban Planning Department
Luxembourg City

*"If we can allow to cut trees for new developments and plant the same amount somewhere else today, why can we not apply the same principle to development rights to preserve natural land covers?"*

# TDR benefits

TDR provides several financial benefits to local governments, private developers, and the general community. Limiting development in outlying open space or agricultural areas will reduce municipal infrastructure costs that would result from large scale subdivision development. Preservation of these areas therefore decreases the local tax burden required to keep pace with sprawl. Conversely, because this technique does not limit the overall development potential within a community, the act of preserving land does not translate into a loss for the community's tax base (Krueckeberg, 1995) TDR allows a community to preserve land without using public funds, a cost that otherwise would be borne by the municipality's taxpayers. Land owners in sending areas and private developers can realize significant financial gains through TDR programs especially if development rights are increased through density bonuses during the transaction. Landowners in the sending areas can actually demand a higher price for their land than if they were to convert it to residential development. Developers in the receiving district can also realize a higher investment on their property when it is developed at a higher density than what was allowed under conventional zoning.

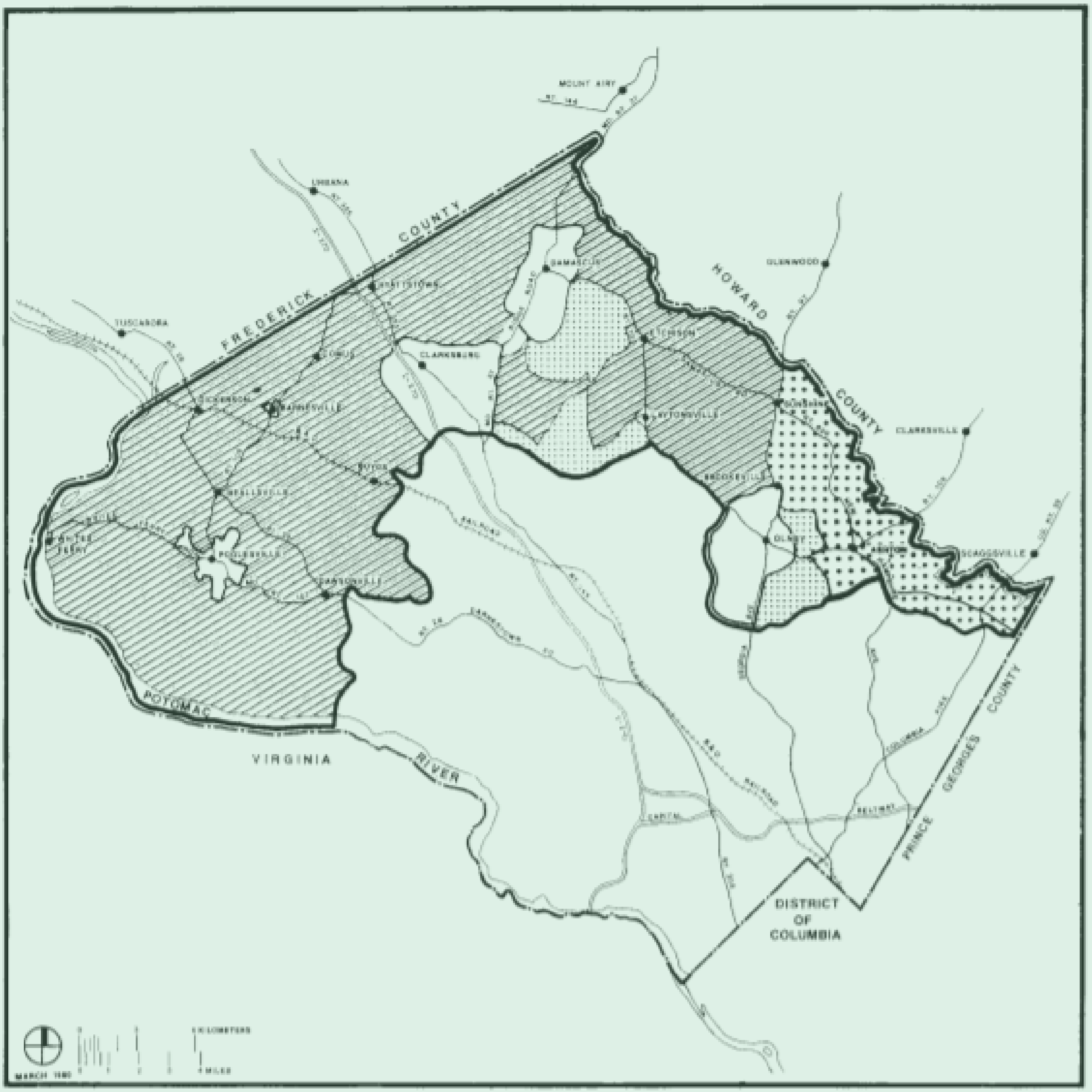
It is worth noting that TDR credit banks can be used to store development rights that have been purchased, if a receiving area development project has not yet been identified. This mechanism is used when the time of the sale in the sending area is not concurrent with a development in the receiving area. It is also useful in communities that have the opportunity to purchase the rights from an area of high conservation interest but do not have a development project that can receive higher density at the time (Commonwealth of Massachusetts, 2020).

Ingeldorf: the mall as town center

# PROPOSED RURAL AREA LAND USE AND ZONING

Legend:

- Montgomery County Boundary
- Study Area Boundary
- Population Centers
- Agricultural Reserve (Rural Density Transfer Zone)
- Rural Open Space (Rural Cluster Zone)
- Residential (RE-2)




# FUNCTIONAL MASTER PLAN FOR THE PRESERVATION OF AGRICULTURE AND RURAL OPEN SPACE

image 8

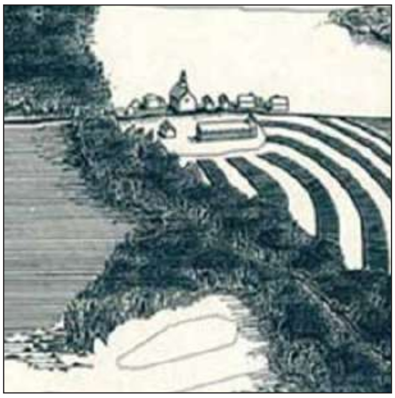
# Cases of preservation

Montgomery County's Building Lot Termination program (2020);
Established by law in 2008, the Building Lot Termination (BLT) Program is a farmland preservation tool. It has defined an Agricultural Reserve zone, and any permit within that can be bought and transferred outside that zone, based on a benchmarked price. Since its initiation, it has been responsible for preserving more than 1000 acres of agricultural land.

Calvert County's TDR program;
The main goals of Calvert County's TDR program is to "preserve prime agricultural and forestry land", "utilize the free market system for financing preservation" and "guide development away from prime agricultural and forestry lands" (Calvert County Agricultural Preservation Rules and Regulations). The program also aims to "promote and preserve the identity of intact rural agricultural communities" and to "minimize conflicts between agricultural and non-agricultural land use by providing for functional separation of the two". The County also has a Forest Conservation TDR program which was designed to help meet the goals of the Maryland Forest Conservation Act (For New Jersey Future, 2010).

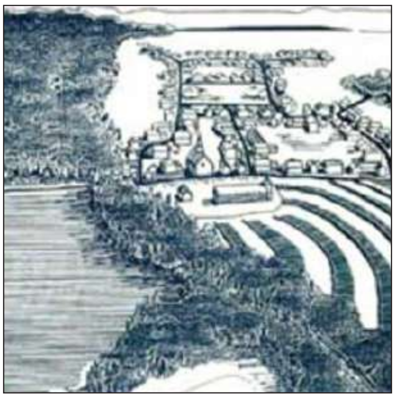
New Jersey's Pinelands Development Credit (PDC) program;
This program is a transfer of development rights program which helps to redirect growth in the Pinelands Area from the preservation and agricultural districts to infrastructure-supported Regional Growth areas. Each PDC transfers the right to build four homes and can be bought and sold in 1/4 (or 1 right) increments. PDCs are bought and sold privately, with all sales transactions administered by the publicly chartered Pinelands Development Credit Bank (Pinelands Commission, 2021).

**Existing village**



**Conventional Development**

**Development with TDR**



images 9,10,11

# TDR around Europe

| Country | Type | Name | Description |
|---|---|---|---|
| **Germany** | Research project | Cap&Trade of land use certificates | Case studies & simulation game |
| **Switzerland** | Planning principle | Principle of zero land take | Avoiding new land take during rezoni land swaps |
| **Switzerland** | Research project | simulating TDR markets | PhD thesis, using agent based mode |
| **Switzerland** | Referendum | Rejected by a referendum: intercommunal transfer of construction land | Law initiative |
| **Belgium** | Research project | Research project: Adaption of TDR to Flemish legal and administrative framework | comparative law study |
| **France** | TDR application | transfert de COS | 4 french municipalities experimented independently from each other with T |
| **Netherlands** | TDR application | Space for Space program | tearing down unused stables to build somewhere else |
| **Spain** | TDR application | General Plan of Almeria | Conservation of Ameria's historic buil |
| **Netherlands** | TDR application | VORm (Verhandelbare ontwikkelingsrechten methode) | TDR for contryside development |
| **Italy** | TDR application | TDR in regeneration schemes for historic city centres | Transferable BONUS development ri when regeneration and restoration w have been completed and may only b outside the historic centre |
| **Italy** | TDR application | Territorial Government Plan | Instead of generating additional build capacity, it protects almost two millio square meters of land from urbanizat |

| | Results | Scope | Actor | Year |
|---|---|---|---|---|
| | 50% of land take avoided; 80-90€/m² of construction land | 15-87 german municipalities | German Environment Agency | 2013-2017 |
| ng by | It is said that land take has stalled | Whole canton | Canton of Thurgau, CH | Since 1985 |
| lling | no increase in land prices; decrease in land use | Switzerland | Swiss federal Institute for Forest, Snow and Landscape Research WSL | 2009-2013 |
| | got rejected (~60% voted against) | Canton of Zurich & Canton of Luzern | Swiss Green, “Kulturland-initiative” | 2016 |
| | not published yet | Flanders | University of Antwerp | 2016-2020 |
| DRs | success in terms of take-up varies strongly. Since the COS has stopped in France since 2016, the TDR method is no longer used in these communes | single municipalities | Lourmarin , Le Grand Bornand, la commune de Taninges (Praz de Lys), La Cadiere d’Azur | since the 1970s |
| | Despite some missed opportunities, we can conclude that the goal of Space for Space, improving the overall quality of the landscape, has been achieved. | region: North Brabant | regional administration | since the end of 1990s |
| dings | 146 transfers in 4 years | Communal level: Almeria | City adminstration | 1980s |
| | no project applying TDR yet (in first 4 years) | Limburg | regional administration | since 2005 |
| ghts<br>orks<br>be used | taken up by 15 citites | Umbria Region | regional administration | since mid 1990s |
| ing<br>n<br>ion | on average 50 certificates per year; and 23k m² per year of gross floor area built | City of Milan (Rome and Florence have experience too) | city adminstration | since 2014 |

table 1

*“Even though TDR currently has no legal basis, it could be set up through contracts between all involved parties. However, during the approval process, municipalities always need to refer to the applicable laws.”*

Mike Poiré
Jurist and Mayor
Commune of Mertzig

# Bettendorf

To demonstrate the potential of TDR in the spatial planning of Luxembourg, we have showcased an application of the tool over two sites.

In Bettendorf, the PAG anticipates a canonical growth, for which the population will have to almost double to meet the projections. We did not challenge this growth as our focus has been on redirecting growth distribution rather than its size.  As the periphery of the village constitues of large parcels of arable land, the municipality has introduced development rights for a collection of such parcels. The projected density ratios for these parcels are very similar to each other. Through a series of exercises attempting to test the spatial growth of the village, we understood that the regulated growth projection guides the developer to construct two to three storey houses of similar sizes. The lack of diversity in typologies is also fueled by a guidance on maximum number of residential units per PAP, notes as “DL”. This contraint takes away the financial incentives for development of apartments with smaller floor areas.

To illustrate what such growth would mean, the sketch on the opposite page shows the comparison between the status today and growth following PAG in white. The grey sillouetes present a possible extension of the same principles across the next layer of arable lands surrounding the village.
It is clear that this type of development does not take into account the sequestration deficit of landtake, the burden of infrastructural cost of such sprawl, the lack of provisions for economic or service activities, and the loss of character and demographic diversity which will results from an overwhelming quantity of similar typologies.

## PAG

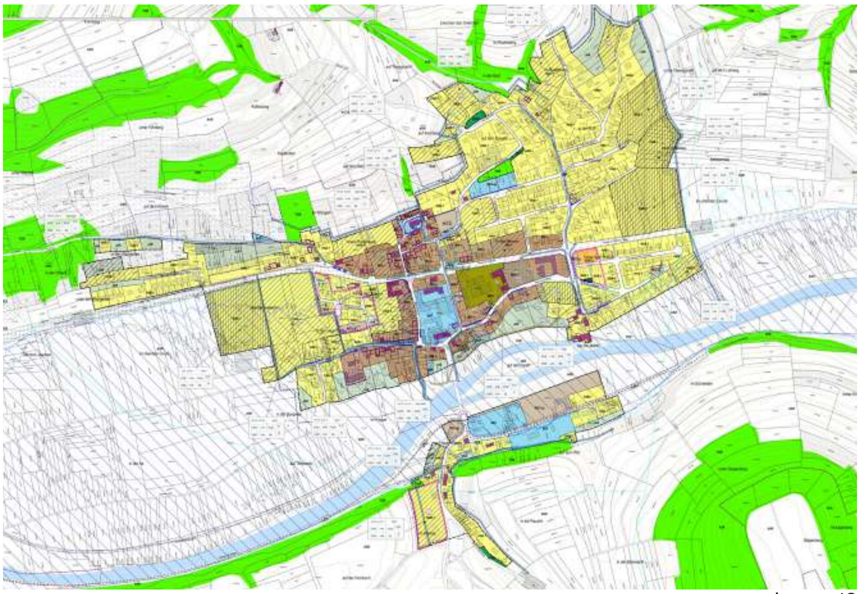
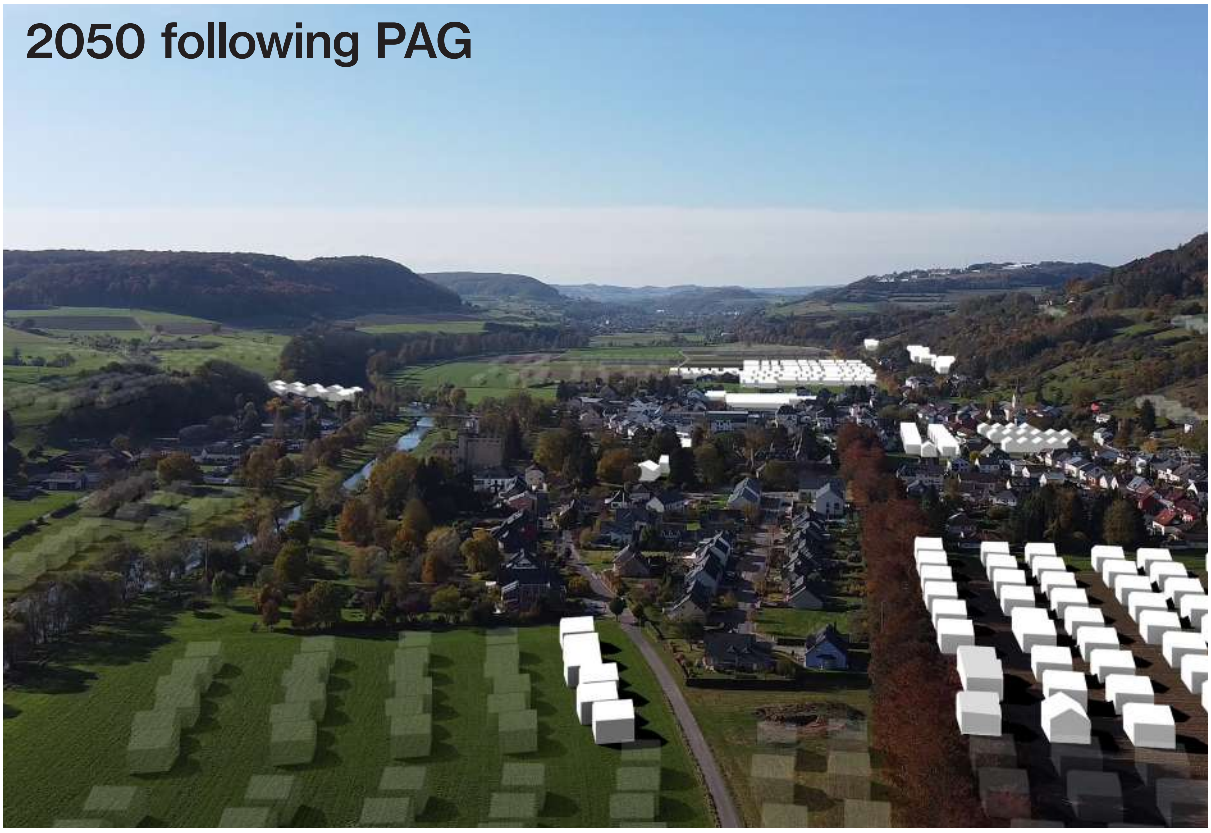


image 12


images 13,14

# Bettendorf sending & receiving zones

To begin the TDR procedure in Bettendorf, we first identified the arable lands categorised as developable parcels in the PAG as our sending zones accounting for 166,700 sqm in total. We also scouted for potential receiving zones in and around the village, which are comprised of a collection of parking surfaces, in between spaces, and out of use barns and warehouses.
This collection of sending and receiving zones, build the foundation for a new market of trade for development rights.

TDR can guide the nature of the deed that the landowners of the sending zones need to sign after the transaction, to respond to the challenges that Bettendorf faces such as flooding. How long shall the deed last? Shall the use after the transaction be determined? What is the process after the deed is terminated? These are some of the questions which need to be thought about for the sending zones.

The receiving zones on the other hand, need to be simplified both in terms of ownership status and in the planning process for their redevelopment. The municipality can also suggest a bonus scheme where by provision of public amenities, higher quality of construction and architecture, and accommodation of diverse typologies can be rewarded with development right credits, to be used on the site in discussion or elsewhere in the village.

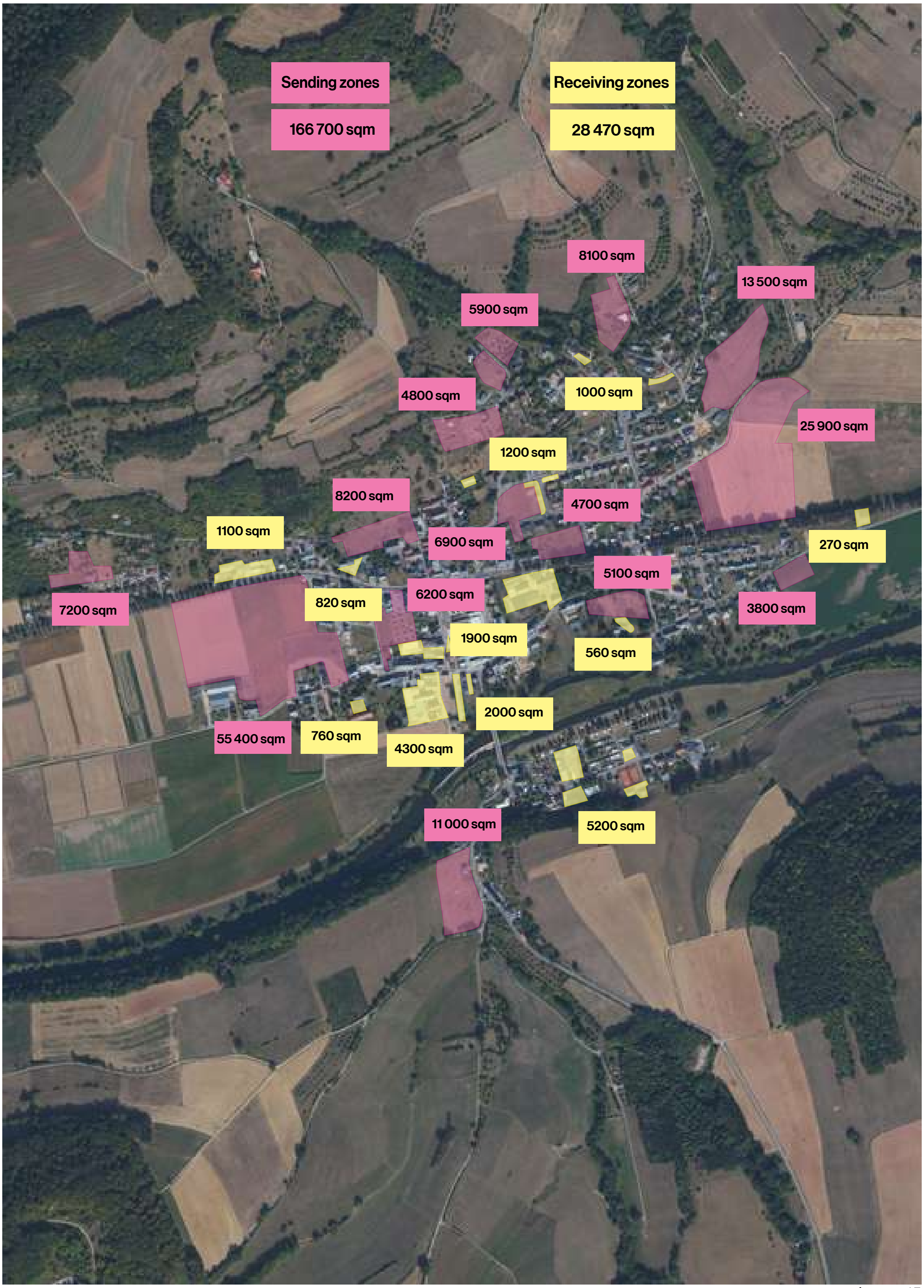

Sending zones
166 700 sqm
Receiving zones
28 470 sqm
8100 sqm
13 500 sqm
5900 sqm
4800 sqm
1000 sqm
25 900 sqm
1200 sqm
8200 sqm
4700 sqm
1100 sqm
6900 sqm
270 sqm
5100 sqm
7200 sqm
820 sqm
6200 sqm
3800 sqm
1900 sqm
560 sqm
2000 sqm
55 400 sqm
760 sqm
4300 sqm
11 000 sqm
5200 sqm

image 15

image 16

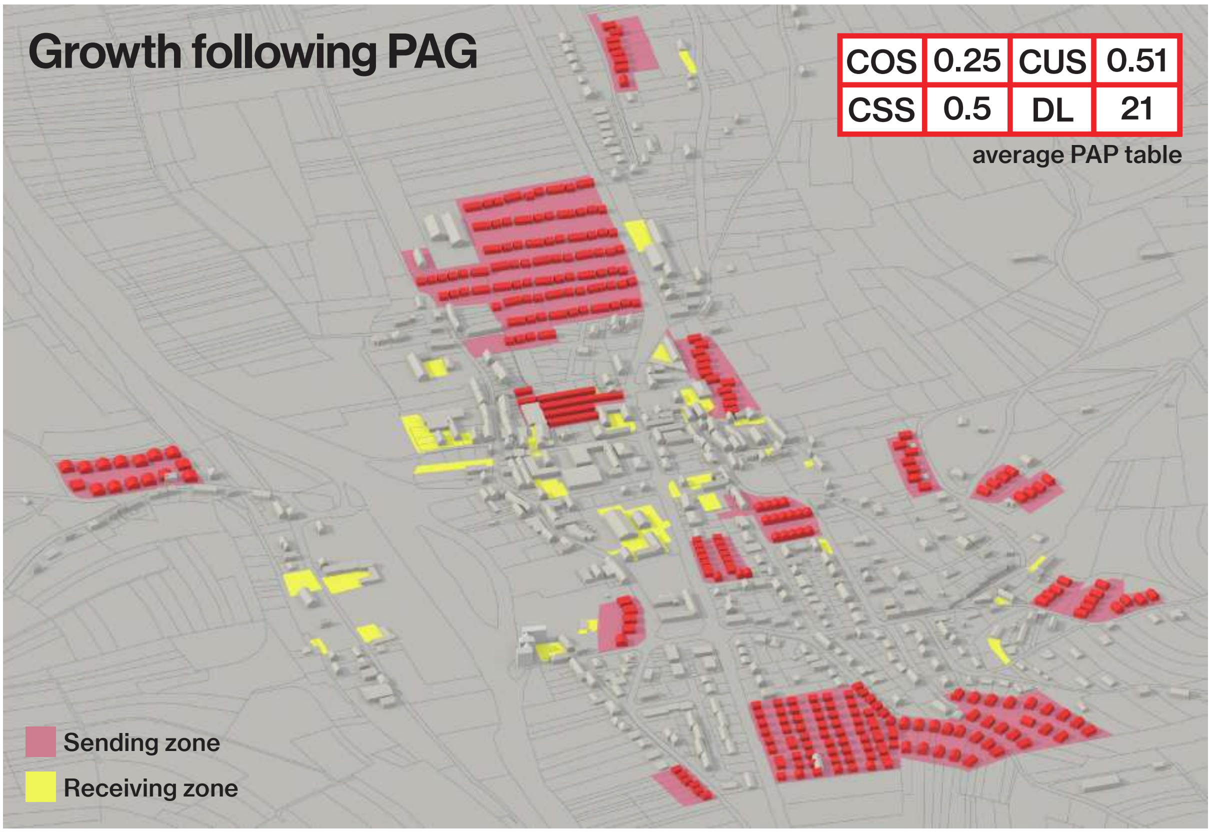
imags 17, 18

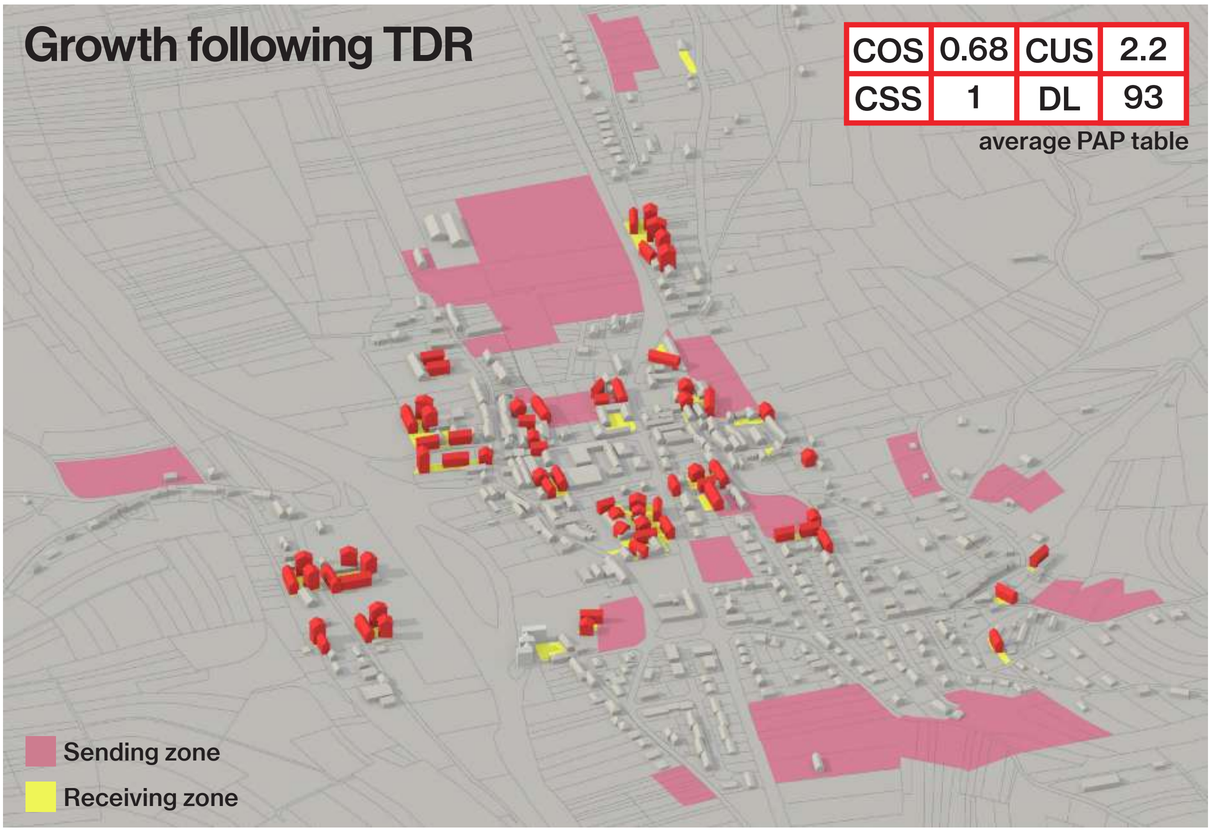
# Bettendorf
# Business as usual vs LiT proposal

With the TDR instrument in place, and following our proposed sending and receiving zones, we carried out a scenario where growth is projected over the receiving site as much as possible, while considering the identity of the village. Two factors were taken into consideration while planning the receiving sites. First was to not build more than 4 floors along the streets which form the historical core of the village built before 1900s. For all other areas, Moulin de Bettendorf stood as a reference for maximum height. Using this guidelines, 64,900 sqm of floor area was projected over the receiving sites.

With a more compact village, there is a higher incentive for services such as grocery stores and leisure amenities to serve the community. Village centres will become more lively especially if spaces for economic activities are also considered while planning growth.
The growth of the village over its existing sealed surfaces also has a limit. When and if the village reaches this cap and exhausts its sealed surface capacity, the deeds which have matured in the sending zones can be revisited. The use and rights of those sites can be reimagined in alignment with the future vision of the village and the ambitions of its community.

image 19


Growth following PAG
COS 0.25 CUS 0.51
CSS 0.5 DL 21
average PAP table
Sending zone
Receiving zone


Growth following TDR
COS 0.68 CUS 2.2
CSS 1 DL 93
average PAP table
Sending zone
Receiving zone

*“Zones that are on the edge of the villages are sometimes easier to activate in comparison to the more central locations which tend to have more complexities in ownership.”*

Lex Faber
Urban planner & Managing partner
Zeyen+Baumann

*"To further incite qualitative development through TDR, there could be a bonus structure, where projects would be rewarded with development credit if they achieve innovative typologies, enhances public spaces, higher energy efficiency, and so on."*

# Helfent

In Helfent, the PAG anticipates a relatively modest growth. However the vast arable lands beyond its edge are subject to landtake as well.
For the purpose of consistency in this exercise we have not taken into account the areas beyond the helfent perimeter, but our approach allows for capturing much higher floor areas and foresees the possibility to capture the growth projected beyond Helfent, over Helfent.

The PAG has projected new development rights for a number of arable parcels, in addition to a few sealed parcels. Following the principles of the PAP tables for these parcels we have illustrated the resulting fabric if business as usual continues. These volumes are visible in bright white on the opposite page. In transparent grey, we have shown how this spirit of landtake can infinitely grow to occupy the whole valley, if environmental values are disregarded, and the planning culture remains unchanged.

Benefiting from a strategic location, and a unique mix of functions, Helfent has the key ingriedients to move beyond its suburban state, and to elevate itself to a core on the edge of the city. Compacting the demand for growth over the vast existing sealed surfaces of Helfent provides the opportunity to respond to growth without landtake, or the burden of infrastructural cost of sprawl, while moving towards a visionary outlook for Helfent as an active edge, complementing Luxembourg city.

## PAG

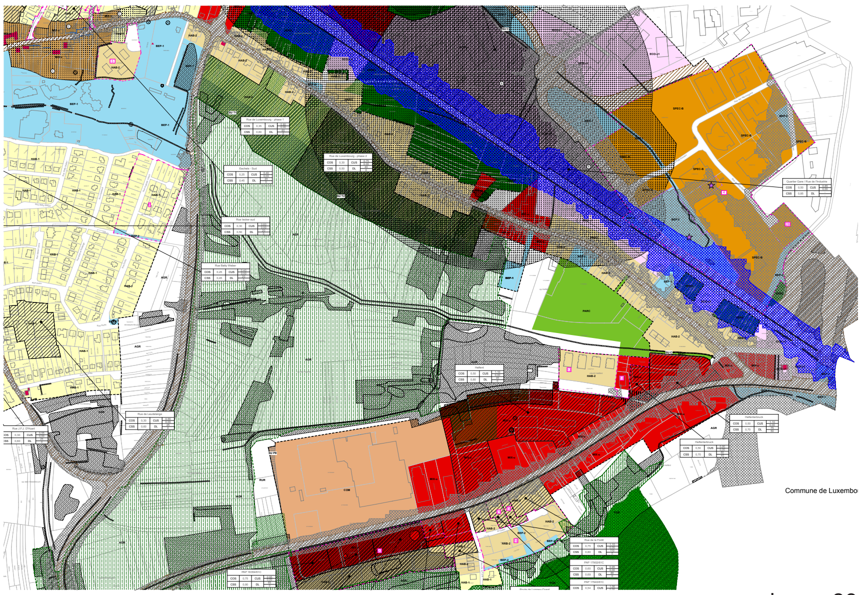



image 20



images 21,22

images 23,24

image 25

# Helfent
# sending & receiving zones

To begin the TDR procedure in Helfent, we first identified the arable lands categorised as developable parcels in the PAG as our sending zones accounting for 128,800 sqm in total. We also scouted for potential receiving zones, which constitute of the vast open-air parking surfaces and a number of single story sheds and warehouses which are planned for further densification under their new PAP tables.

This collection of sending and receiving zones, build the foundation for a new market of trade for development rights.

By protecting the natural land cover in and around Helfent, we would be able to enhance its sequestration capacities in addition to preserving the generous natural assets around Luxembourg city. Rehabilitating the Petrusse riverbanks and introducing leisure activities along the green corridors released from the pressure of landtake, would contribute to biodiversity, community wellbeing, and water infiltration.

image 26

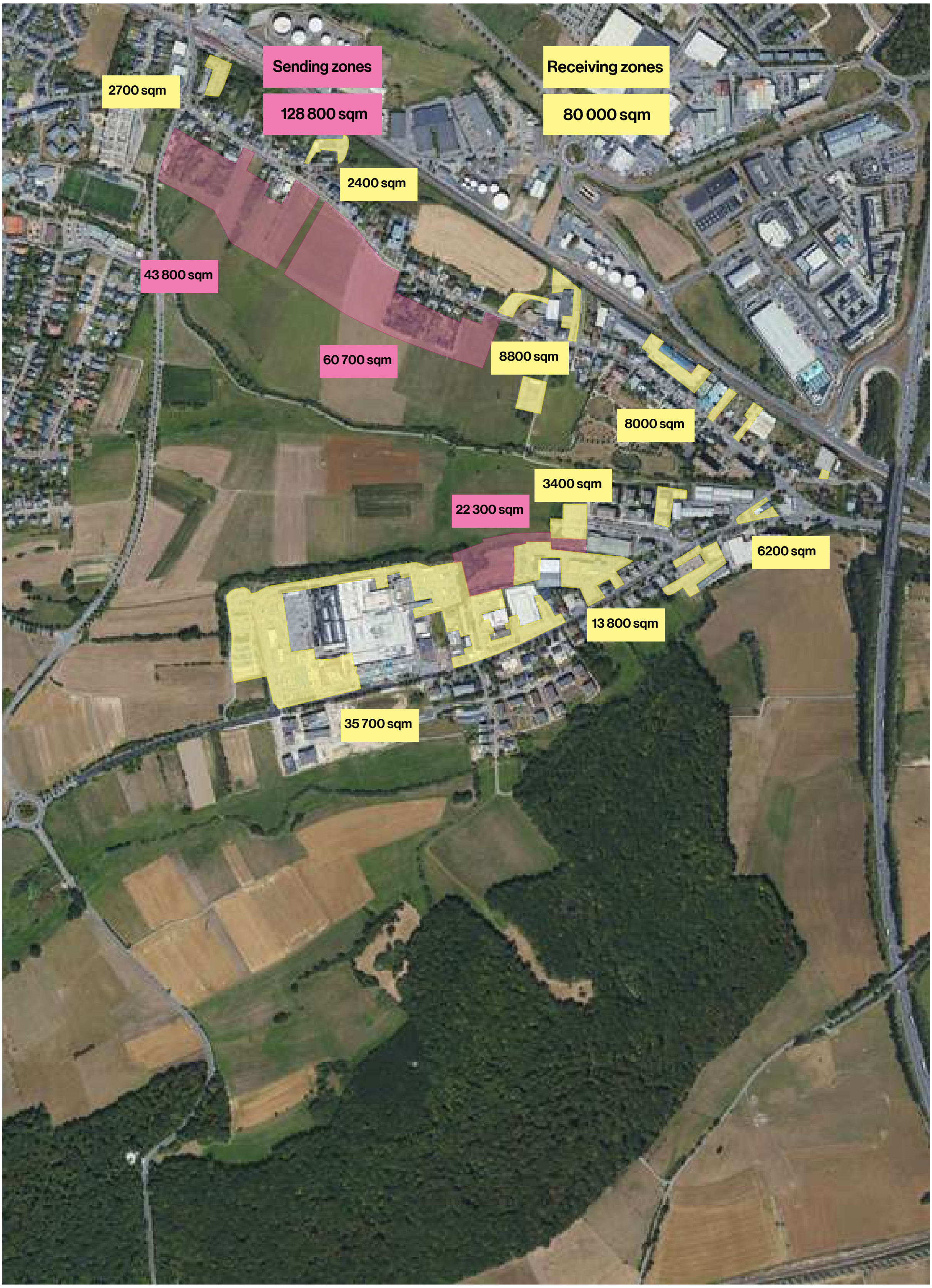

Sending zones
128 800 sqm
Receiving zones
80 000 sqm
2700 sqm
2400 sqm
43 800 sqm
60 700 sqm
8800 sqm
8000 sqm
3400 sqm
22 300 sqm
6200 sqm
13 800 sqm
35 700 sqm

image 27


images 28,29

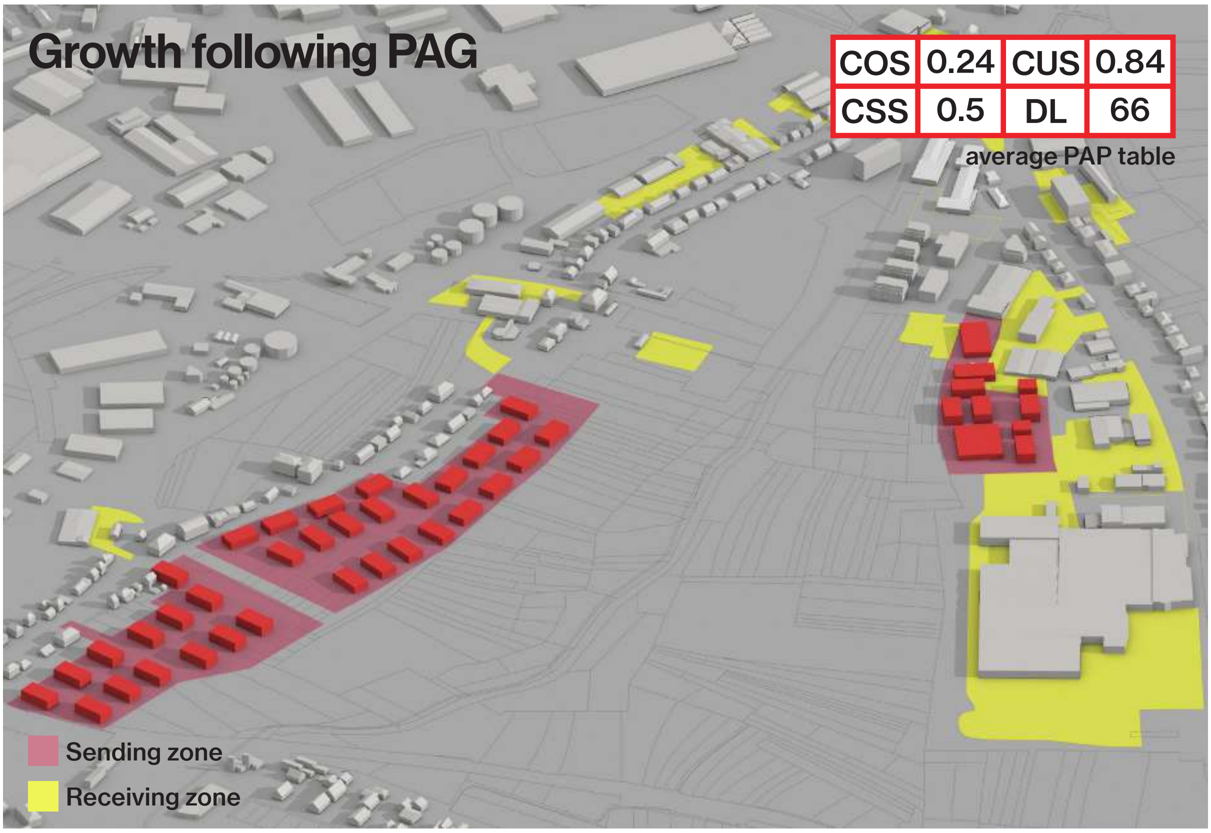

images 30,31

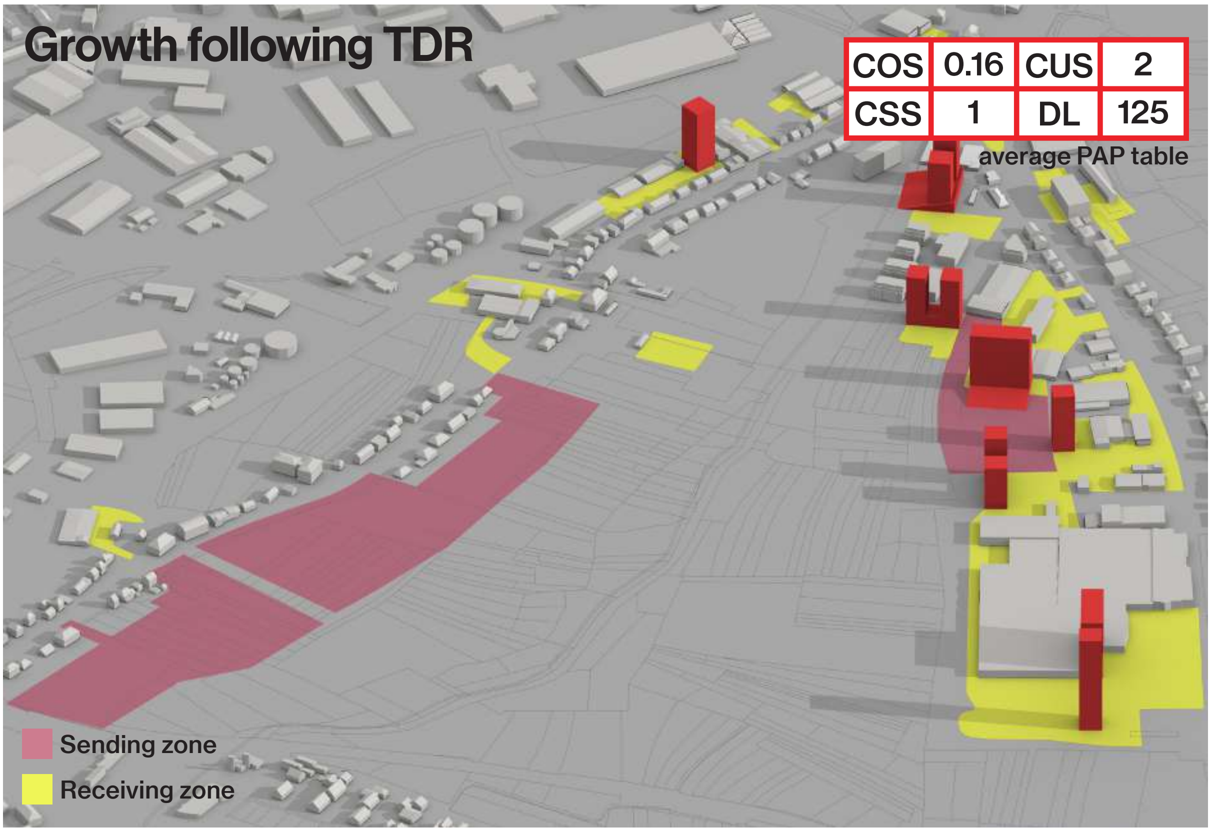
# Helfent
# Business as usual vs LiT proposal

With the current rate of landtake proposed in the PAG, Helfent will lose 128,800 sqm of its arable land. Taking the current state of affairs in Helfent into account, including structures and landscapes that are of large proportions, we came to the conclusion that the highrise typology will serve as the most land-efficient choice. We also took into account the limitation of construction with timber, to determine the height of the highrises, which are capped at 20 floors. Taking inspiration from existing compounds on site such as Piwel, the plinths of the highrises were seen as multistorey industrial, civic and commercial facilities. The floors above were treated as residences and offices.

With these considerations in mind, we developed new PAP tables for the sites, with emphasis on net-zero landtake and minimum soil sealing. This resulted in 163,600 of floor area in new developments over existing sealed surfaces, which surpassed the growth trajectory of the PAG within the boundary of Helfent. In this way, the area could now take in the growth that is projected beyond its edges as well.

image 32


Growth following PAG
COS 0.24 CUS 0.84
CSS 0.5 DL 66
average PAP table
Sending zone
Receiving zone


Growth following TDR
COS 0.16 CUS 2
CSS 1 DL 125
average PAP table
Sending zone
Receiving zone

*“Through an intricate system of subsidies, PAGs, and lack of taxation, owners of undeveloped construction land have become accustomed to a “golden cushion” in which their indecision provides them with the highest returns. Their land value continues to increase, while they have a stable income from their agricultural products. There is not enough incentive to transform even when they have the right to develop their land, as they enjoy the speculative dimension of keeping it as an option for the future.”*

Antoine Paccoud
Research Scientist
LISER

*“To facilitate the implementation of TDR, we can imagine a precondition for municipalities to put the TDR system in place before being able to designate new growth areas.”*

Lex Faber
Urban planner & Managing partner
Zeyen+Baumann

*“Municipalities could benefit from such a tool, as they can use it to unlock transfer of large development backlogs which have been standing still since the 1960s and do not correspond anymore to their spatial ambitions today.”*

*"TDR could potentially be integrated into the point system in practice today which compensates for the loss of biodiversity values with new constructions. In this way municipalities can take into account land use emissions in a quantifiable manner. TDR would also add a new perspective to the evaluation system of the climate pact which is mostly focused on reducing CO2 emissions caused by the use of fossil energies."*

Rainer Telaar
Pacte Climat consultant

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**Tables**

table 1

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**Figures**

fig. 1: The sequestration deficit of landtake. 51n4e, 2001, LOLA. (2021). LiT Report Phase 2. https://luxembourgintransition.lu/wp-content/uploads/2021/06/2phase_2001-komprimiert.pdf

fig. 2: The carbon cost of one hectare. 51n4e, 2001, LOLA. (2021). LiT Report Phase 2. https://luxembourgintransition.lu/wp-content/uploads/2021/06/2phase_2001-komprimiert.pdf

**Images**

image 1: Nathan, P. (photographer). (2020). Luxembourg [photograph]

images 2,3: Google Earth. (2020). https://www.google.it/intl/it/earth/

image 4: Nathan, P. (photographer). (2020). Luxembourg [photograph]

image 5: Justinian, Corpus iuris civilis (“Digest”). (1275). [Single folio on vellum]. Https://Digitalcommons.Winthrop.Edu/Medievalmanuscript/6/.

image 6:  Kohlstedt, K. (2017, June 23). Selling the Sky: “Air Rights” Take Strange Bites Out of Big Apple Architecture. 99% Invisible. https://99percentinvisible.org/article/selling-sky-air-rights-take-strange-bites-big-apple-architecture/

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image 9,10,11: Commonwealth of Massachusetts. (2020). Smart Growth / Smart Energy Toolkit Modules -Transfer of Development Rights (TDR). Mass.Gov. Retrieved December 23, 2021, from https://www.mass.gov/service-details/smart-growth-smart-energy-toolkit-modules-transfer-of-development-rights-tdr

image 12: Geoportal. (2021). https://www.geoportail.lu/en/

images 13, 14: Nathan, P. (photographer). (2020). Luxembourg [photograph]

image 15: Google Earth. (2020). https://www.google.it/intl/it/earth/

images 16, 17, 18: Nathan, P. (photographer). (2020). Luxembourg [photograph]

image 19: Mill of Bettendorf seen from the river Sûre (2014). Wikimedia commons. https://commons.wikimedia.org/wiki/File:Moulin_de_Bettendorf_01.jpg

image 20: Geoportal. (2021). https://www.geoportail.lu/en/

images 21,22: Nathan, P. (photographer). (2020). Luxembourg [photograph]

images 23, 24, 25, 26: oNathan, P. (photographer). (2020). Luxembourg [photograph]

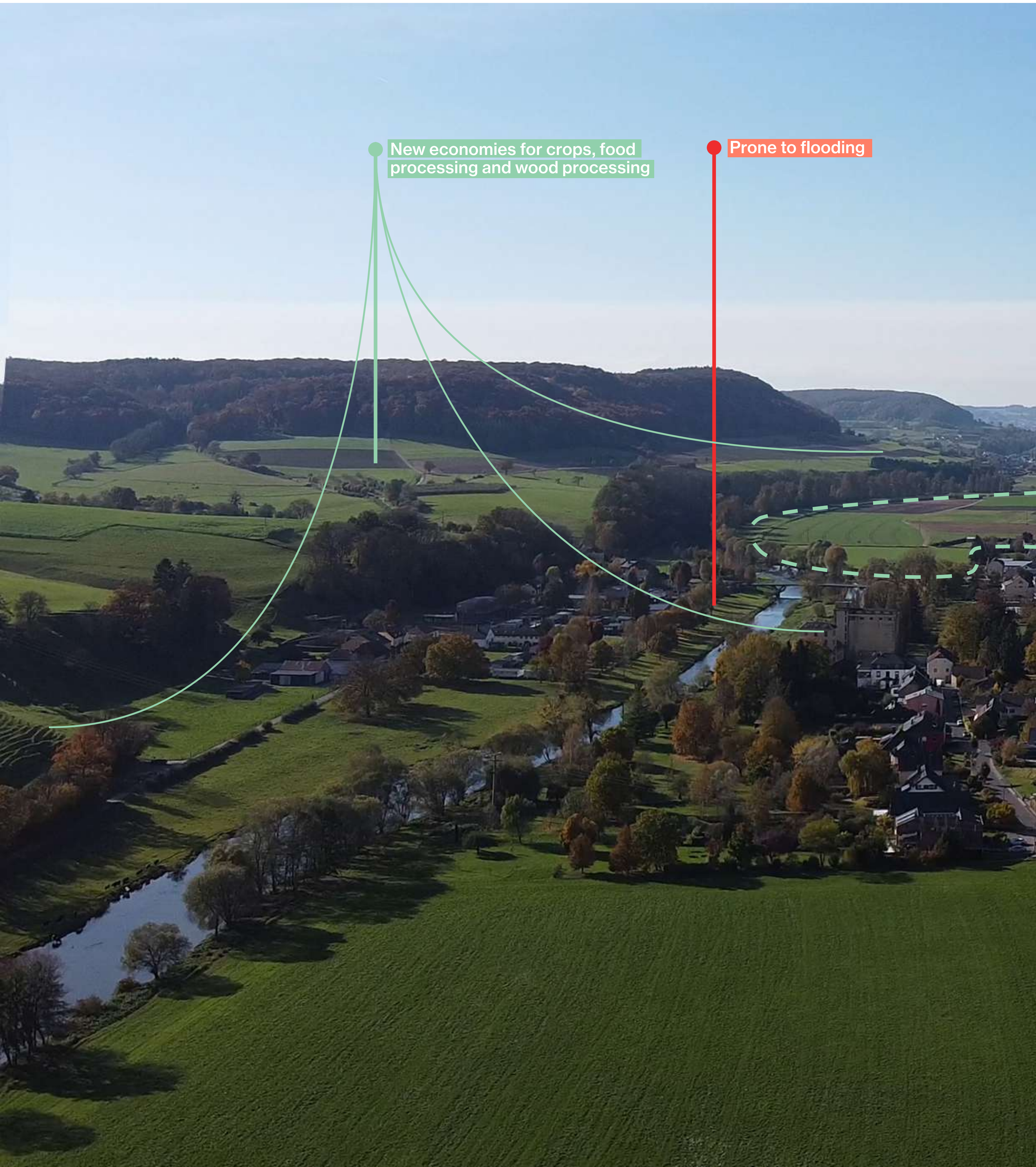
image 27:Google Earth. (2020). https://www.google.it/intl/it/earth/

images 28,29 30, 31: Nathan, P. (photographer). (2020). Luxembourg [photograph]

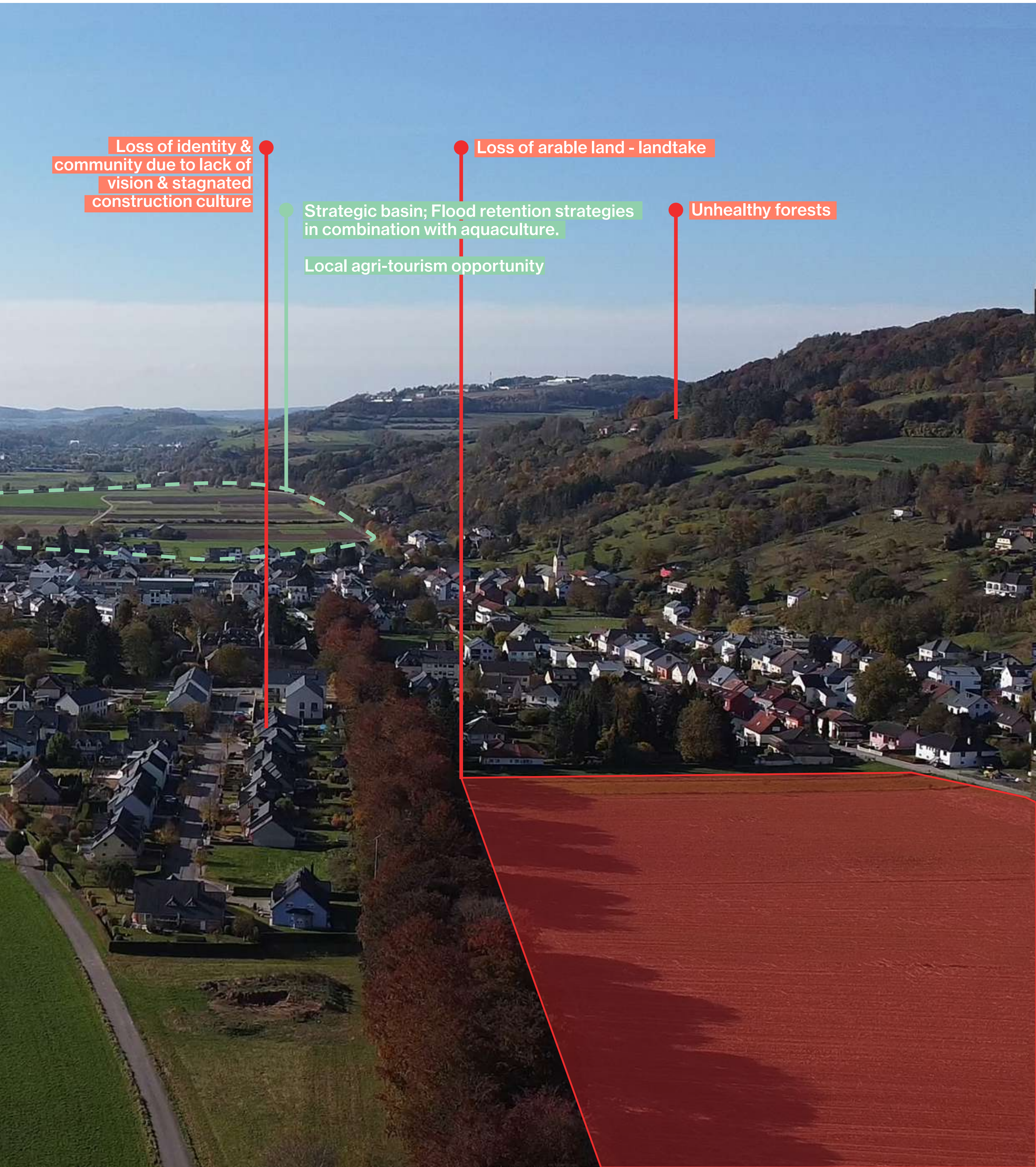
image 32: CF Moller (2020). Kajstaden tower. https://www.cfmoller.com/p/Kajstaden-Tall-Timber-Building-i3592.html

# Territorial Showcases

# Showcase 1


New economies for crops, food processing and wood processing
Prone to flooding

# Bettendorf

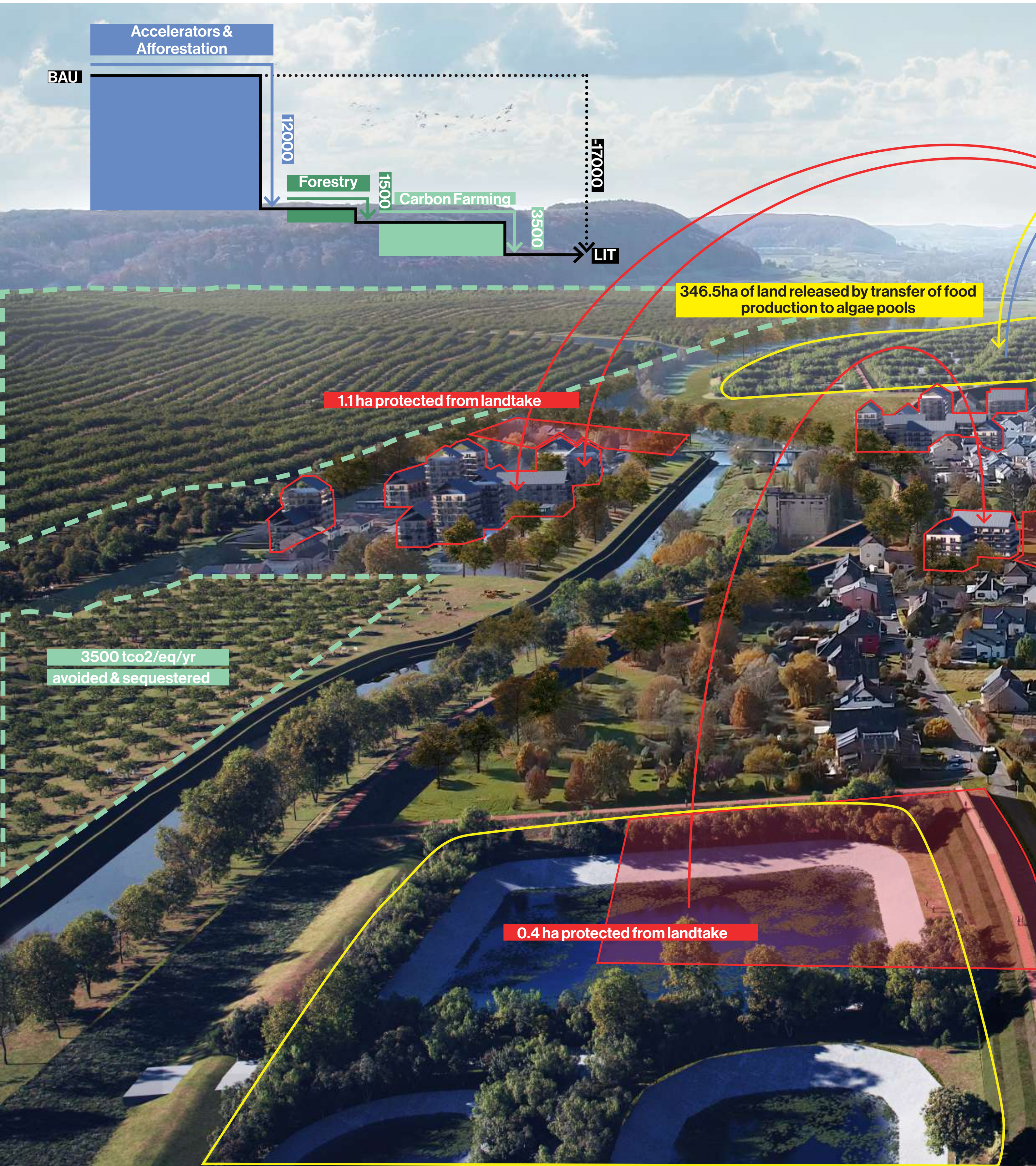

Loss of identity & community due to lack of vision & stagnated construction culture
Loss of arable land - landtake
Strategic basin; Flood retention strategies in combination with aquaculture.
Local agri-tourism opportunity
Unhealthy forests

# Bettendorf 2050 Business as usual

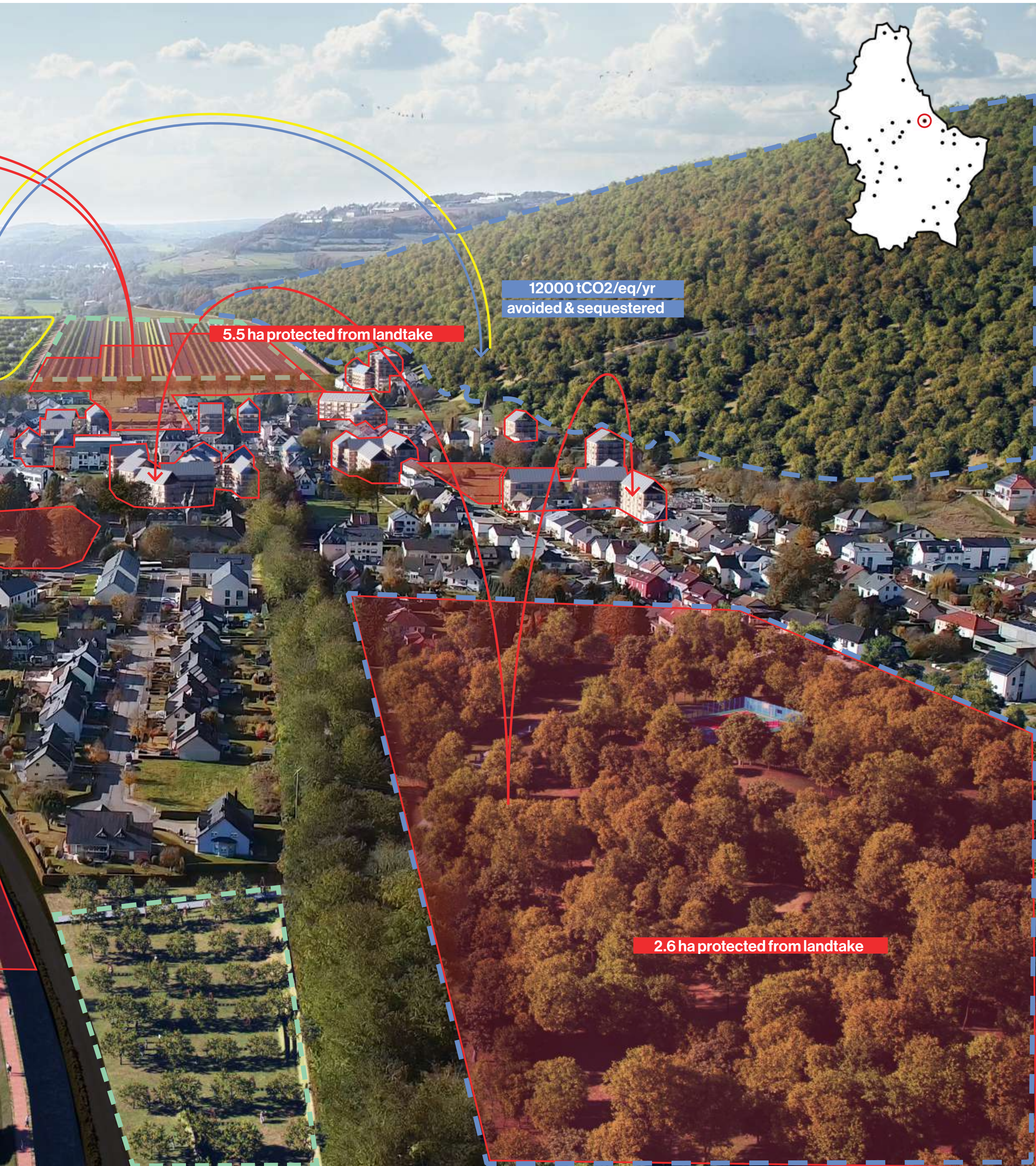
Landtake in combination with speculative low density development will lead to an evergrowing sprawl condition resulting in a gradual loss of character for the village. Sealed soil will put a burden on climate mitigation activities. Without addressing the food & wood value chain, the opportunity for new economies will be lost, and when the Sauer floods again, the village will be subject to costly damages.

# Bettendorf 2050 Proposal
# Resilient Ruralities

Bettendorf in 2050 is a dense and compact village with a strong rural character. The new apartments allow for the natural land cover to be preserved and enhanced. New public forests connect the existing forests together and form accessible treks to walk and cycle through. The algae pools have provided the village with new economies and have made the region much more resilient in face of floods. In addition they have accelerated the land release from feed production



which can now be afforested. The timber from afforested lands and new crops have also contributed to a more vibrant economy in the village attracting new demographies to its social fabric. With the village having a higher population and a more vibrant community, services such as groceries, bakeries, schools, medical facilities and leisure activities are more present. The arrows over the image below show the land management interventions in action which result in enhancing negative emissions of Bettendorf, as shown in the timeline.



# Bettendorf
# Decarbonsation menu

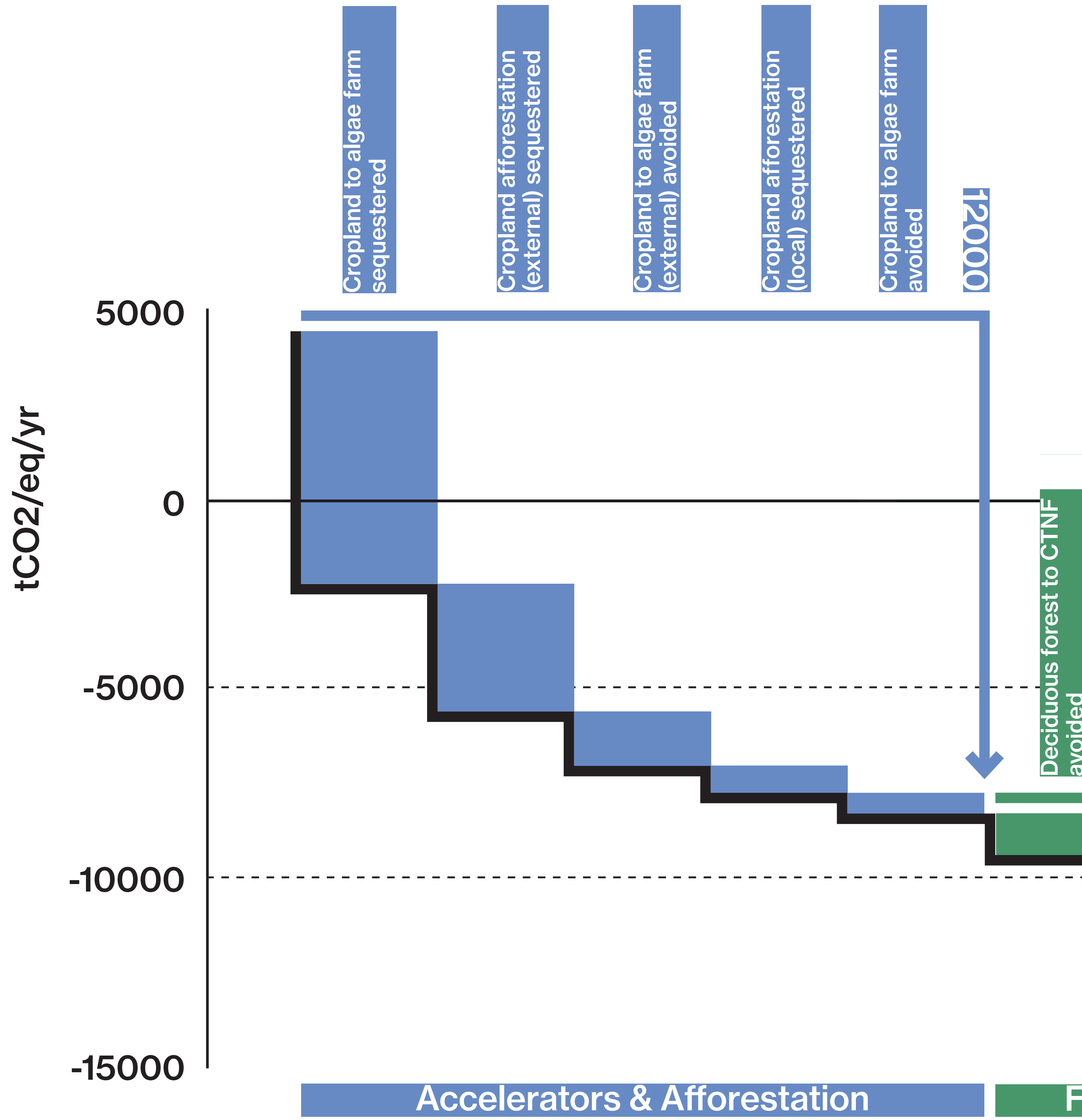
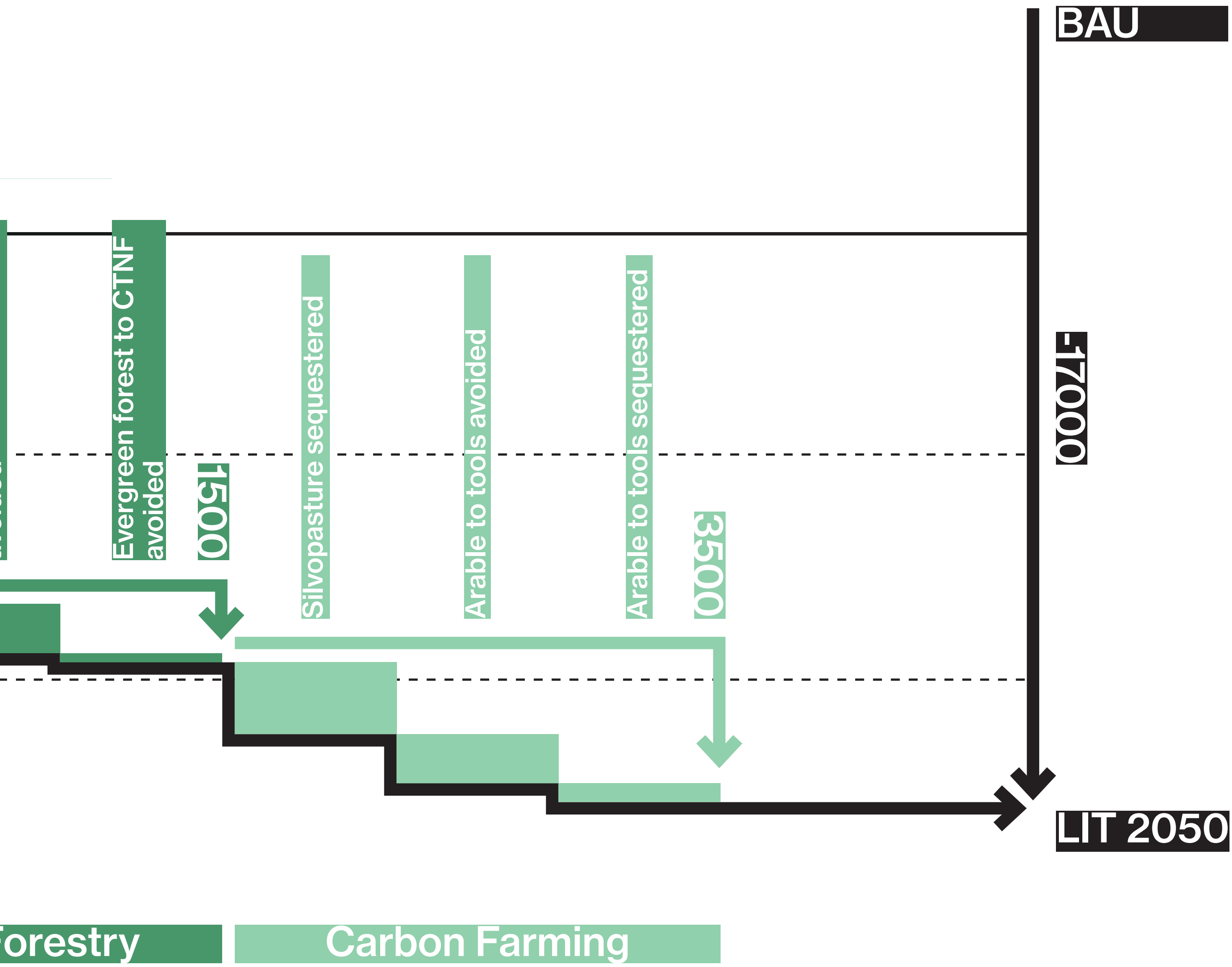



fig 3: Decarbonization menu showcase 1.


BAU
-17000
Evergreen forest to CTNF avoided
1500
Silvopasture sequestered
Arable to tools avoided
Arable to tools sequestered
3500
LIT 2050
Forestry
Carbon Farming

# Bettendorf 2050; Resilient Ruralities

The sealed surfaces of abandoned farm barns become new housing experiences with activated ground floors. Heritage serves as prospective base for socio-economic revitalization of rural villages.

In central locations, inhabitants of 4 to 5 level collective housing villas will benefit from services and small retail that shoulder light agroforestry processing.

1. Old farmhouses are preserved and refurbished. Their architecture allows them to become either collective housing or services such as medical practices.
2. Single floor barns are replaced by active ground floors hosting services like small-scale shops or cafés.
3. These ground floors can also integrate processing and craft, linked to working with local resources.
4. Ground floors boast intensely vegetised roofs on which smaller housing units sit
5. In less central areas, 4-5 floor villas of collective housing are articulated around shared park areas

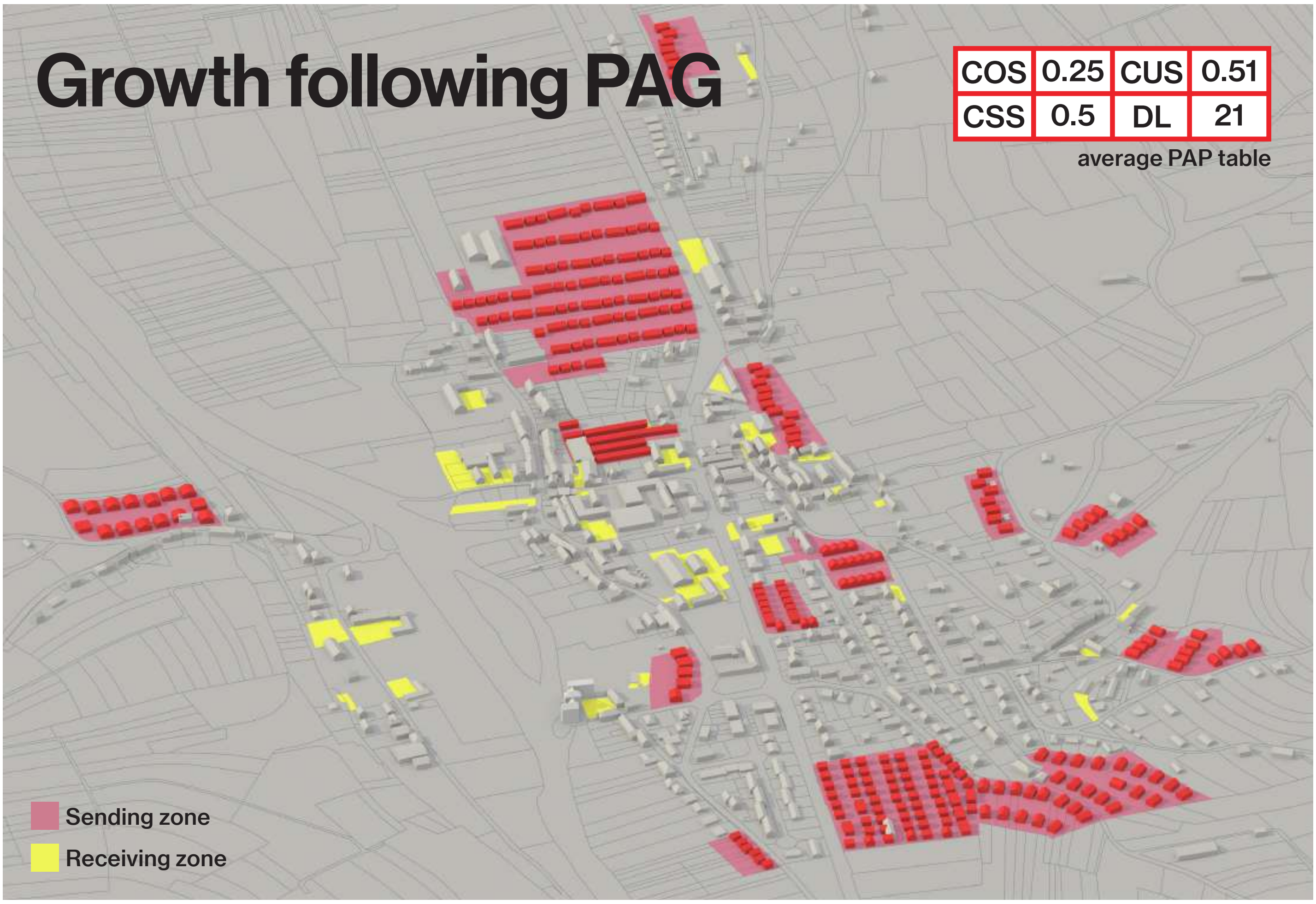
# Bettendorf
# Transfer of Development Rights

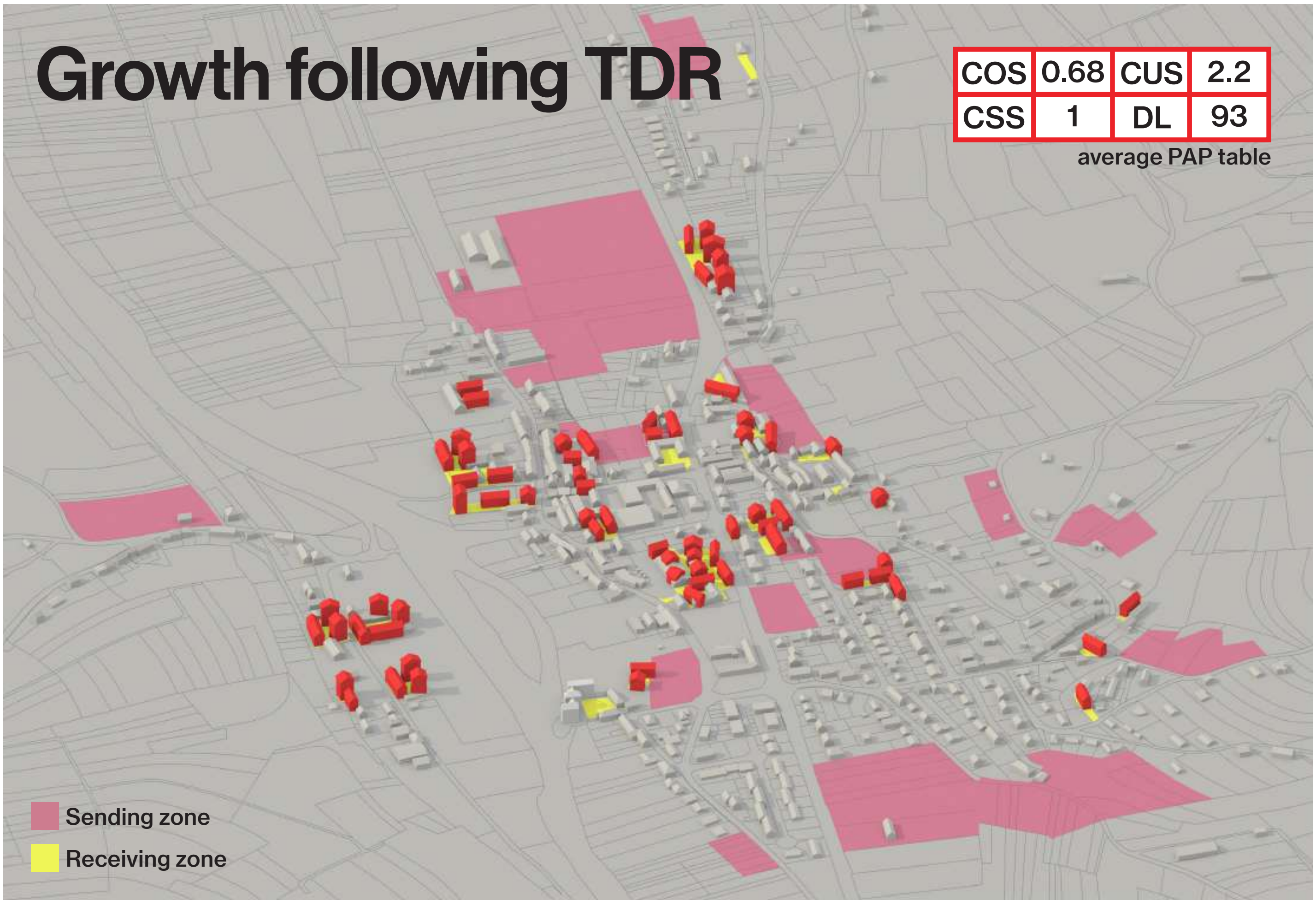
With the TDR instrument in place, and following our proposed sending and receiving zones, we carried out a scenario where growth is projected over the receiving site as much as possible, while considering the identity of the village. Two factors were taken into consideration while planning the receiving sites. First was to not build more than 4 floors along the streets which form the historical core of the village built before 1900s. For all other areas, Moulin de Bettendorf stood as a reference for maximum height. Using this guidelines, 64,900 sqm of floor area was projected over the receiving sites.

With a more compact village, there is a higher incentive for services such as grocery stores and leisure amenities to serve the community. Village centres will become more lively especially if spaces for economic activities are also considered while planning growth.

The growth of the village over its existing sealed surfaces also has a limit. When and if the village reaches this cap and exhausts its sealed surface capacity, the deeds which have matured in the sending zones can be revisited. The use and rights of those sites can be reimagined in alignment with the future vision of the village and the ambitions of its community.


image 1: Mill of Bettendorf seen from the river Sûre (2014).


Growth following PAG
COS
0.25
CUS
0.51
CSS
0.5
DL
21
average PAP table
Sending zone
Receiving zone


Growth following TDR
COS
0.68
CUS
2.2
CSS
1
DL
93
average PAP table
Sending zone
Receiving zone

# Bettendorf
# Land use change 2021 to 2050

- Industrial cropland
- Pasture
- Space for river
- Urban green
- Space for river
- Forest
- Afforested (5 yr)
- Afforested (15 yr)
- Afforested (30 yr)
- Silvo-pasture (5 yr)
- Silvo-pasture (15 yr)
- Silvo-pasture (30 yr)
- Strip cropping
- Aquaculture
- Wetland
- River

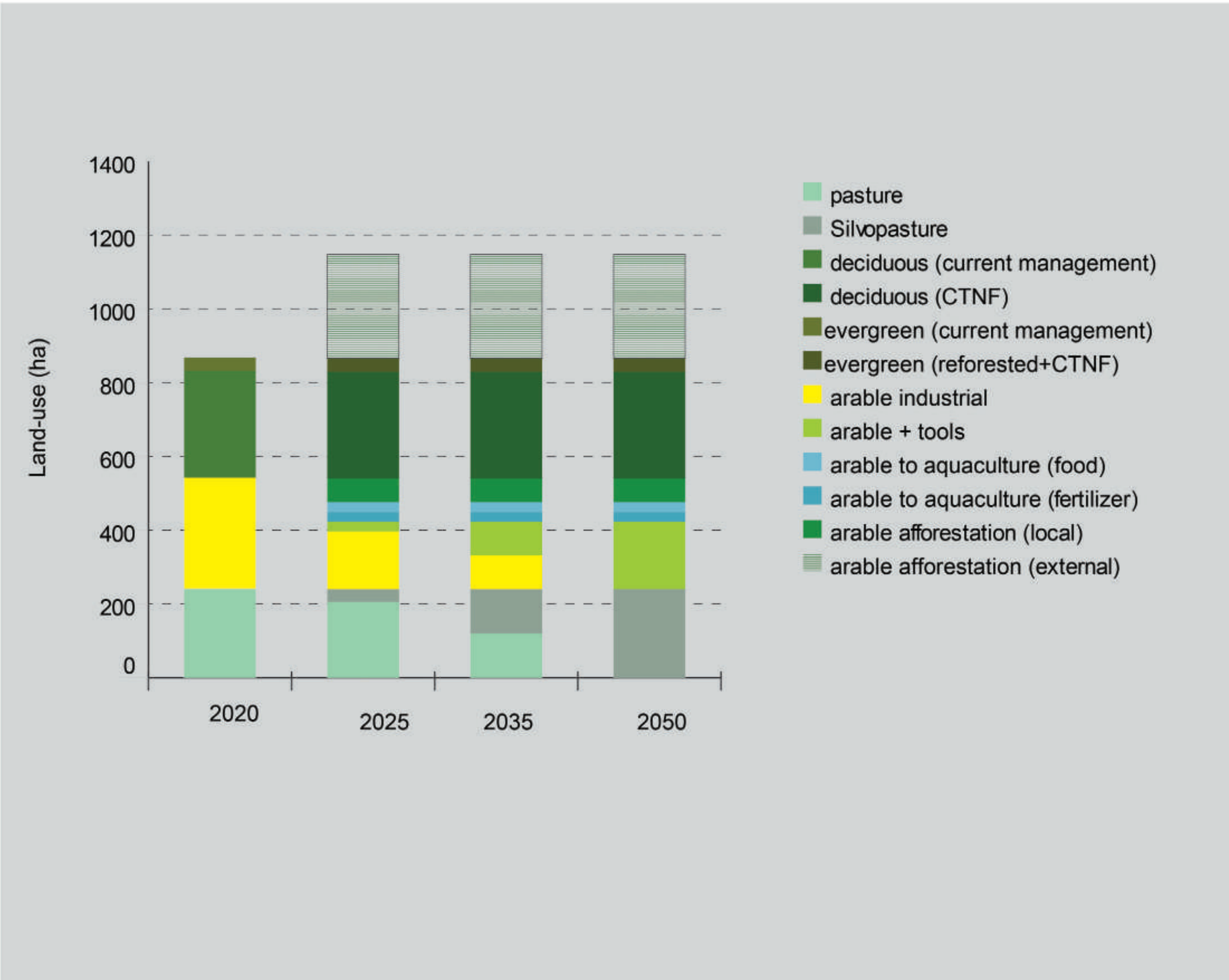



fig 1: Landuse change showcase 1.

2021

2025

2035

2050

# Bettendorf
# Agriculture and LULUCF emissions
# 2021 to 2050

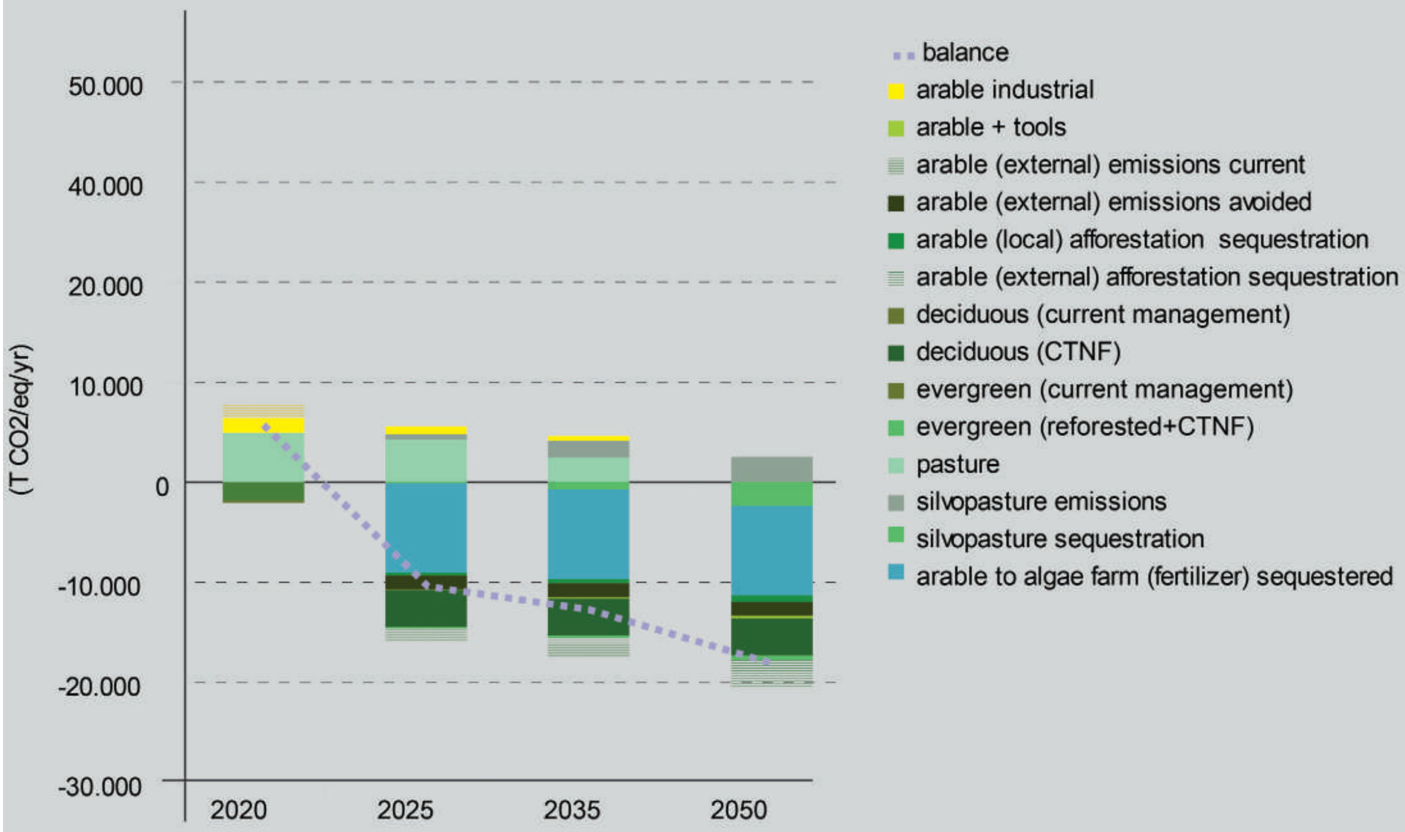



fig 2: Negative showcase 1.

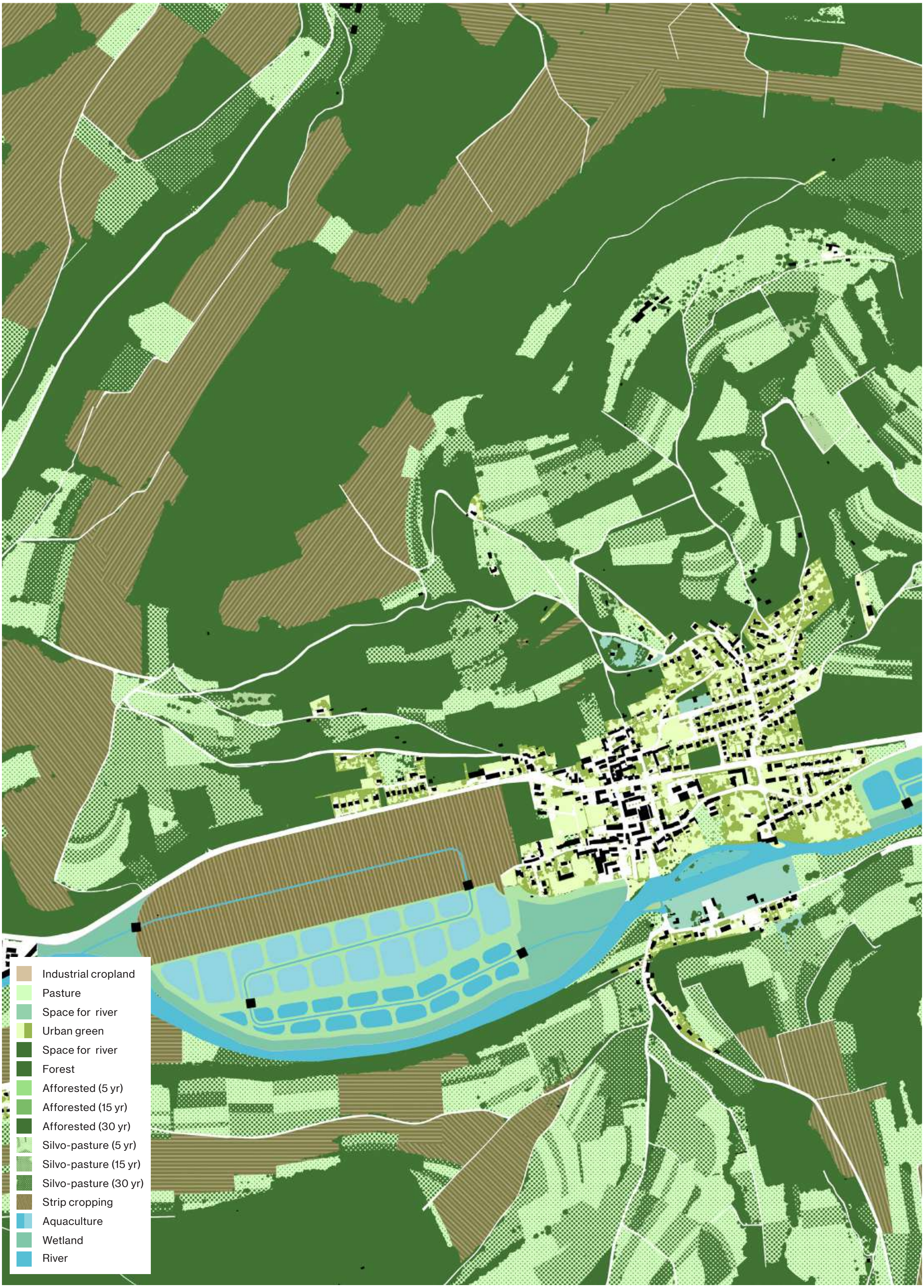
2021

2025

2035

2050

- 12,7 t CO2 eq./ha/yr + 20,47104 & - 10,0771 t CO2 eq./ha/yr - 1.4 t CO2 eq./ha/yr - 335 t CO2 eq./ha/yr

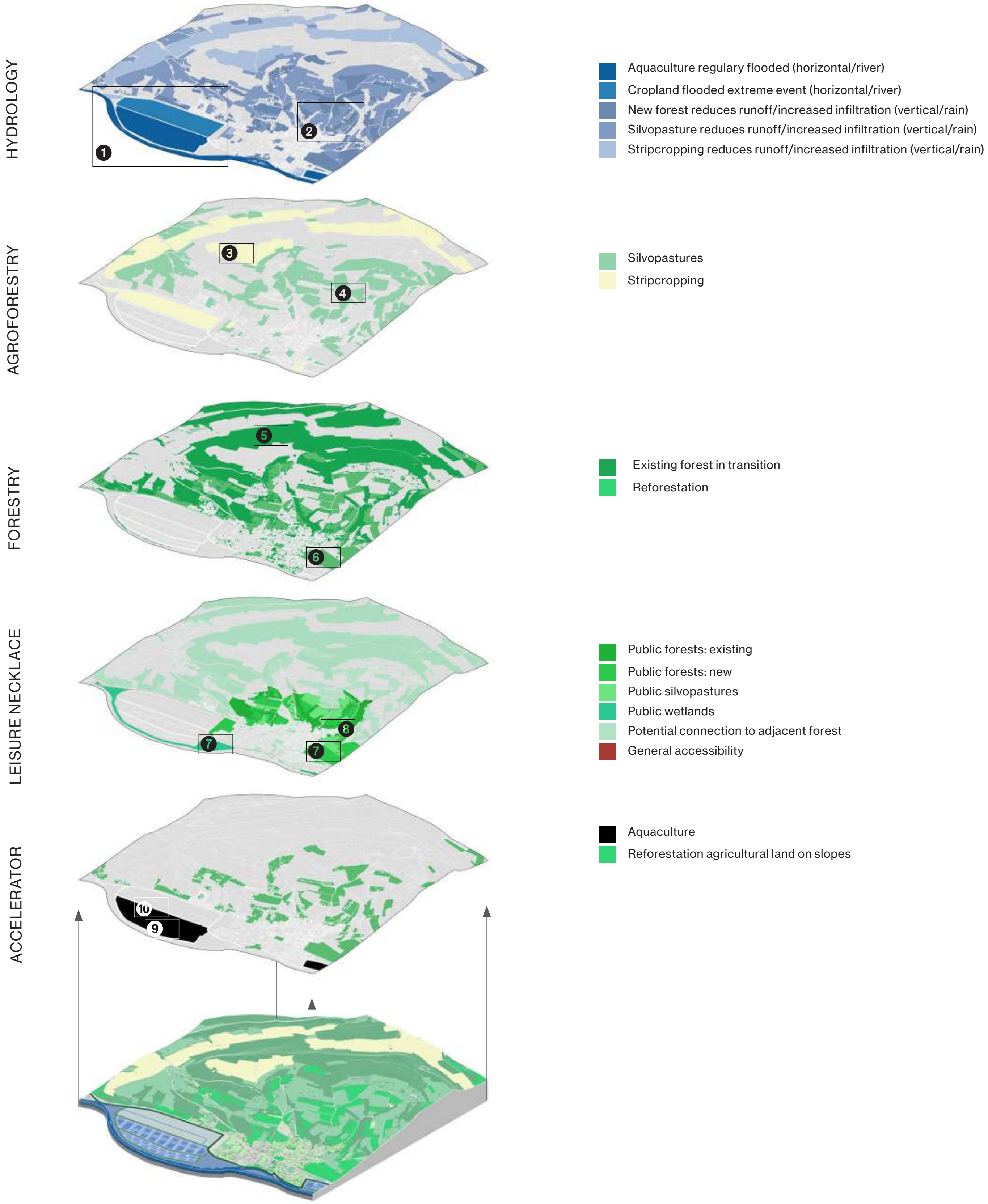



Land use change 2021 to 2050


Agriculture and LULUCF emissions 2021 to 2050

# Bettendorf
# Overview of tactile interventions

Multifaceted landscape development

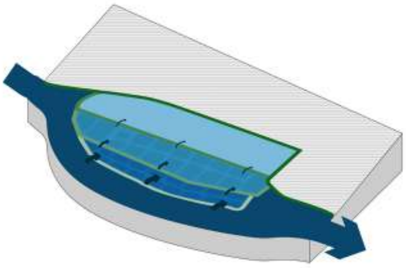



Land-use 2050

# Measures & principles

HYDROLOGY

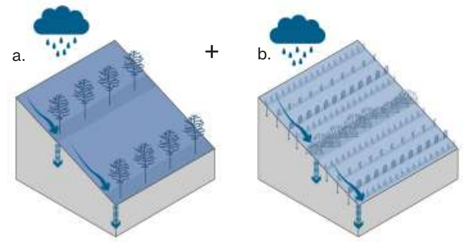
## Horizontal (river) flood relief



- HQ10
- HQ100
- HQ extreme
- safe zone
- high dike
- medium dike
- low dike
- very low dike

1

## Vertical (rain) flood relief

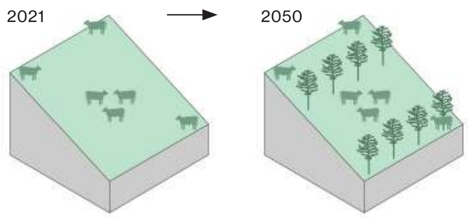



- a. silvopasture
- b. stripcropping
- runoff catchment
- infiltration/ groundwater recharge

2

AGROFORESTRY

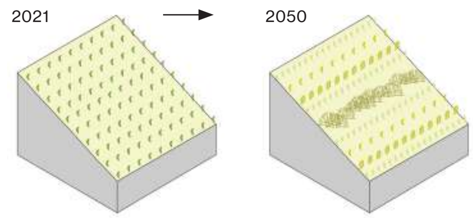
## Silvopastures




- Cattle
- Fruit/nuts

3

## Stripcropping

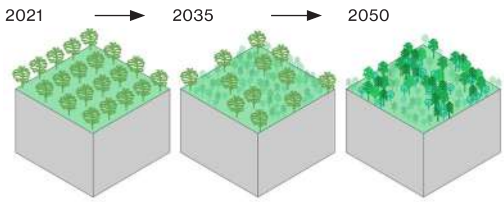



- monoculture
- polyculture
- ecological strip

4

FORESTRY

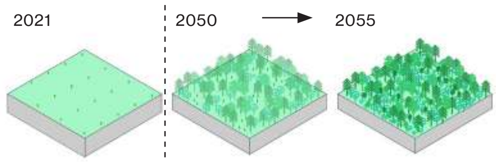
## Existing forest in transition




- Trees unadapted shifting climatic ranges
- Adaptive species diversification approach
- Resilient forests

5

## Close to nature forest management

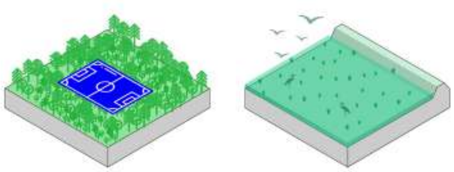



- clearfelling management
- selective harvest management
- mixed and uneven-aged, structurally diverse forest stands

6

LEISURE NECKLACE

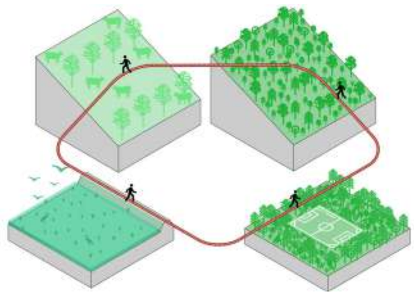
## Public functions



- urban program
- natural program

7

## Connectivity

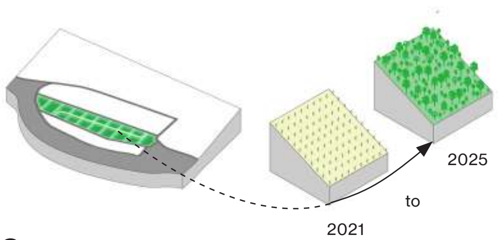


- General accesibility

8

ACCELERATOR

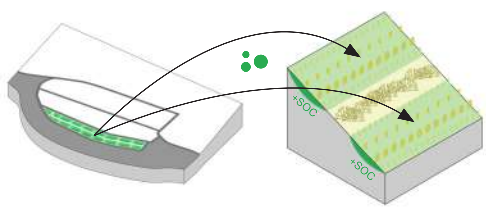
## Aquaculture accelerator: food footprint reduction and afforestation




- 13 x more yield/plant protein/ha
- freed-up cropland
- afforested cropland

9

## Aquaculture accelerator: algae as organic fertilizer and SOC source

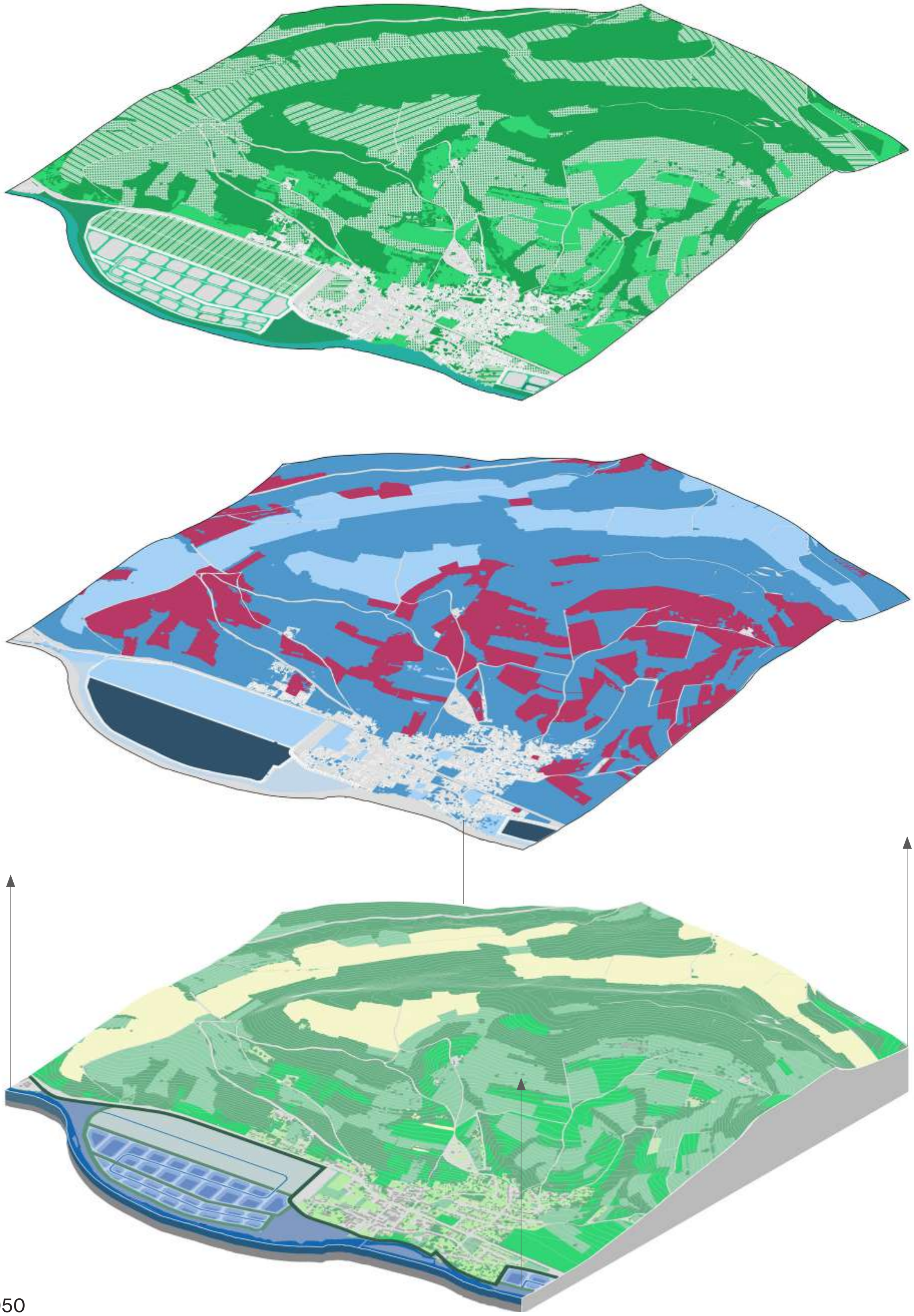



- Algae production 335 t CO2 eq./ ha/yr sequestration
- Organic fertilizer
- SOC increase

10

# Bettendorf
# Overview of tactile interventions

Decarbonisation as leverage for Integrated landscape development



Increased matrix connectivity by ecological intensification agriculture (sharing)

Increased matrix connectivity by sustainable intensification to set agricultural land aside for afforestation (sparing)

Heterogeneous patch types: novel and remnant natural and semi-natural habitats

- 12,7 t $CO_2$ eq./ha/yr

+ 20,47104 and - 10,0771 t $CO_2$ eq./ha/yr

- 1.4 t $CO_2$ eq./ha/yr

- 335 t $CO_2$ eq./ha/yr

Forest

Afforested

Silvo-pasture

Urban green

Strip cropping

Aquaculture

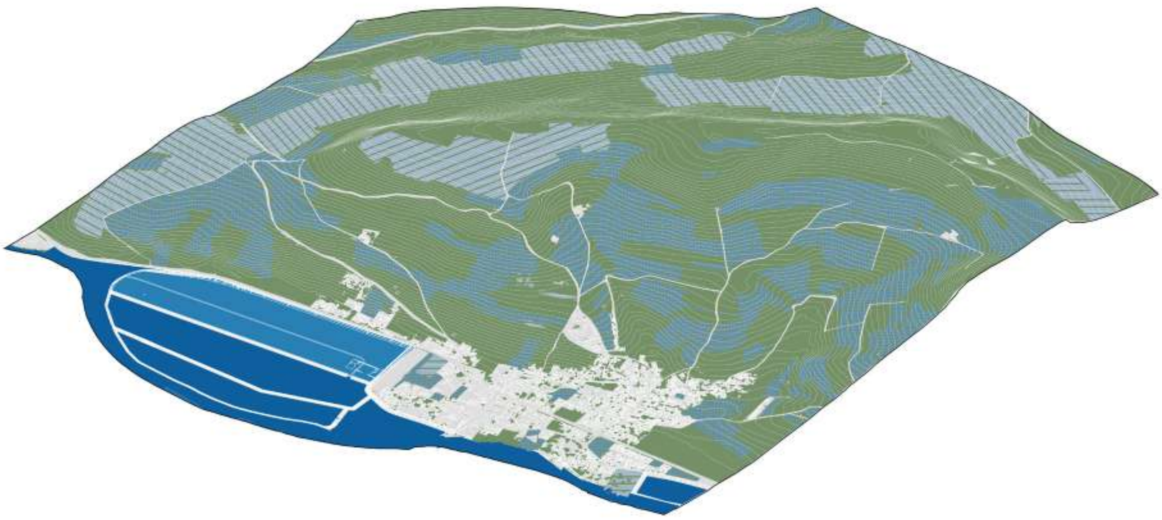
Wetland

River

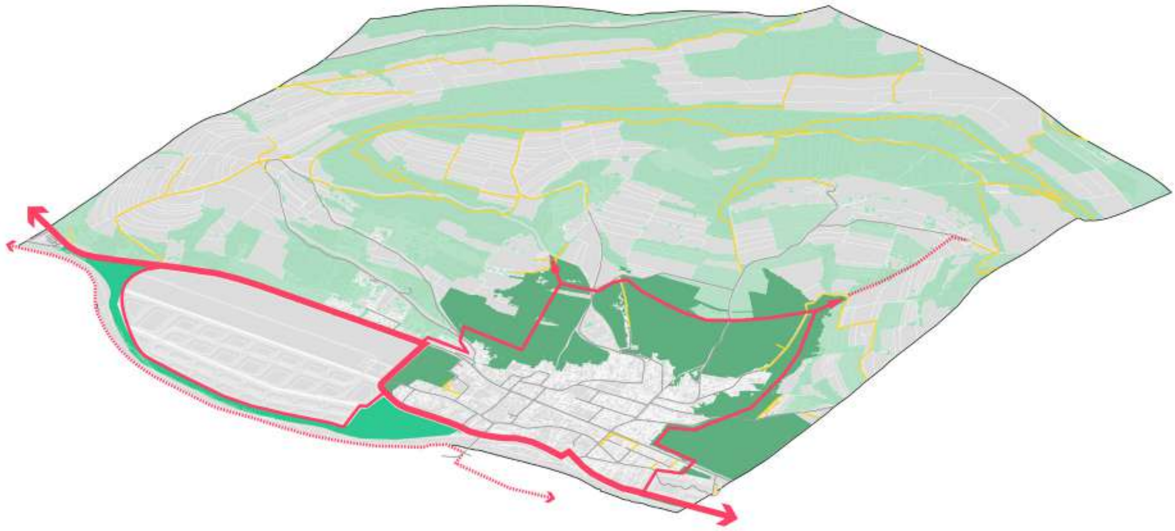
# Bettendorf
# Overview of tactile interventions

Decarbonisation as leverage for Integrated landscape development

RESILIENCE/ADAPTATION



LEISURE



PRODUCTIVE

reduced run-off, increased infiltration

reduced high river levels and reduced (flash) floodrisk low located villages

more space for the river to reduce the waterlevel of excess flows and avoid economical damage downstream due to large scale flooding

HQ 10 & 100: high to medium flood probability

HQ extreme: floods only during extreme event

climate/drought & future disturbance resilient forests

crop disease control, soil fertility increase, reduced erosion soil loss, increase soil water retention and availability

climate/drought & future disturbance resilience trees, increase soil water retention and availability

Existing bike path

New bike path

Leisure necklace access

Existing paved

Existing path

Leisure necklace

Existing forest

Mean annual merchantable
= 8 m3/ha/yr with close to nature forestry management

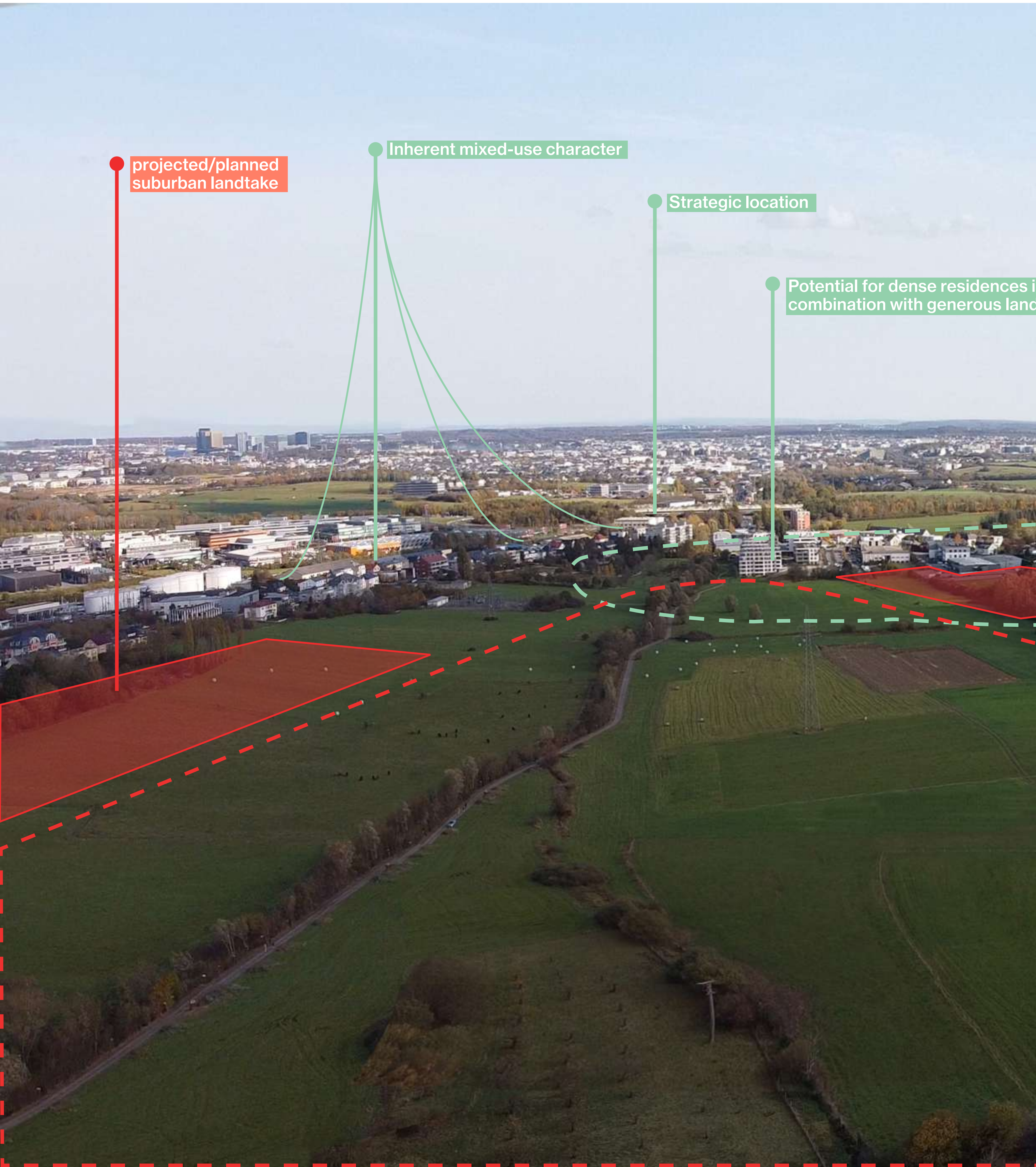
Silvopasture: 0.01 to 0.23 tons/ merchantable/protein/ha/yr

Protein crops: 1.8 tons/ merchantable/protein/ha/yr

Aquaculture algae for food: 13 tons/ merchantable/protein/ha/yr

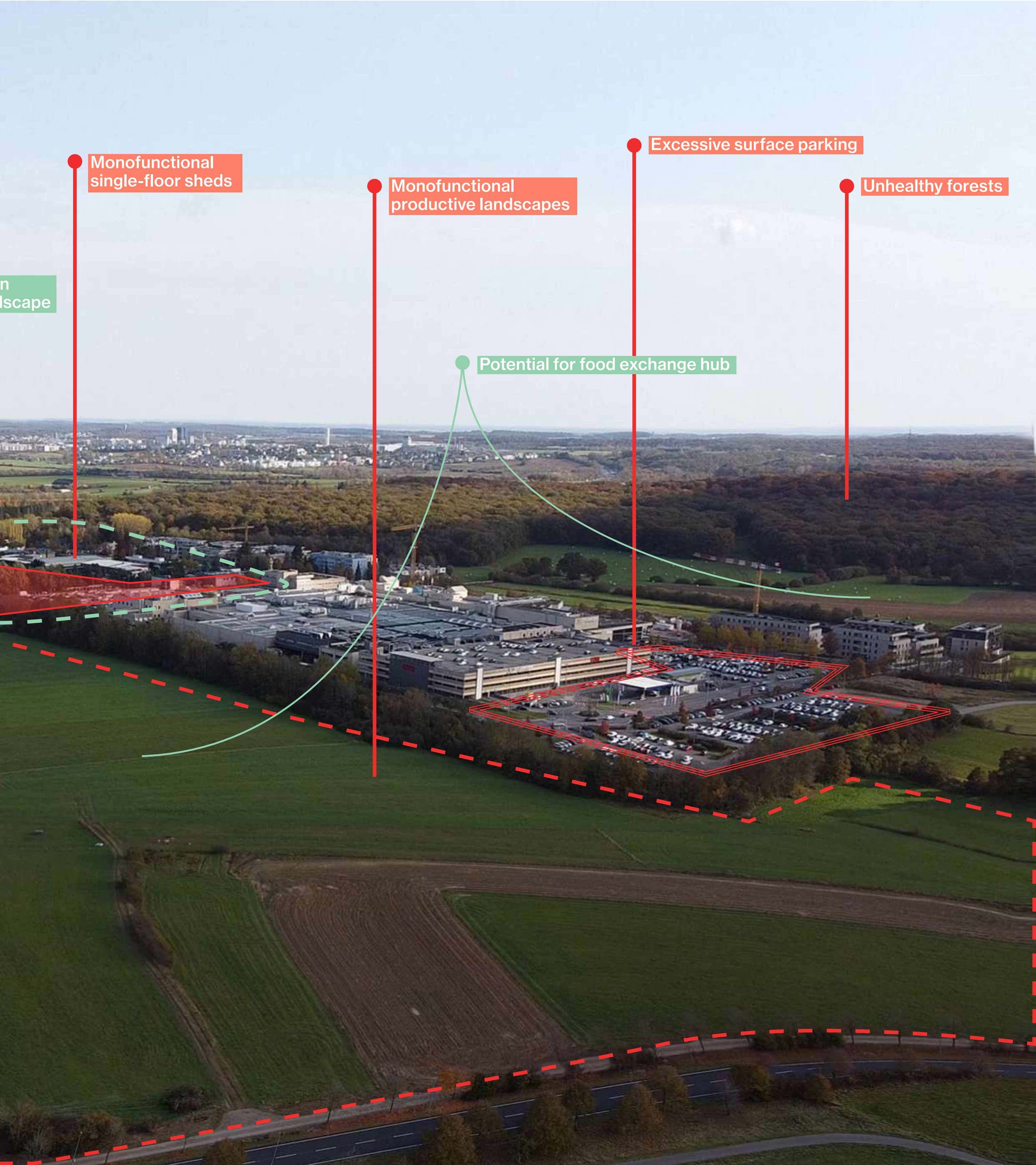
Aquaculture algae for fertilizer: 150 to 300 tons/ merchantable/biomass/ha/yr

# Showcase 2



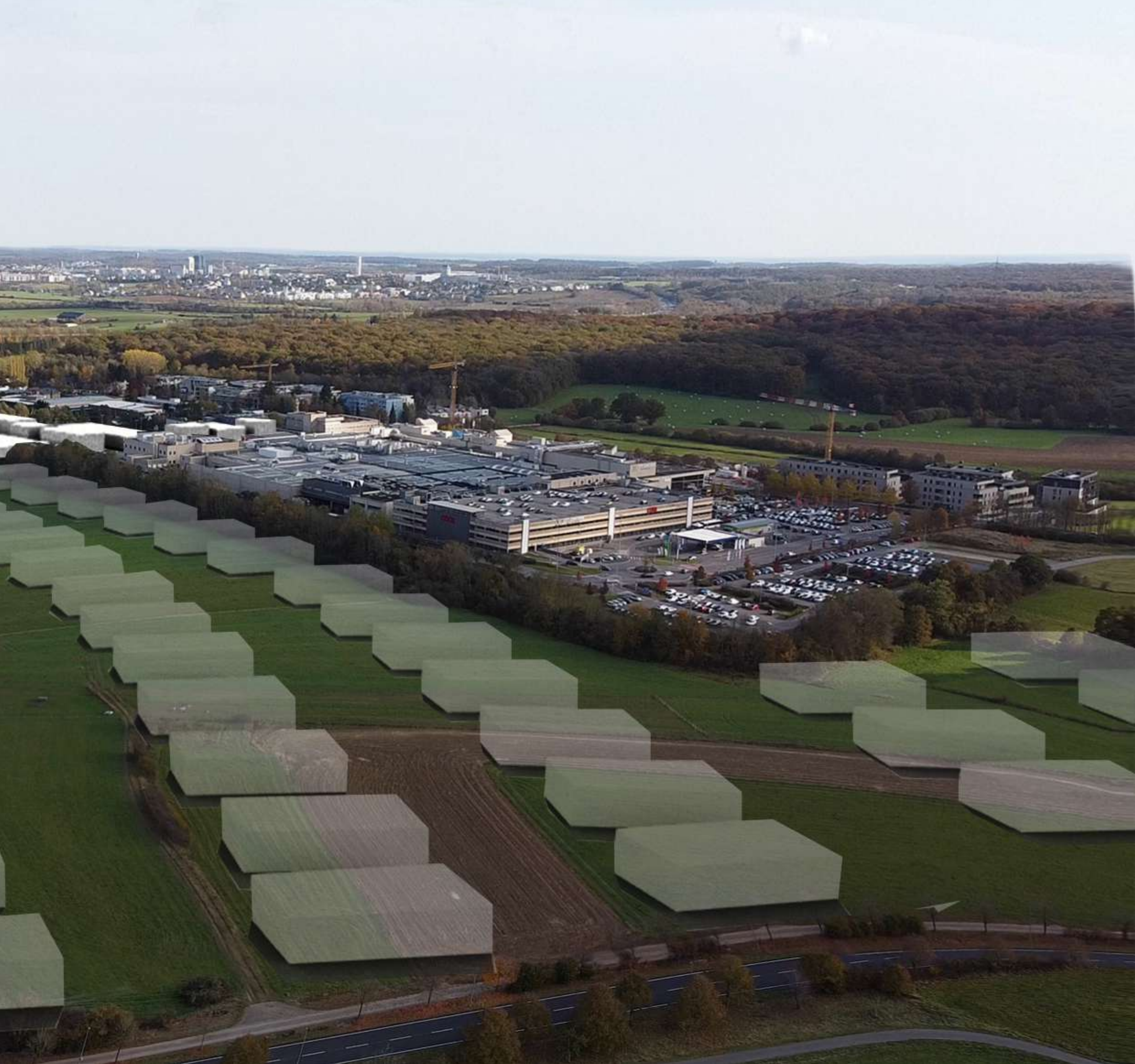
projected/planned suburban landtake
Inherent mixed-use character
Strategic location
Potential for dense residences i
combination with generous lanc

# Helfent


Monofunctional single-floor sheds
Monofunctional productive landscapes
Excessive surface parking
Unhealthy forests
Potential for food exchange hub

# Helfent 2050 business as usual

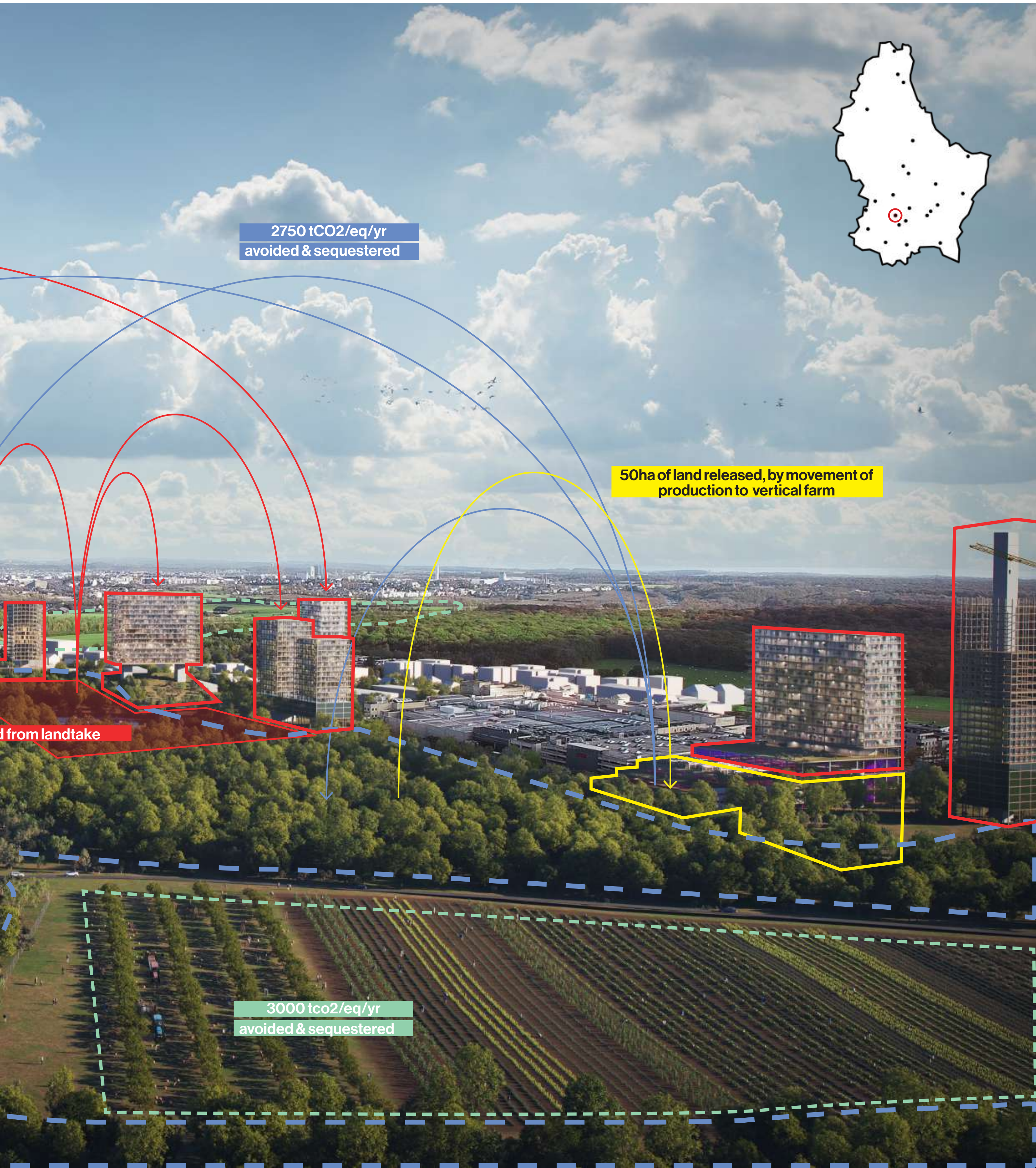
Suburban sprawl and excessive soil sealing around the Petrusse river will diminish the potential that Helfent has to turn into a compact, resilient and lively neighbourhood.  The agricultural activities within Helfent will be pushed away to the margins and heat island effect will contribute to loss of biodiversity and lowering quality of life. The sealed surface expansion will not allow the soil underneath to play its role in natural carbon capture.



# Helfent 2050 proposal
# Sublime Suburbia

Helfent in 2050 has become as much a generous renaturalised valley and afforested land, as a lively neighbourhood made of new typologies of living and working in mixed-use highrises. These highrises play a key role in preserving arable land and forests. The plinths of these towers are accommodating economic, civic and leisure facilities and services. The City Concorde is now a hub for food production and distribution. Produce from the surrounding silvopastures and the

vertical farm is processed and sold there directly to consumers, in the market which stretches over the terraces of the old parking towards the landscape. The afforested pastures now connect the previously fragmented forests into a necklace of leisure destinations around Luxembourg city. The arrows over the image below show the land management interventions in action which result in enhancing negative emissions of Helfent, as shown in the timeline.



# Helfent
# Decarbonsation menu

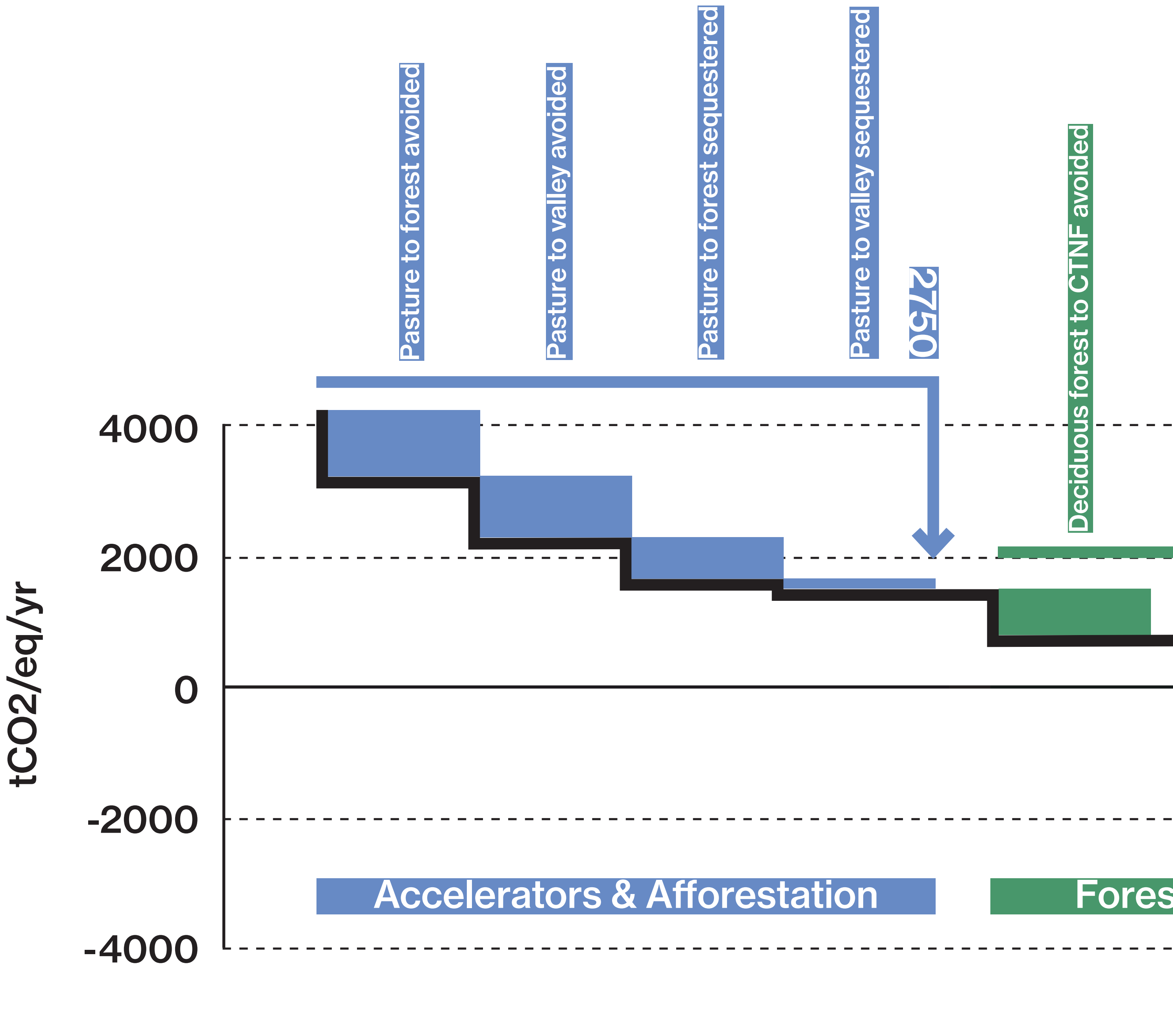
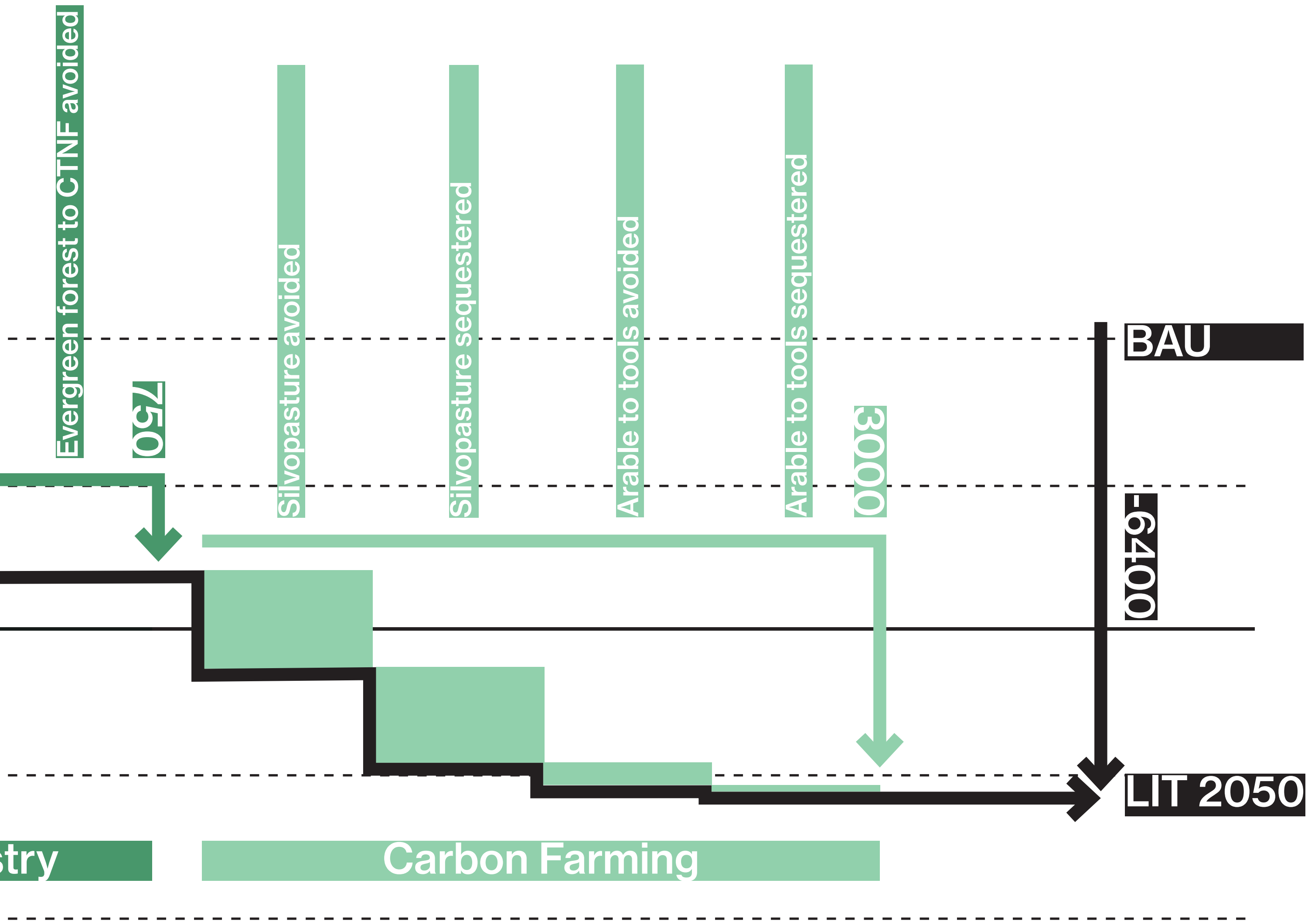



fig 6: Decarbonization menu showcase 2.


Evergreen forest to CTNF avoided
750
Silvopasture avoided
Silvopasture sequestered
Arable to tools avoided
Arable to tools sequestered
3000
BAU
-6400
LIT 2050
stry
Carbon Farming

# Helfent 2050 proposal
# Sublime Suburbia

Sublime Suburbs: surface parking and single-story commercial buildings hold the potential to centralize development rights and turn suburban archipelagos into lively mixed-used neighbourhoods.
Residual landscapes are preserved and activated as productive leisure environments, framed by high-rise timber constructions combining public gardens and generous housing experiences.

1. Parking and economic activities compose the plinths. They have a double orientation: opening towards the built tissue, their roofs extend the landscape into the towers.
2. Timber towers rise over the plinths and produce a critical mass of affordable good quality dwellings, challenging the lifestyle of the single-family house and suburbia.
3. The waterfront performs as an active connection between destinations around Helfent while preserving and enhancing its natural qualities.

# Helfent
# Transfer of Development Rights

With the current rate of landtake proposed in the PAG, Helfent will lose 128,800 sqm of its arable land. Taking the current state of affairs in Helfent into account, including structures and landscapes that are of large proportions, we came to the conclusion that the highrise typology will serve as the most land-efficient choice. We also took into account the limitation of construction with timber, to determine the height of the highrises, which are capped at 20 floors. Taking inspiration from existing multifunctional complexes such as Piwel, the plinths of the highrises were seen as multistorey industrial, civic and commercial facilities. The floors above were treated as residences and offices. With these considerations in mind, we developed new PAP tables for the sites, with emphasis on net-zero landtake and minimum soil sealing. This resulted in 163,600 of floor area in new developments over existing sealed surfaces, which surpassed the growth trajectory of the PAG within the boundary of Helfent. In this way, the area could now take in the growth that is projected beyond its edges as well.

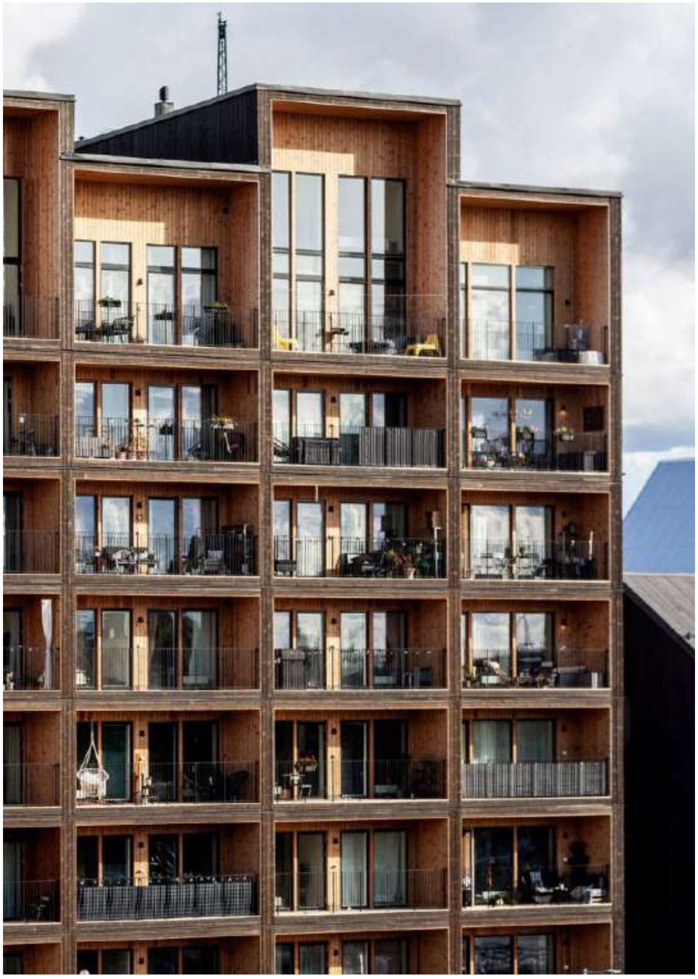
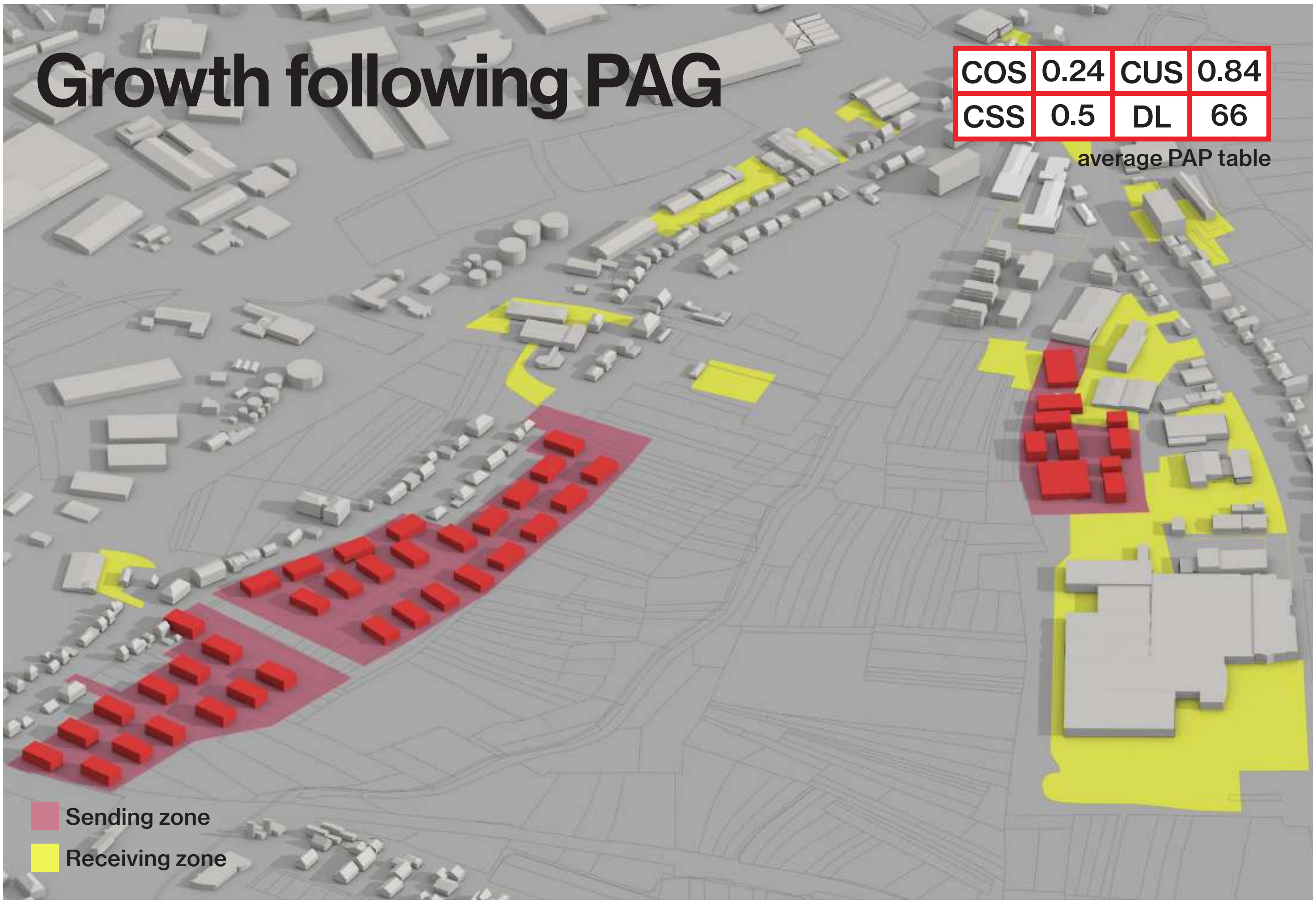
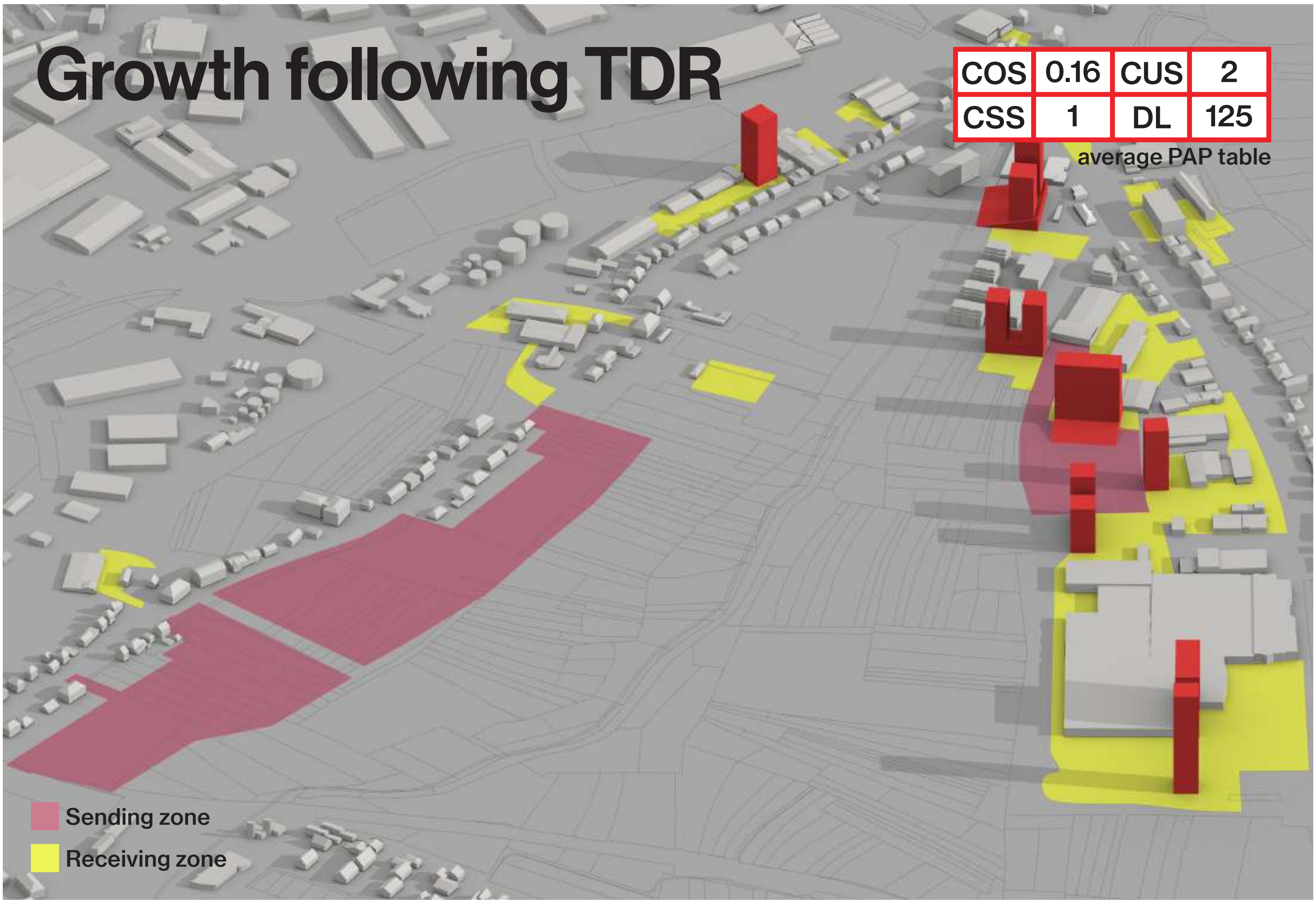


image 2: CF Moller (2020). Kajstaden tower.


Growth following PAG
COS 0.24 CUS 0.84
CSS 0.5 DL 66
average PAP table
Sending zone
Receiving zone


Growth following TDR
COS 0.16 CUS 2
CSS 1 DL 125
average PAP table
Sending zone
Receiving zone

# Helfent
# Land use change 2021 to 2050

- Industrial cropland
- Pasture
- Space for river
- Urban green
- Space for river
- Forest
- Afforested (5 yr)
- Afforested (15 yr)
- Afforested (30 yr)
- Silvo-pasture (5 yr)
- Silvo-pasture (15 yr)
- Silvo-pasture (30 yr)
- Strip cropping
- Wetland
- River

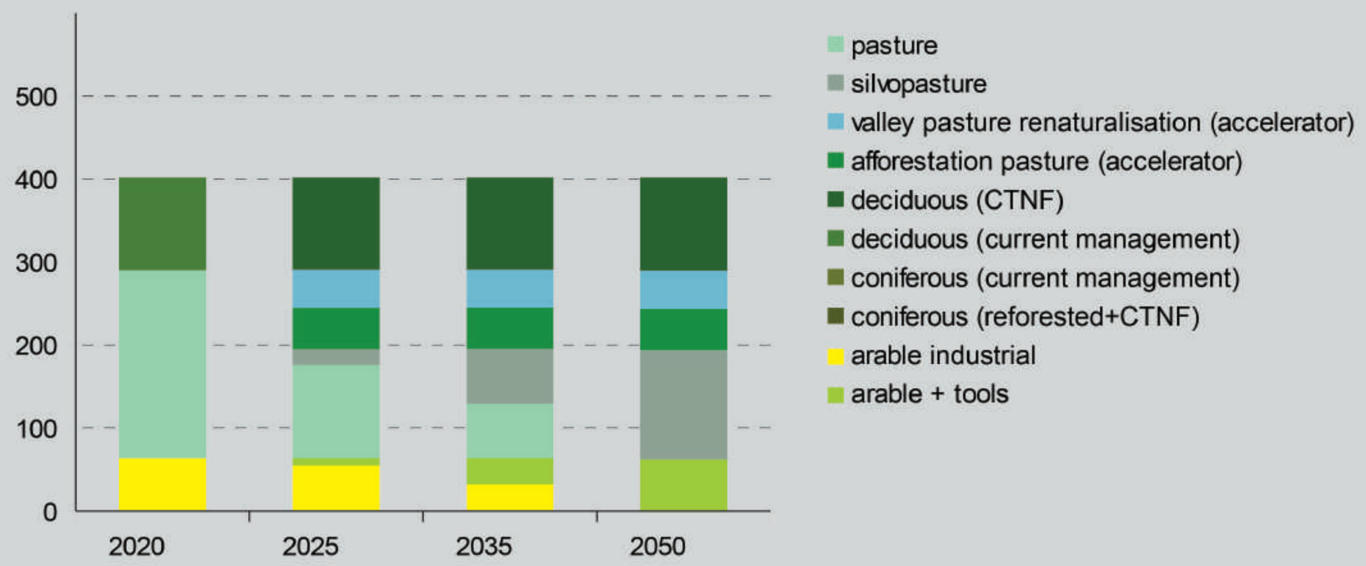
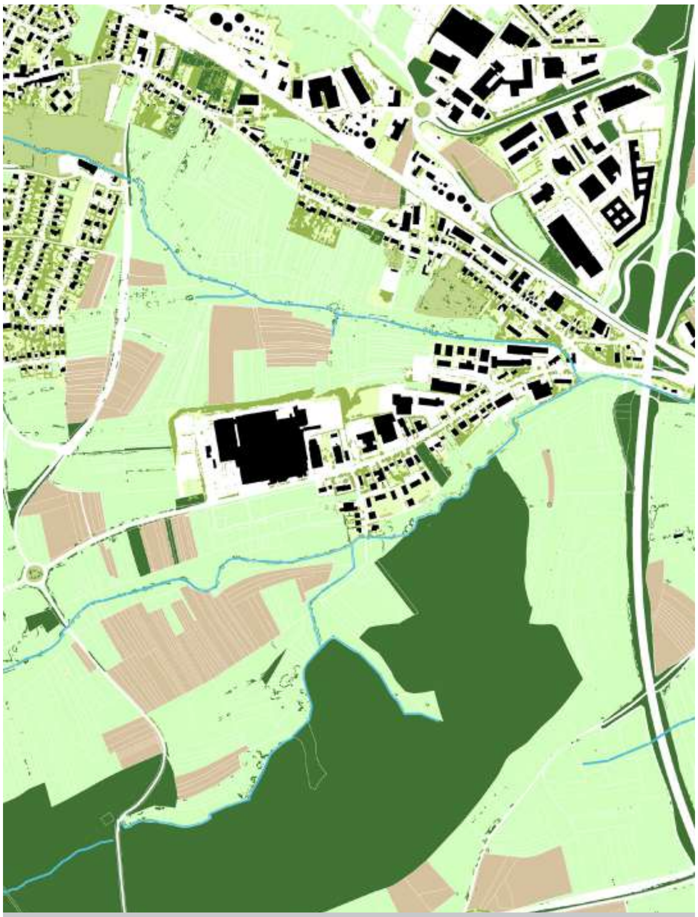
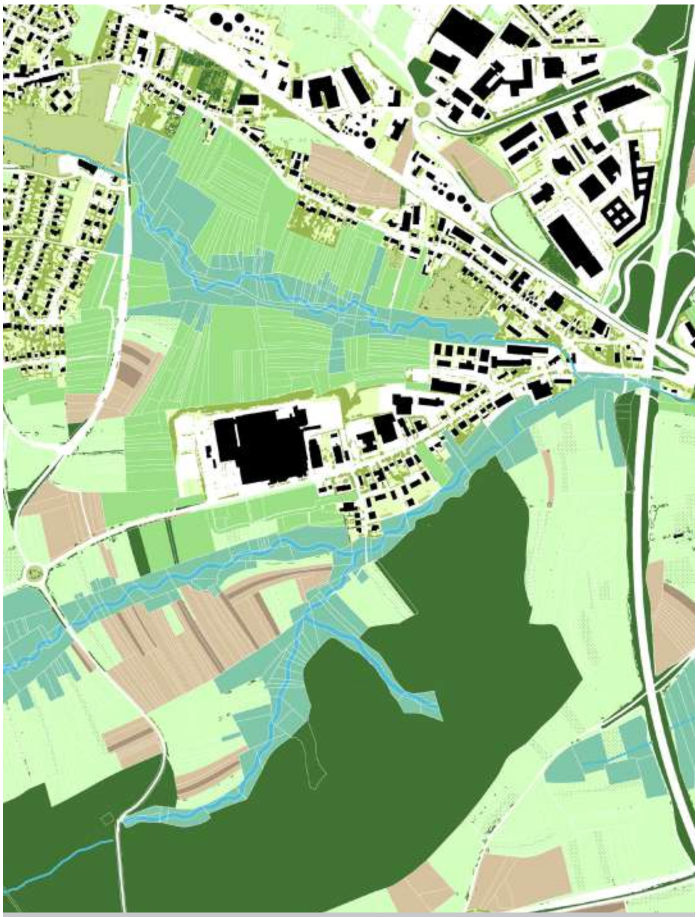


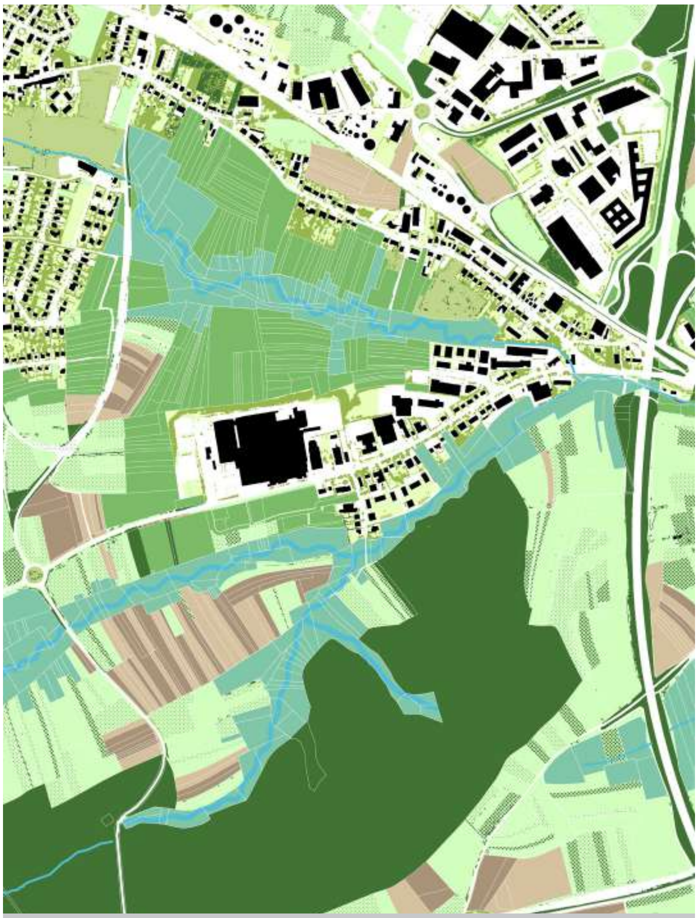

fig 4: Landuse change showcase 2.



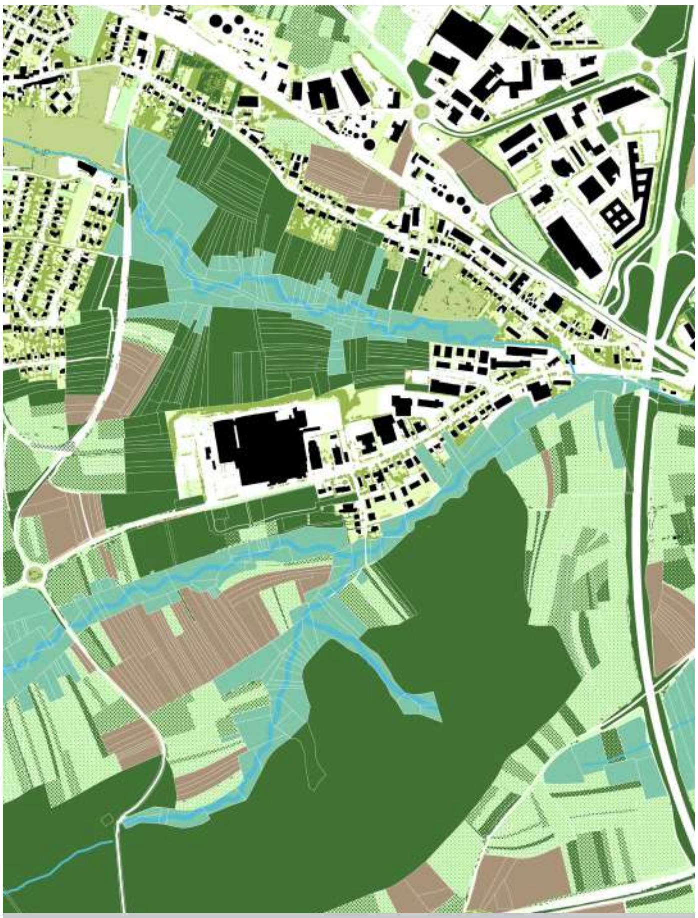
2021



2025



2035



2050

# Helfent
# Negative emissions 2021 to 2050

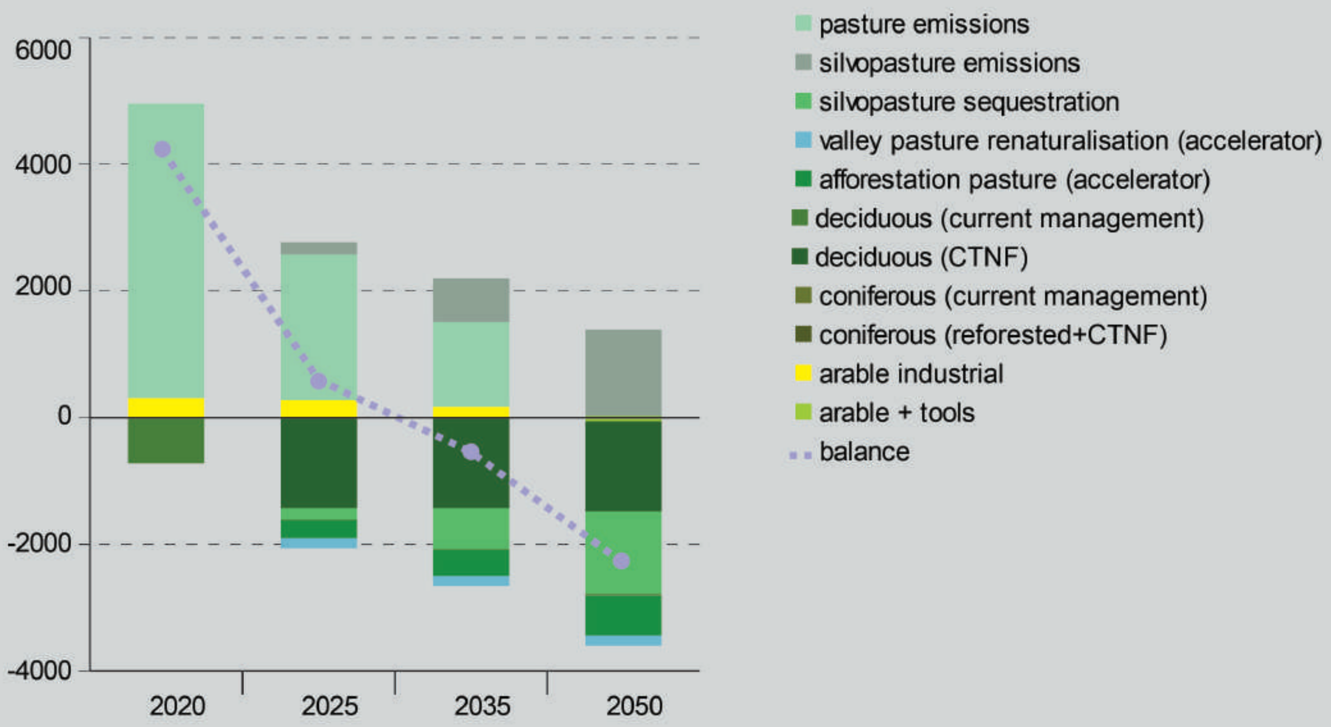
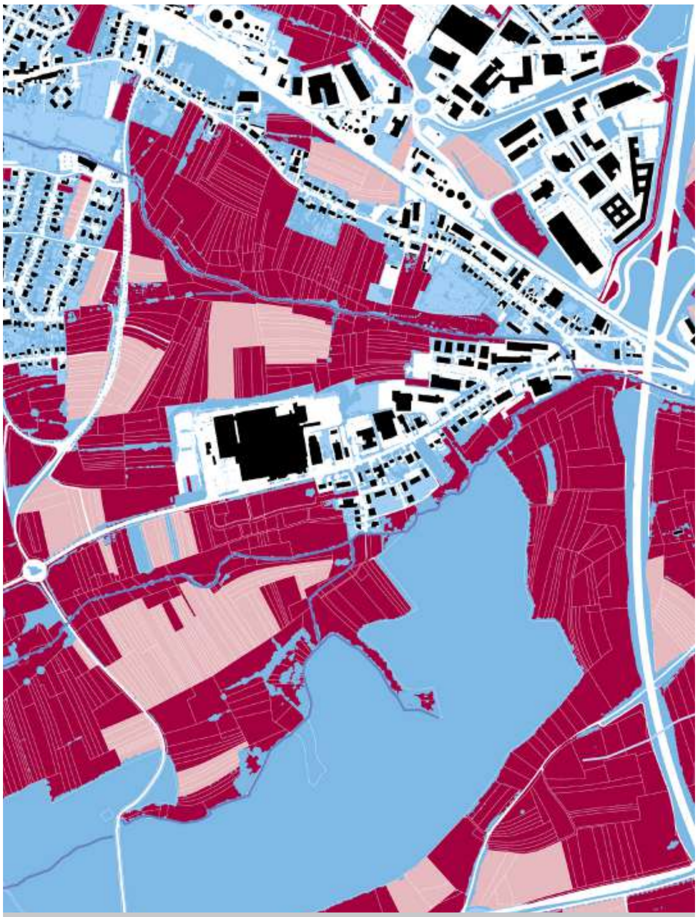
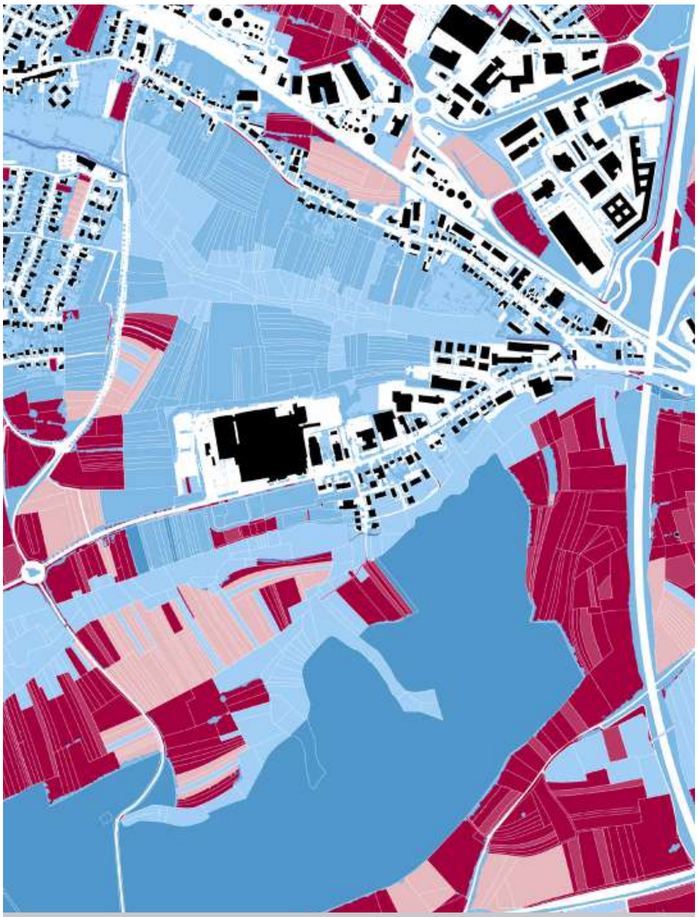


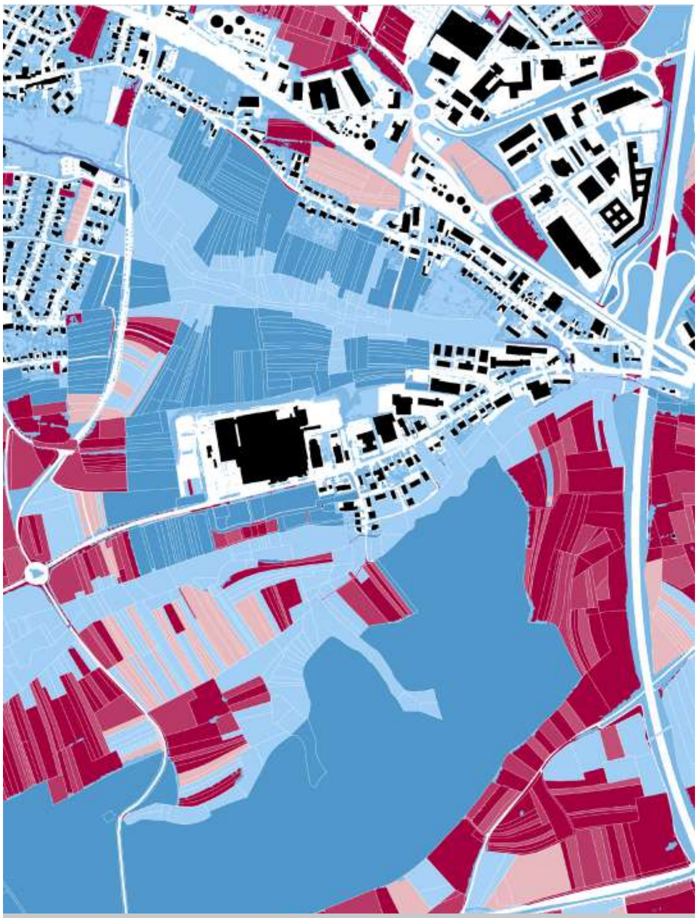

fig 5: Negative showcase 2.



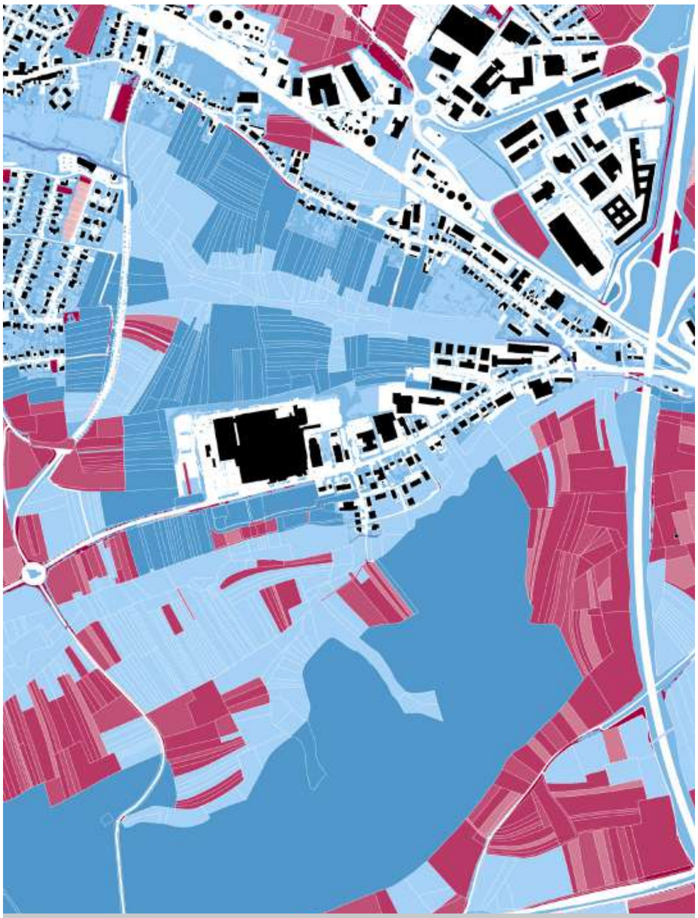
2021



2025

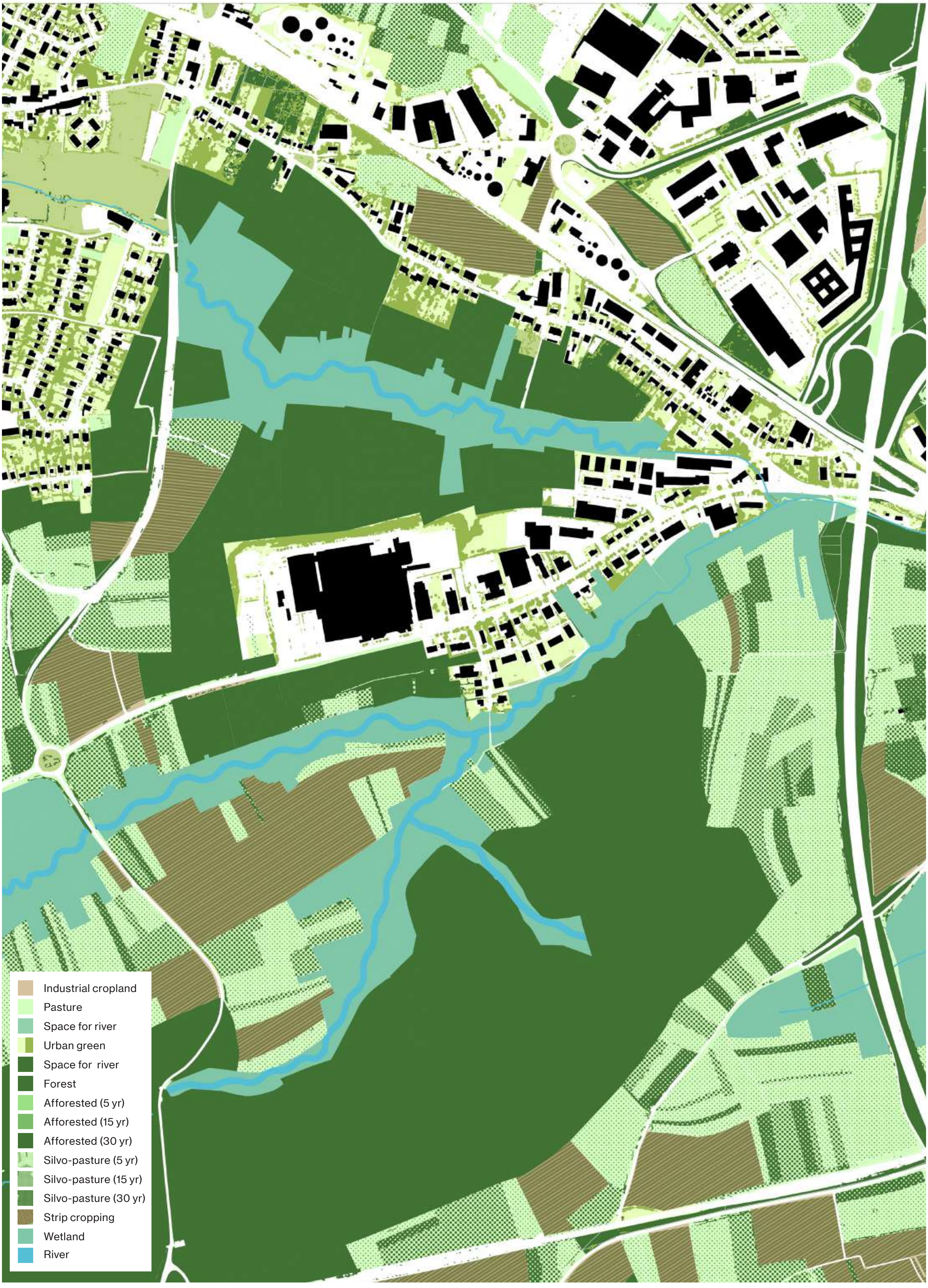


2035

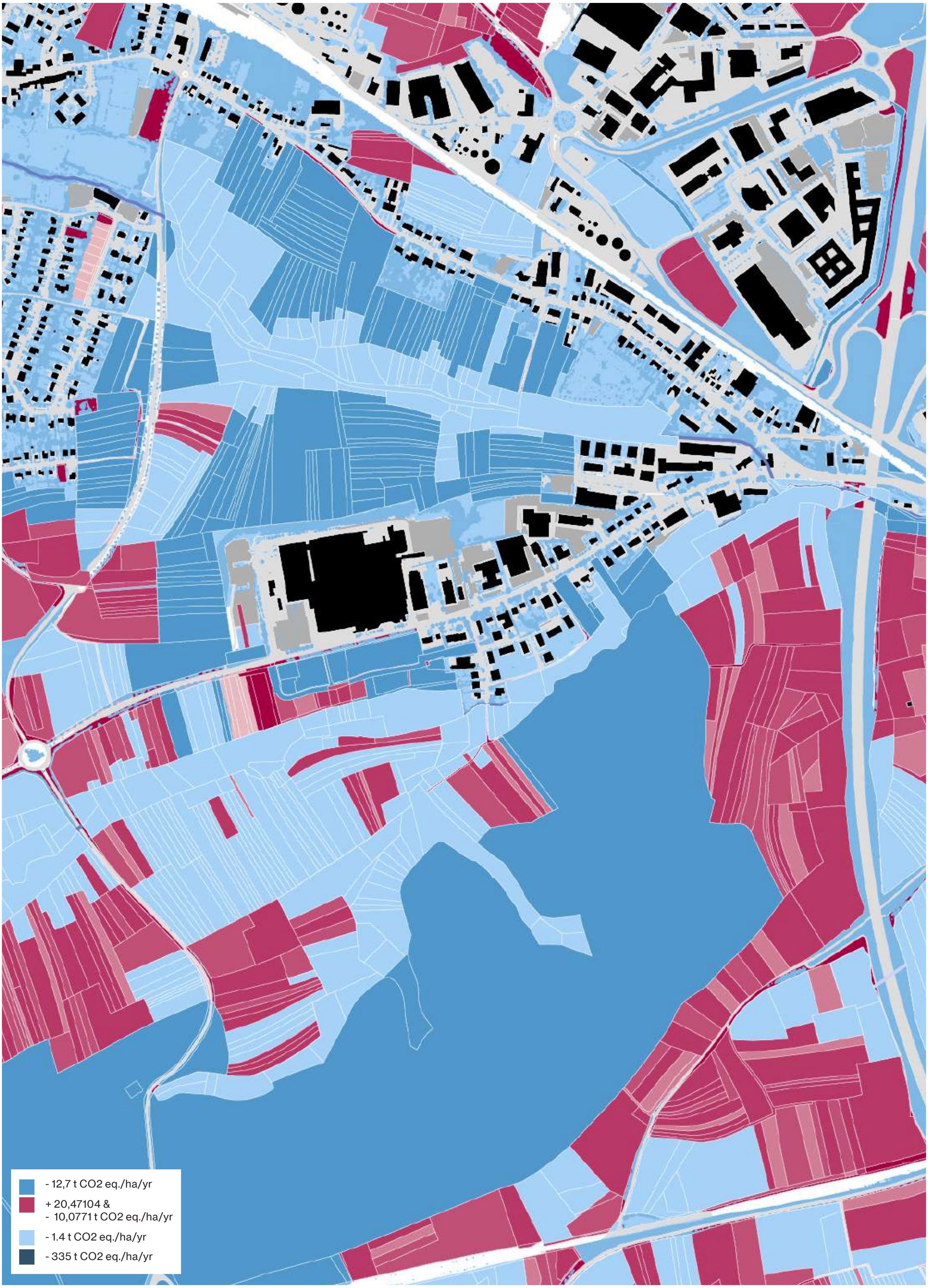


2050

- 12,7 t CO2 eq./ha/yr + 20,47104 & - 10,0771 t CO2 eq./ha/yr - 1.4 t CO2 eq./ha/yr - 335 t CO2 eq./ha/yr



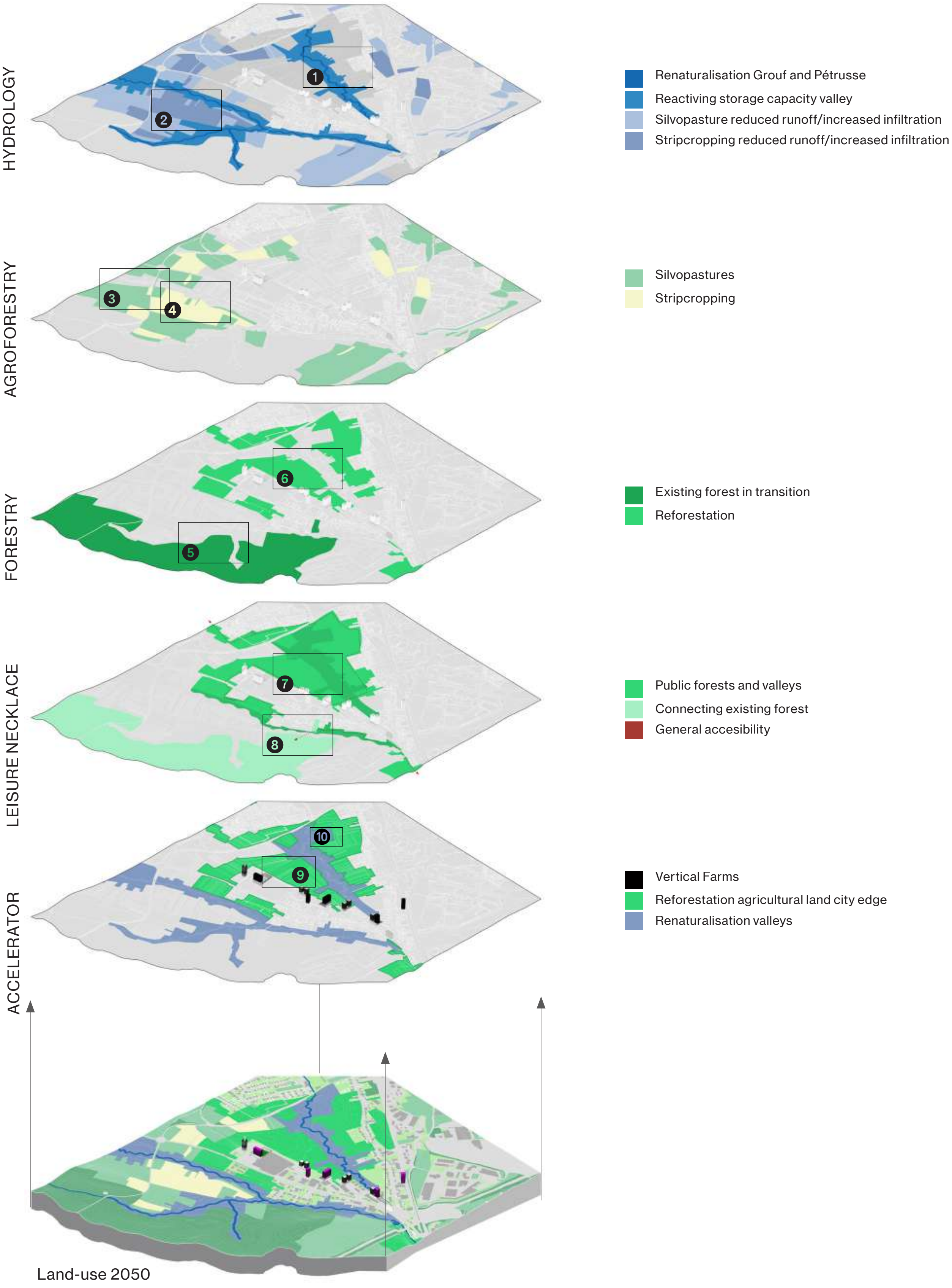

Land use change 2021 to 2050



Negative emissions 2021 to 2050

# Helfent
# Overview of tactile interventions

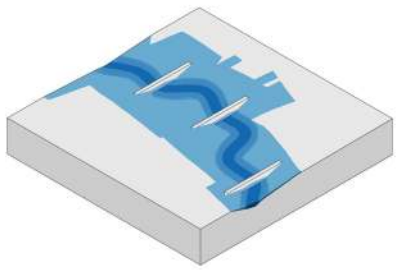
## Multifaceted landscape development



# Measures & principles

HYDROLOGY

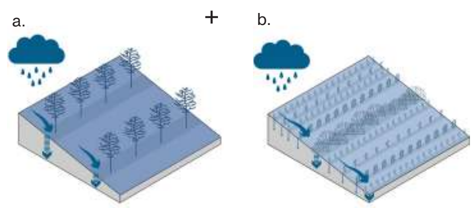
## Horizontal (river) flood relief



1

- renaturisation river
- reactivating storage capacity valley
- Maximum floodable surface during extreme events
- Weir increasing water retention capacity of valley

## Vertical (rain) flood relief

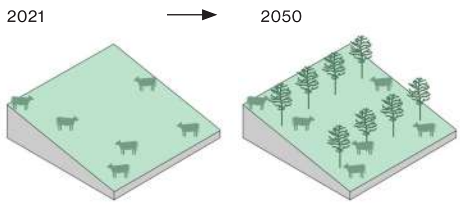



2

- a. silvopasture
- b. stripcropping
- runoff catchment
- infiltration/ groundwater recharge

AGROFORESTRY

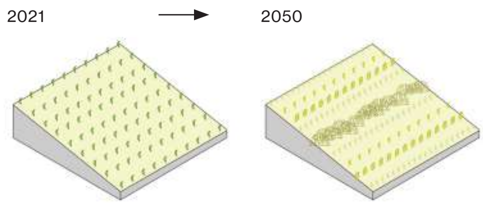
## Silvopastures




3

- Cattle
- Fruit/nuts

## Stripcropping

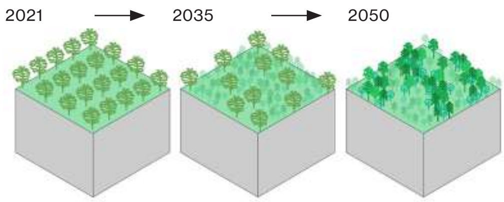



4

- monoculture
- polyculture
- ecological strip

FORESTRY

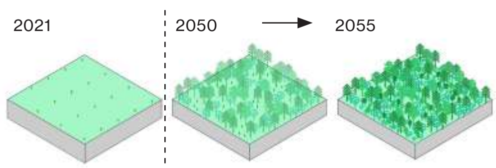
## Existing forest in transition




5

- Trees unadapted shifting climatic ranges
- Adaptive species diversification approach
- Resilient forests

## Close to nature forest management

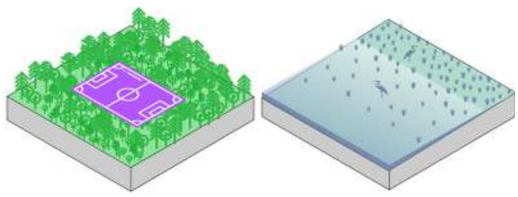



6

- clearfelling management
- selective harvest management
- mixed and uneven-aged, structurally diverse forest stands

LEISURE NECKLACE

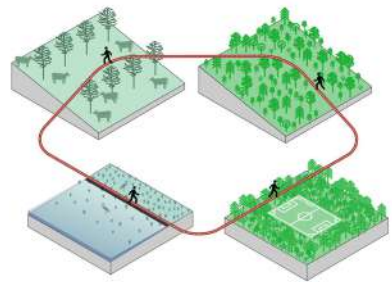
## Public functions



7

- urban program
- natural program

## Connectivity

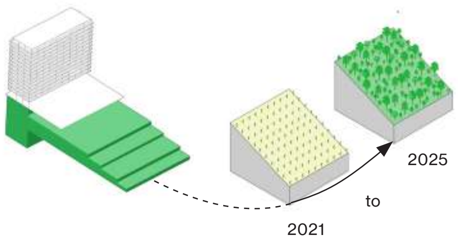


8

- General accesibility

ACCELERATOR

## CEA accelerator: food footprint reduction and afforestation




9

- Yield 1 ha VF (footprint 2000m2) = 50 ha conventional agriculture
- freed-up cropland
- afforested cropland

## CEA accelerator: food autarky and diet shift

10

- 3500 tons fruits and vegetables/ ha/yr
- Food autarky = exotic foods locally grown
- Diet shift accerator = diversification of local plant based products

# Helfent
# Overview of tactile interventions

Decarbonisation as leverage for Integrated landscape systems

ECOLOGY

CARBON

Land-use 2050

Increased matrix connectivity by ecological intensification agriculture (sharing)

Increased matrix connectivity by sustainable intensification to set agricultural land aside for afforestation (sparing)

Heterogeneous patch types: novel and remnant natural and semi-natural habitats

- 12,7 t $CO_2$ eq./ha/yr

+ 20,47104 and - 10,0771 t $CO_2$ eq./ha/yr

- 1.4 t $CO_2$ eq./ha/yr

- 335 t $CO_2$ eq./ha/yr

Forest

Afforested

Silvo-pasture

Urban green

Strip cropping

Aquaculture

Wetland

River

# Helfent
# Overview of tactile interventions

Decarbonisation as leverage for Integrated landscape systems

RESILIENCE / ADAPTATION

LEISURE

PRODUCTIVE

Land-use 2050

reduced run-off, increased infiltration, reduced high river levels and reduced (flash) floodrisk low located villages

more space for the river to reduce the waterlevel of excess flows and avoid economical damage downstream due to large scale flooding

low to extreme flood probability

climate/drought & future disturbance resilient forests

crop disease control, soil fertility increase, reduced erosion soil loss, increase soil water retention and availability

climate/drought & future disturbance resilience trees, increase soil water retention and availability

Existing bike path

New bike path

Leisure necklace access

Existing paved

Existing path

Leisure necklace

Existing forest

Bordering wetland

mean annual increment merchantable
of 8 m3/ha/yr close to nature forestry management

Silvopasture: 0.01 to 0.23 tons/ merchantable/protein/ha/yr

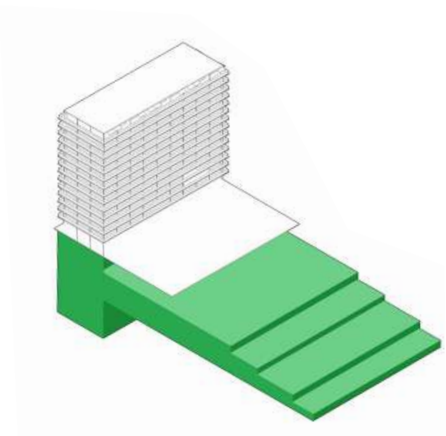
Protein crops: 1.8 tons/ merchantable/protein/ha/yr

Vertical farm: 3500 tons fruits and vegetables/ha/yr

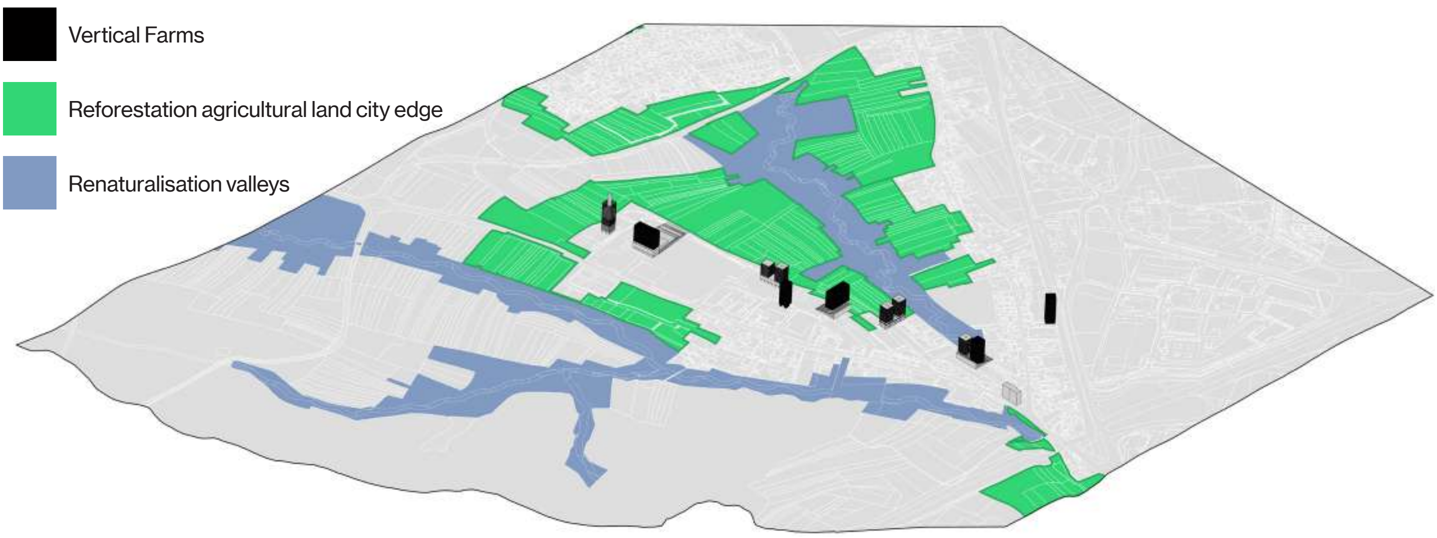
# Helfent
# Tactile recommendation

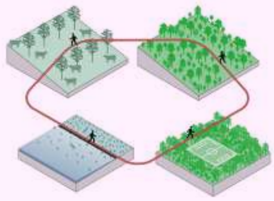
## City Concorde food hub & the Luxembourg City leisure necklace

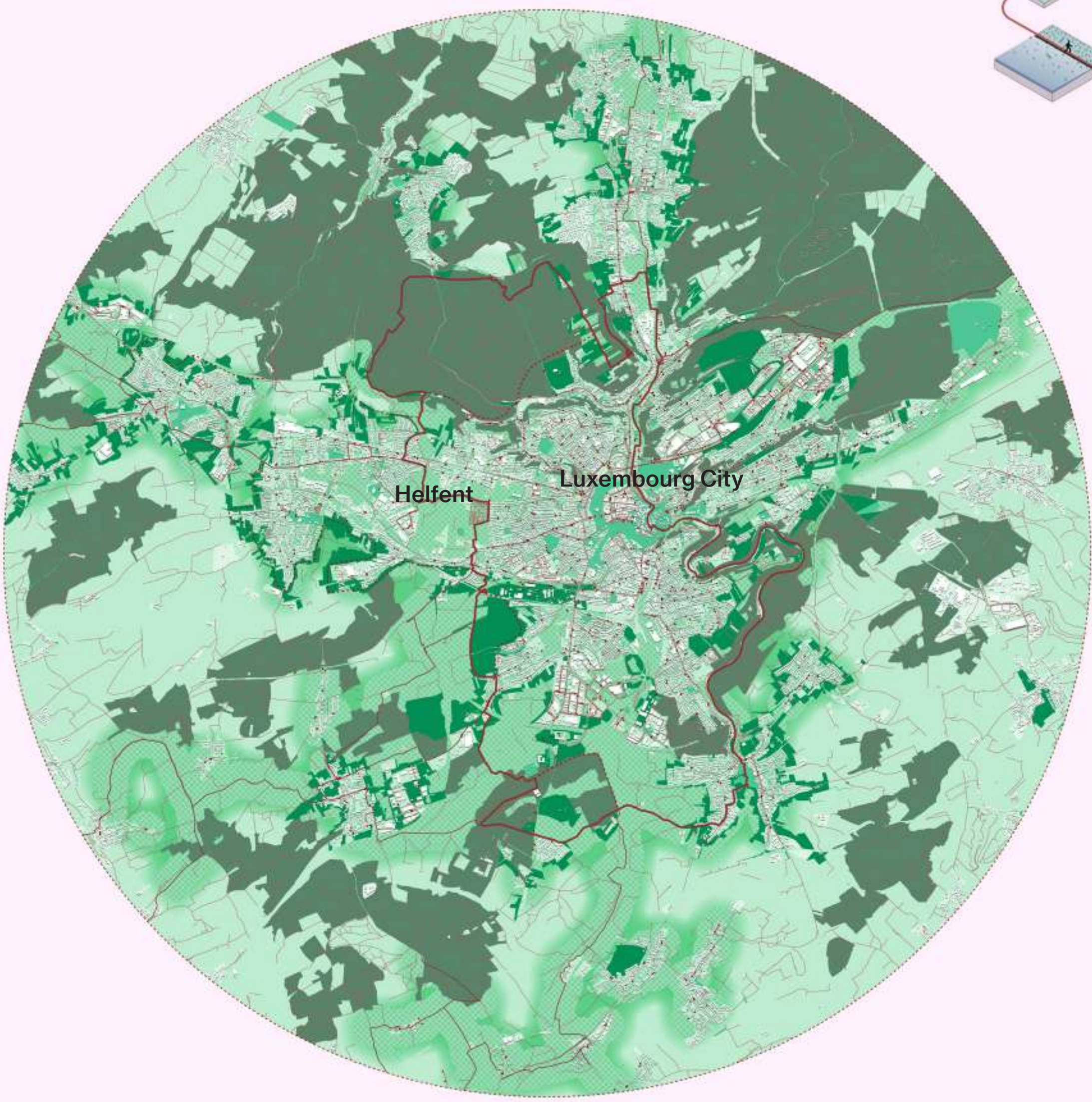
The City Concorde Food Hub, is a proposal for a vertical farm which partly occupies the current parking of Concordia, and adds an additional hybrid highrise which has vertical farm underground and housing on top. The produce from this vertical farm in combination with a number of others around Luxembourg city will allow the afforestation of series of arable lands around the city, to connect existing forests with new forests in form of a continuous accessible necklace. We also propose the addition of leisure functions along this route to further enhance the community interactions with this forested necklace.



3500 tons fruits and vegetables/ha/yr
year-round production








Existing forest

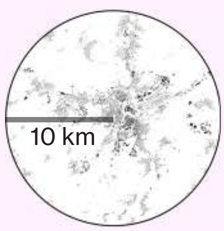
Existing public space

Search area new public forest catching development pressure

Existing recreational access

Search area new recreational access

Existing main national cycle route = main loop in leisure network




Outer Influence zone for metropolitan leisure accessibility

Highly accessible zone: within 300 meters of public transport stop or cycle way

# References

**Figures**

All figures:

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*Forest sequestration rate:* Sequestration rate management scenarios. (n.d.). [Graph]. http://www.stanrams.com/wp-content/uploads/KNAW.jpg

fig 1: Landuse change showcase 1. / fig. 2: Negative showcase 1. / fig. 3: Decarbonization menu showcase 1.

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fig 4: Landuse change showcase 2. / fig. 5: Negative showcase 2. / fig. 6: Decarbonization menu showcase 2.

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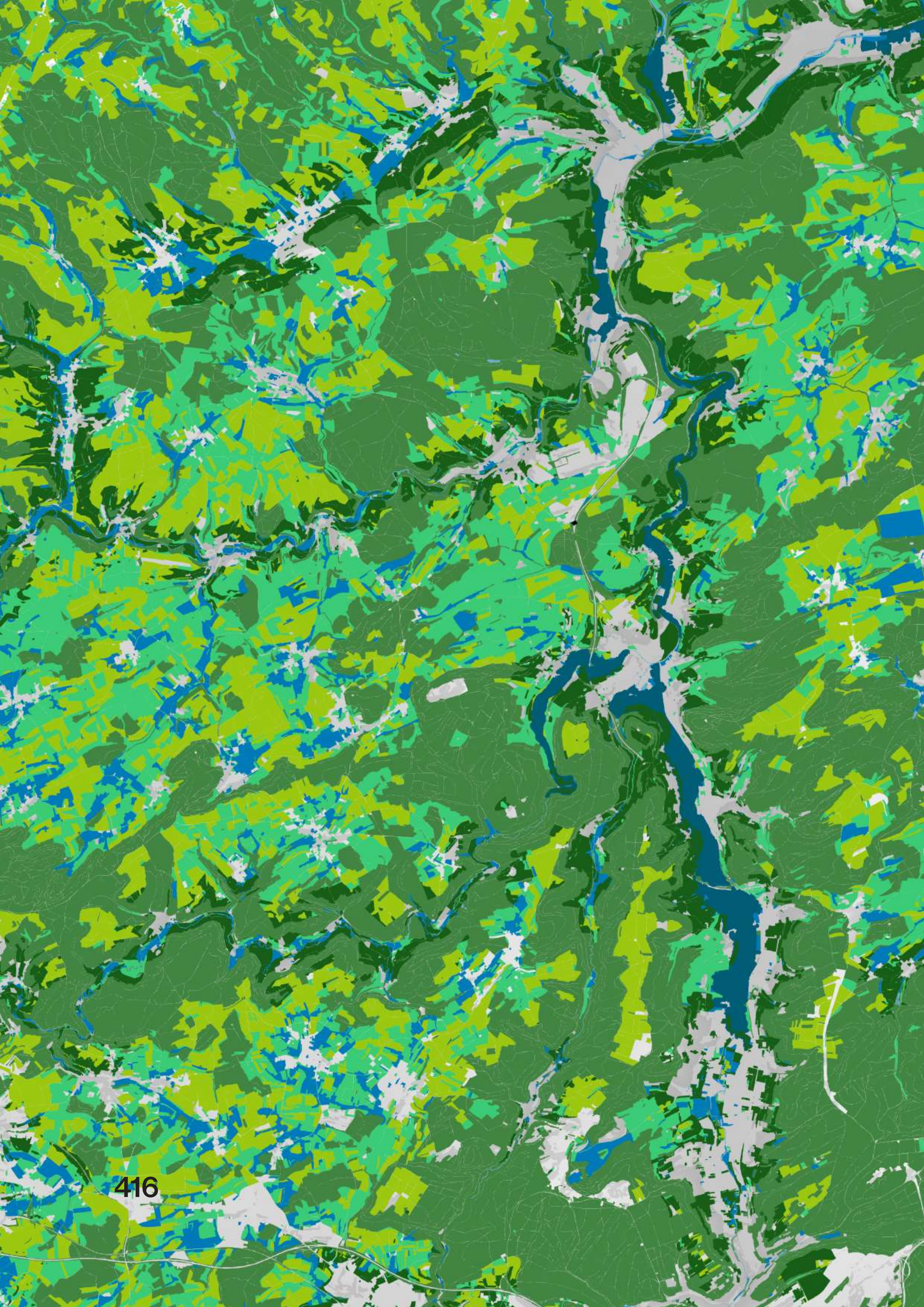
## Images

image 1: Mill of Bettendorf seen from the river Sûre (2014). Wikimedia commons. https://commons.wikimedia.org/wiki/File:Moulin_de_Bettendorf_01.jpg

image 2: CF Moller (2020). Kajstaden tower. https://www.cfmoller.com/p/Kajstaden-Tall-Timber-Building-i3592.html

# Conclusion



# Strategic recommendations

## The Bold diet

Showing the immediate correlations between centimetres of plates and hectares of land, and understanding the imported deforestation that is the consequence, would be a stepping stone for a bold diet shift. And as Line Bauer mentioned in our picnic conversation: “we need to work with all the actors in the ecosystem, resellers, retail, restaurants, and the whole environment to provide healthier and easier choices. We need to make healthy food an easy option.”

## Land Use Accelerators

As societal shifts are slow and gradual, we can accelerate the reduction of land footprint of our diets by Controlled Environment Agriculture and Aquaculture. These non-soil based cultivation mechanisms will boost the territory’s negative emissions if combined with afforestation over released land surfaces.

## Net-Zero Growth

Net-Zero Growth, the contraction between net-zero landtake and smart growth, is an attitude accepting, enabling and promoting demographic and economic growth without grabbing land from agricultural or natural landscapes in order to maximize sequestration and soil productivity. Reaching a common definition of growth across sectors is a necessary first step.

## TDR

Transferable Development Rights can act as a transititory planning mechanism to divert growth in the short-term over existing sealed surfaces. Net-zero landtake will not be possible without this tool. However, for the general legal and planning framework and criteria to be set, conversations need to continue with relative experts and policy-makers to draft the tailored variant for Luxembourg.

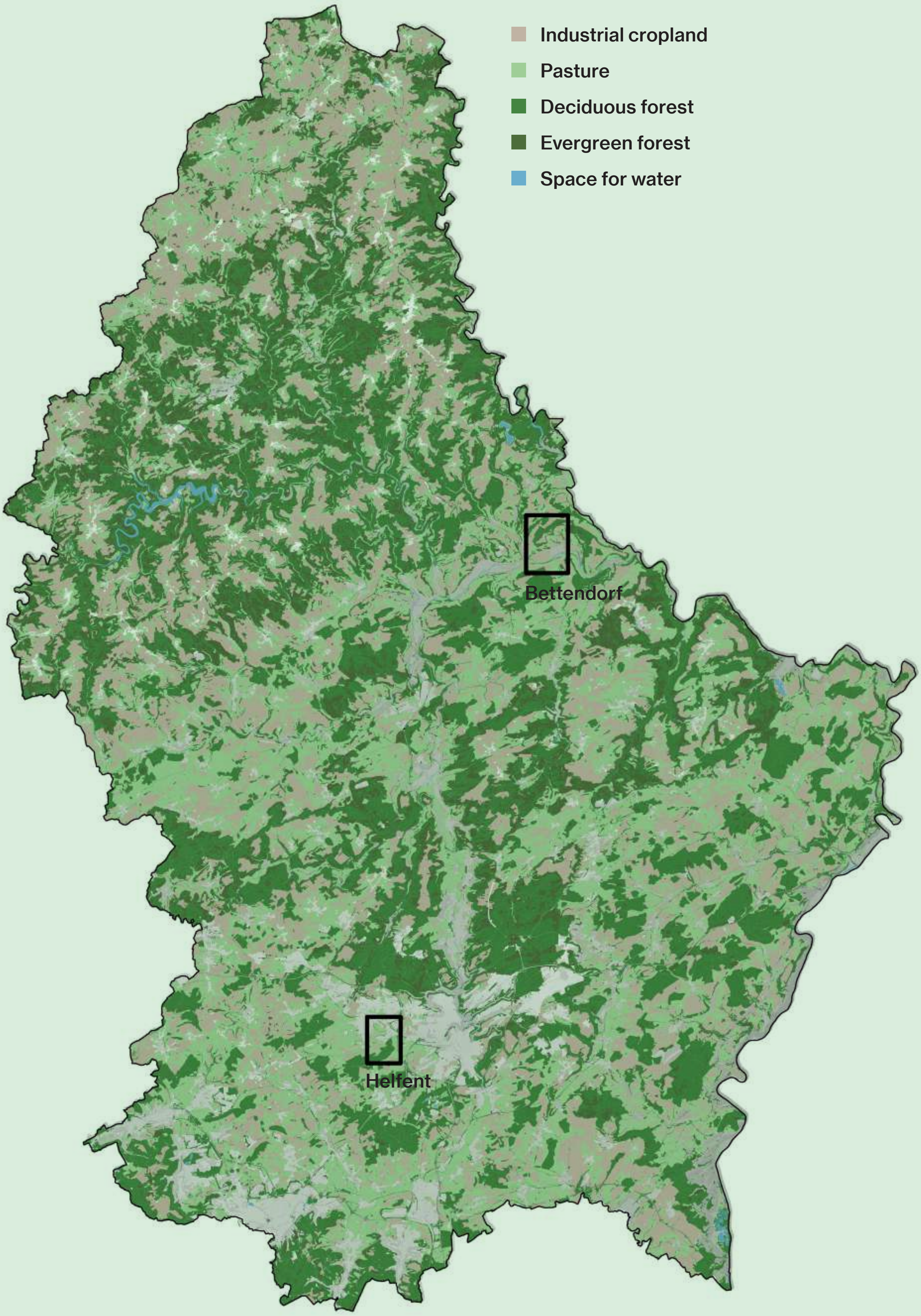
## Carbon Farming

Agricultural practices in Luxembourg are driven by cultural attachments, economics and legislation. A national debate is necessary to redefine agricultural future, and better understand what parts of the culture are integral to the community. From an economic perspective, farmers need business and marketing consultation to economically manage a transition towards sequestering practices. And lastly, legislations must provide room for farmers to experiment.

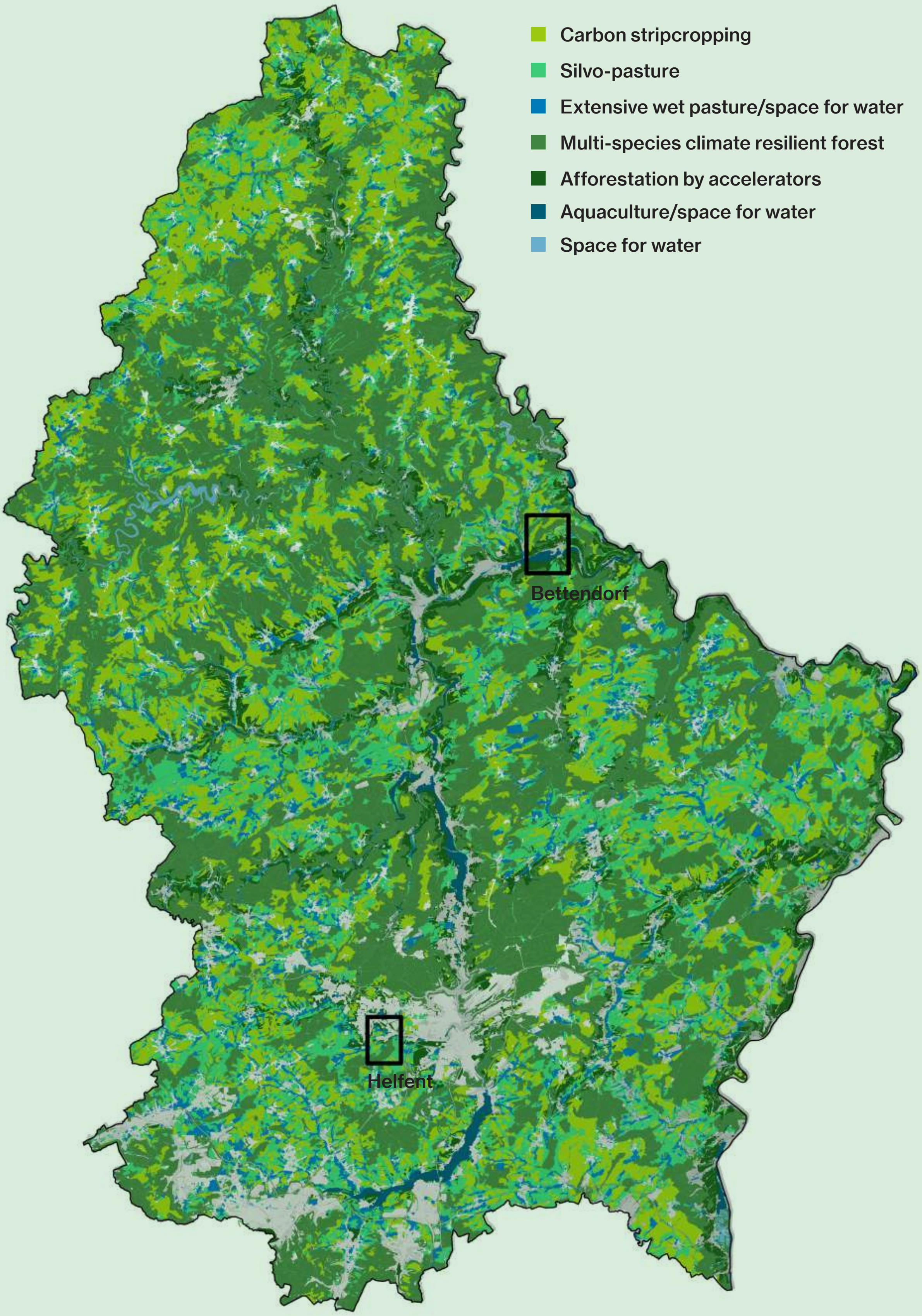
## Afforestation

Afforestation in combination with close to nature forest management is the final piece in the nature-based carbon capture puzzle. Healthy forests can also be productive. Raising awareness around this topic is necessary for the large number of small forest owners and conservationists to reach a consensus about the territorial role forests can play in enhancing negative emissions, in addition to timber production and climate adaptation at large.

# Territorial landscape footprints 2018



# Territorial landscape footprints 2050



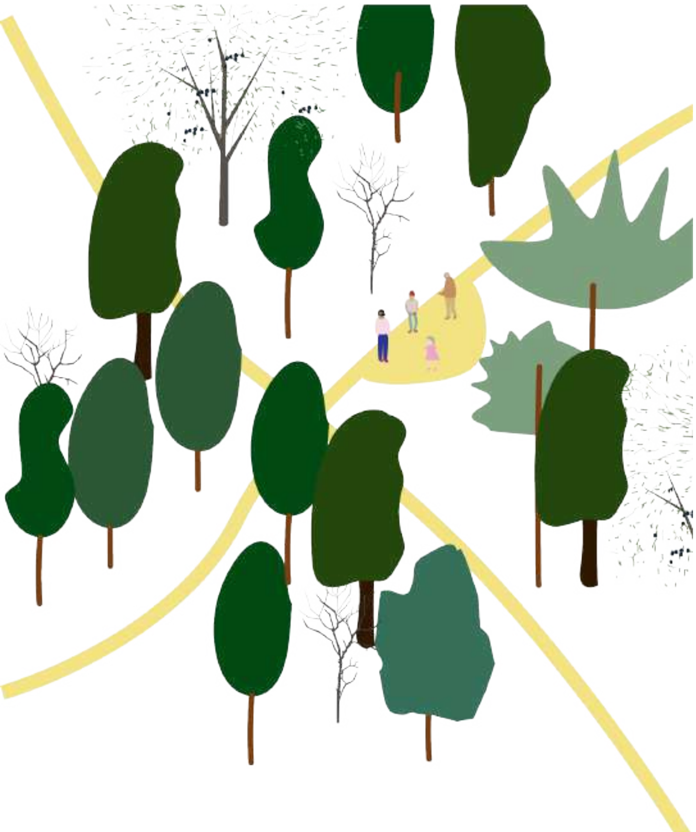
# Pleasures of Decarbonisation in the Lifetime of Marie

Marie is 10 years old. She is visiting the algae pools of Bettendorf for the first time.

Marie and her mom stop on the dyke path to learn more about the new crops of Bettendorf.

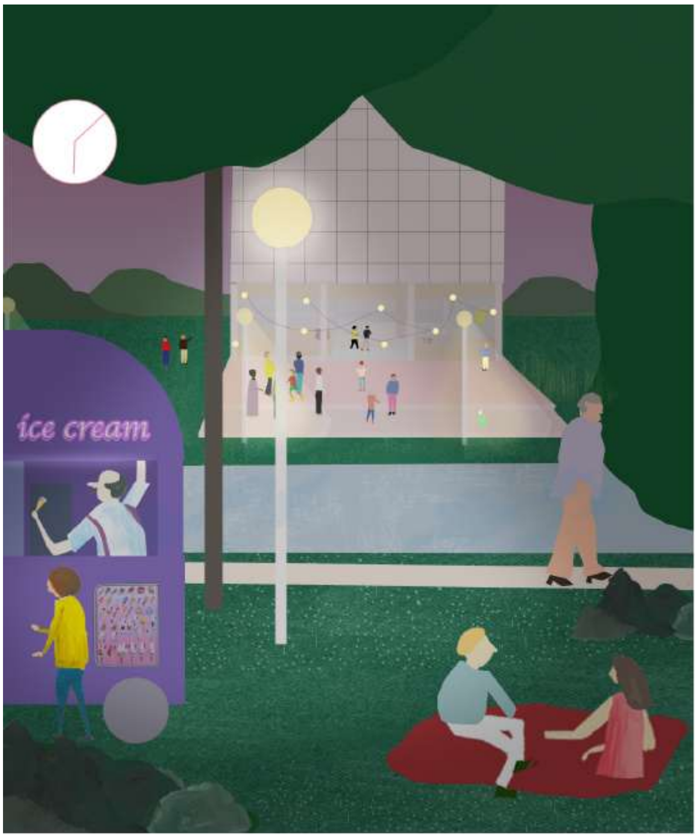
They then take a canoe tour of Nordstad together with local tourists.

At the age of 15 Marie learns about tree species and wood types in the forest workshop at her school.



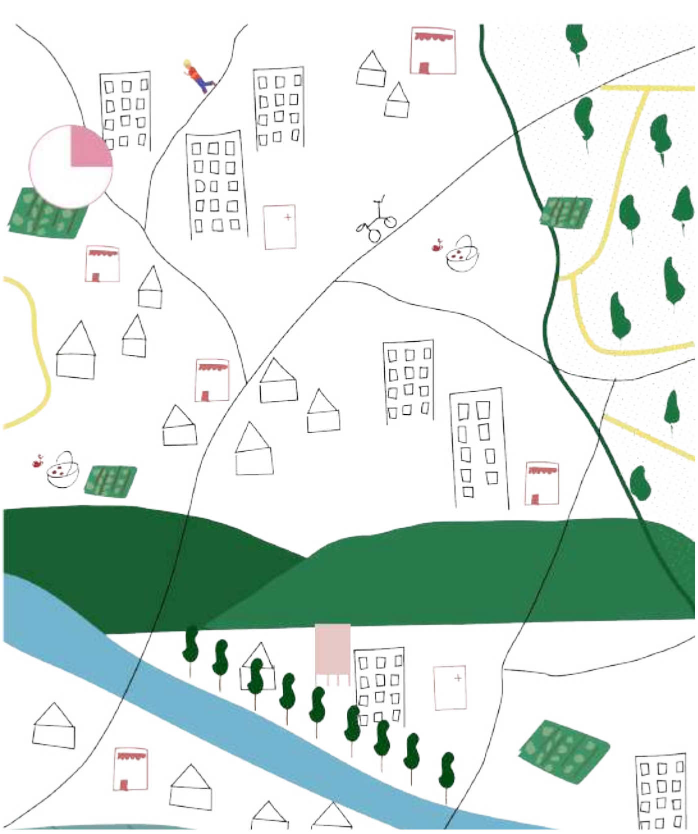
Close to nature forest management is now part of their curriculum.


There they learn about ecological & economic aspects of " close to nature forest management ".



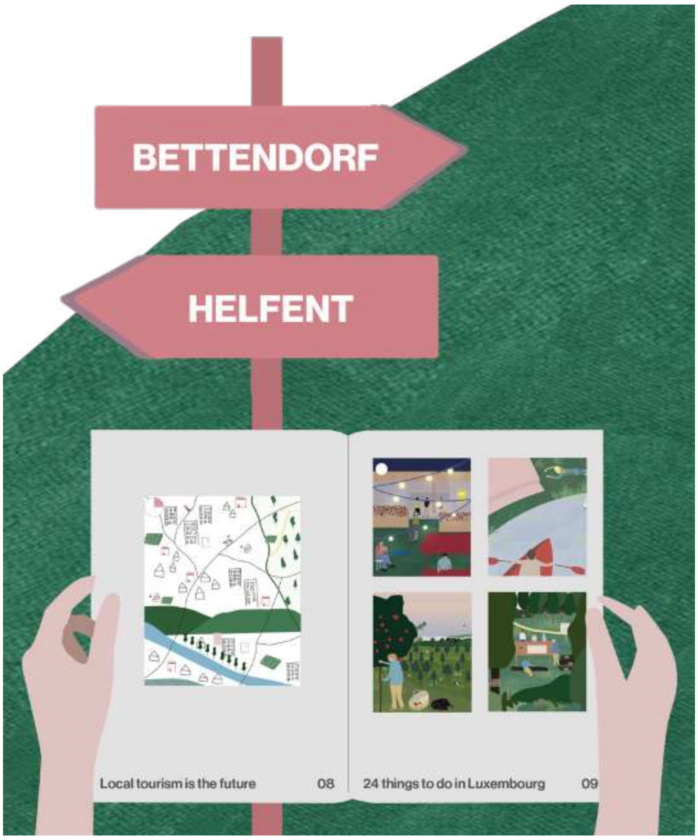

As Marie reaches 20, she moves to Helfent to continue her studies. She lives not far from the Petrusse waterfront.


The waterfront has a very active nightlife thanks to new demographies and typologies.



It is now much easier to move around the city, with every destination within reach by 15 minutes.

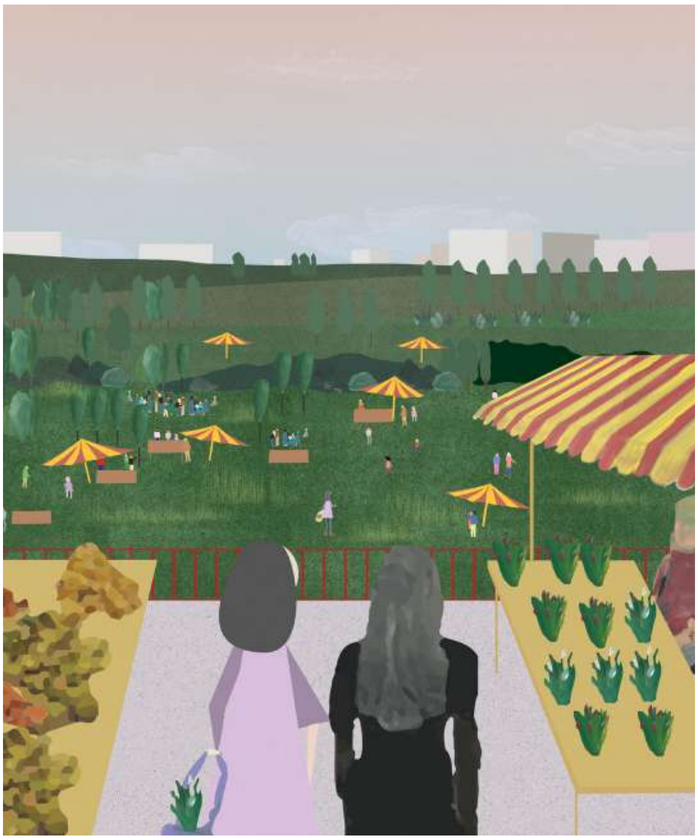

Marie's father like to take Adam, his grandson, to weekend trips around the country.




They are excited to try the newly added destination introduced in the local tourism magazine.


The summer camp they choose, has a few hiking tracks which Adam enjoys very much.

Marie, 30, has her studio in the City Concorde highrise, sitting on top of a market and vertical farm.



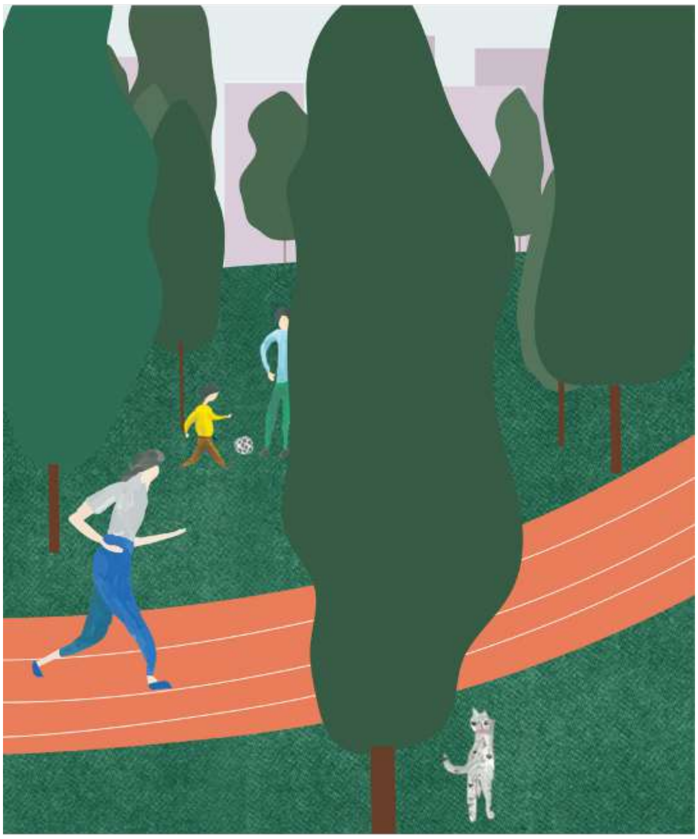
She visits the market on Thursdays to discuss the parsnips of next year with the local farmer.

Luca works at the Concorde vertical farm and co-created the market stand with other food producers in the area.

Silvopastures are now commonplace across Luxembourg, resulting in enhanced water infiltration and record negative emissions.

Citizens are invited to pick the fruits of silvopastures on specified harvest days.

Maria, now 35, is enjoying some fresh cider on silvopasture fields with her friend Noah.



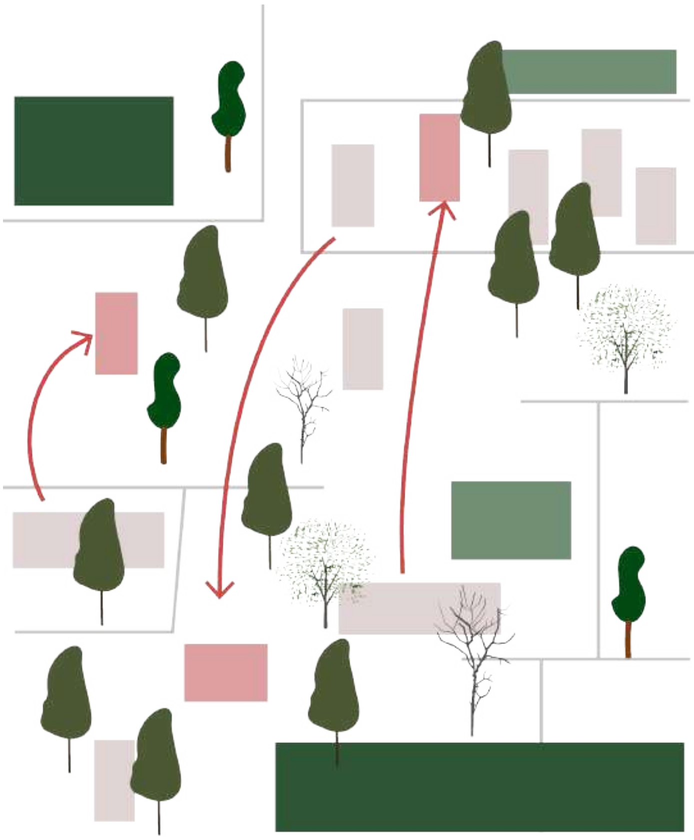
Marie goes for a morning run in running track that is within the forest next to her flat.

The track goes along the Petrusse river where she gets to meet her neighbours.

Now a grandmother, she works from home every other day and can enjoy the forest's view.

Transferable development rights has been in practice for decades now.

Marie is playing a key role in the recent round of votes for assigning sending and receiving zones.



She takes pride in having been a pioneer advocating for Net Zero Landtake.

# Appendix

# The Diet Shift Picnic Conversation

This transcript is from a conversation held in September 2021 with the participation of the Luxembourg in Transition teams and a panel of experts. The discussion revolved around the drivers of a diet shift. Sitting over the food emissions decarbonisation chart prepared by Soil & People team, and located in an arable land soon to be rezoned as an economic zone, the conversation shed light on possible pathways forward.

Experts who participated:
Line Bauer - Nutritionist
Patrick Hoffmann - Communications Expert
Jörg Nussbaum - Head of cultivation from CO-LABOR,
Camille Muller - VegInfo - conseiller en environnement chez Oekozenter Pafendall

Facilitators: Gregor Waltersdorfer and Jan Glas

00:00
Jan: Let us take lunch time and we would be very glad if you would follow us a little bit in the discussion we are going to have here now because we invited some experts on the topic of foods and this is part of the Project Soil and People, one of the working groups and I first ask the people. I am Jim, I am a moderator, and there is Gregor, he is moderating as well and also, the brain behind the topic idea of dietal shift is Line. Please can you please quickly introduce yourself and then we do the rounds and then after that we have some questions. Please, I don't know if you are hungry, but please start, don't worry.
Line: Hi everybody, my name is Line and I work as a health and nutrition coach and I help busy people mainly, to help transition to a healthier lifestyle by adopting a plant-based diet which then makes them feel better in the first place but then gives them more energy to perform in their daily work.
Patrick: Hello, my name is Patrick and Jan asked me to join this round table as a communication expert. I run a company called Scope, we can help out in communications and yes, that is it.
Jorg: Hello, I am Jorg, and I have been an organic vegetable producer for 20 years in combination with being a social worker for an organisation called *Inaudible 02:02 (1 word)* here in Luxembourg.
Camille: [FRENCH 0 2:11 – 02:35]
My name is Camille Muller, I continue in French. I'm sorry, but this is to avoid misunderstandings. I have been vegan for at least 17 years. I am active in several associations dealing with vegan nutrition.
Jan: thank you for your introduction and so, the aim of our discussion round here today is to discuss how the diet shift can happen. So, it is to know that our diet requires a lot of energy and that it also emits a lot of carbon emissions that contribute to climate change So, the question is how can we make the transition from meat and milk-based diets to a plant-based diet? How can we make it happen and also, most importantly, how should we communicate about this shift to the public? For that, we plan to have one direct question to each expert and after that we will have an open discussion. I want to start off with Line, so as a nutrition consultant, in your daily work how important is a plant-based diet in your work and how important has it become in the past few years?
03:52
Line: I actually started working as a nutrition consultant and coach a few years ago, because I have been on a plant-based diet, or mostly a plant-based diet for a lot of years. Offering this service as a coach and a consultant is actually the essence of my work. I only started to do the work as a coach because my aim is to help people transition to a plant-based diet. That is also the difference between a nutritionist and what I do because a plant-based diet is at the essence of what I do. For me, there are 3 key aspects to it. The first is the heath aspect of it obviously. The second is animal welfare, I think that also vegans relate to and the third is obviously the environmental aspect of it.
Jan: Thank you Line. Question to Mr Miller, to Camille. I will do it first in English and then in

cc Philippe Nathan


cc Rawdish

cc Adrien De Hempten

French. What is your experience from all the years of activism and promoting plant-based diets, have you had arguments? Have they changed? And what are the main arguments at the moment to change diets? [FRENCH 05:24 – 05:44]
Camille: [FRENCH 05:45 – 06:24]
The reasons haven›t changed that much, but the weight of the different arguments has changed. When we started with the vegan and vegetarian movement in Luxembourg it was mainly animal welfare that was at the forefront and now it is mainly the environment. Even those who are not environmental experts find this the most important argument, because the environment affects everyone. It›s the first emergency in all our arguments.

Jan: [FRENCH 06:25 – 06:27]
But are people more aware now?
Camille: [FRENCH 06:27 – 07:49]
People are more aware. Veganism is much more accepted. It always depends on the approach. I rarely talk about veganism «out there», but rather about plant-based eating. Then people accept it much better. I never argue with the animal protection aspects. Everyone is very aware of that. If you go to the websites of all the ministries you can find what you need. You just have to know where to find it, because the ministries don›t put it on the first page. The Ministry of Agriculture, for example, has a flyer on meat consumption. I once asked our former minister Etgen, why don't you distribute this flyer? It is recommended to consume between 300-400gr per week. The minister answered: I am also the minister for the farmers. So he doesn›t want to advertise too much.
Jan: [FRENCH 07:49 – 08:02]
Here we come to the subject of communication. This is a very important topic. Do you have anything to add?
Camille: [FRENCH 08:02 – 08:17]
No. When we talk about «plant based» everyone knows what it is. I think there is a movement going on, but it›s mainly thanks to flexitarians. I think we›ll come back to that.
Jan: D'accord, merci.

Gregor: Okay. Next question goes to Patrick Hoffman as a communication expert. So, from your experience how can tradition and social media help in communicating and changing diets?
08:33
Patrick: Well, first of all I think it's important to be aware that these shifts take time. It's often when we discuss social media and other things, we expect things to go quickly and these shifts are taking generations in my opinion, because we are coming from a time where meat consumption was at least sold as something very essential to nutrition and these are probably post-second world war reflexes we still have. There are a lot of triggers to push or to pull, to change this. There is education, we are talking about education and we are talking about politics, we are talking about social media and I think social media is one way to go into this shift. When you communicate, in my opinion, on whatever media, I think these changes should be communicated in a positive way and without finger pointing at other people. If we are talking about how it should be done, I think it needs a longer thought into it, and maybe a deeper dive into it because there are videos, there's messaging, there is image and so on. Social media should be one part of a bigger communication companion.
Gregor: Thank you.
Jan: Jorg, can I say Jorg? What could be the role of the Luxembourg produces? Because you are producing this diet transition. What could producers do to get people to also consume differently?
Jorg: So, the producers do produce so that is already the main thing.
Jan: I know, you are reacting to demands but maybe you have an idea about that.
11:17
Jorg: Yeah, so they make sure that you have a possibility to survive with that. So, it's a political question where people are not aware, people fear, and other producers fear that they may not survive in producing vegetables, so they produce animals which...
Jan: You are talking about the farmers, the producers.

Jorg: The producers yeah, what about the customers, the consumers? I think we have to show that we can produce, that there is a lot more possible in this country to produce and the customers need to see what kind of quality they get for a good price.
Jan: So, there is a change going on? Do you agree or not yet?
Jorg: There is a change going on cause when we started COLABOR in 1998, with the subscription box, first of all, the number of customers is just rising up always especially in the Corona times now and a lot of other organisations developed like *Inaudible 12:48 (2/3 words)* so we never see each other as a concurrence because everybody is filling up his niche with the needs of the customers so, we just see that there is no concurrence and...
Jan: There is still room to grow.
Jorg: There is still room to grow, yeah. A lot of.
Jan: Good, good to hear. Before we go to the open questions now. I would like to ask Andreas, where is Andreas? Can you quickly explain what we are eating now?
Andreas: Well, we have 2 salads, we have a fermented red cabbage and then we have a tabbouleh with zucchini and then we have a vegan apple pie, and we have a strawberry mint shot. The sandwich is made of a spread with whit beans, and it tastes a bit like, well if you just taste the spread it tastes like schmaltz. Do you know what Schmaltz is? And then we put salad and roasted vegetables in there and that is what we are eating right now. It is all organic, and all assembled and made here. Big thanks to our cook, he is standing right there very quiet. So, he created this whole new menu just for this event. That's Danny by the way.
Audience: *Inaudible murmurs 14:22*
Andreas: That is a very good question and I just had a great discussion here right now with Jorg from COLABOR, who I hadn't met before and he said Andreas, they've got carrots. My next question is are they organic? The thing is this organic label which is great in one way is not necessarily carbon neutral because we buy most of it from Italy or Spain and I am always looking for local but there is very little in the local market. They have potatoes and carrots but if I start asking for other things in a consistent supply because I don't need it just for one day or one event, I need it for all year round and I work with different menus obviously. I try to adjust to the season, but that's the *Inaudible 15:10 (1 word)* of any thing that the Luxembourg government could do. The criteria to become organic is so tough that a farmer has to go 3 years creating organic produce, not using an organic label but putting an organic price on. Who is covering the difference there? And these are changes where the government could really come in and say no, we will subsidise that change to push to get you organic because at some point, when we reach certain thresholds of economy then of course it gets cheaper. It gets more affordable. People do have to change their habits, it's a generational hinge definitely, not too long ago, I never thought I would not eat steak and then just a week ago Stephanie who is the CEO of Rodish invited all her family and we did a super vegan meal and she invited generations including her grandparents and none of them could believe that we were eating vegan. They said well we aren't missing a thing so, it's just  harder work doing it.
16:19
Jan: Thank you very much Andreas. Do you have an open question?
Audience 1: So, we heard now about subsidies for organic farms, so that is the one side of becoming carbon neutral. Should there be subsidies for plant-based food as well?
Jorg: So, I think in the far future, we should eliminate all subsidies, that is my point of view. But, on the way to that, the policy of subsidies has to be changed from that export-based meat and milk production that is helping here for carbon neutral nutrition, nothing at all. It's just producing CO2 by the transport costs that we have. I think we show that more vegetable production is possible here. It is never 100%, never 50% because we just have 1 summer season so we cannot produce tomatoes from October to June. This is just for the people that love tomatoes, but the subsidies have to be transformed from meat-based production to vegetable-based production. But all this

machinery in Brussel who are handing out the subsidies, they are paid by taxes. So, like 50% of our payments to the European government is going back to the farmers in subsidies. So, the price policy is the biggest problem. When the customer is aware that the food has a certain value, so in my opinion food is too cheap. So, we earn like the wholesale price of €1.60 for a bag of carrots, do it on your own and try to survive with that. That is nearly impossible. So, the price has to rise up to like €2 or something like that in the wholesale price for a bunch of carrots because if not you cannot survive. So, if the customer is aware of that, he has less money to buy a gin for leisure, for buying new cell phones or whatever, and this is also giving a good impact to the climate and all that.
Jan: Thank you Jorg, so subsidies, finance incentives. Are there other incentives you can think of to make people change? What could we do?
Line: I believe that customer demand needs to be at the forefront of this but one of the things that might make this easier is convenience and availability because if you want to eat plant-based, there are a number of places you probably won't go because they aren't really offering what you are looking for. You might get a vegan dish, but a lot of the time vegan doesn't mean healthy. So, I believe we need to work with all the actors in the ecosystem, resellers, retail, restaurants, I mean the whole environment to provide healthier and easier choices because I think that is one of the key things. We need to make healthy food an easy or an easier option.
Jan: But how would you bring those people together? What is their incentive for them to bring themselves together to find a solution on this domain? What could you mention?
20:36
Line: I think the tricky part of this is obviously what I said earlier is customer demands. There needs to be a customer demand for it and there needs to be maybe an incentive for it. It means that if you go int a shop and you are trying to buy a snack, there are other, maybe healthier options. Maybe the government could make some kind of recommendation. There could be incentives in terms of presenting at the checkout other examples such as cookies or crisps for example. But it obviously needs...
Jan: A good friend of mine, he's a professor in a university and the faculty for architecture decided to be completely vegetarian now, so these are possibilities.
Line: There are possibilities, I mean I recently heard of a hospital in Lebanon that is completely plant-based. So, there are places and, in the States, there are a lot of initiatives happening where the communities are trying to get together to try and get... because they even have the problem where they can't find good quality vegetables so there are challenges there. But generally speaking, especially in the private sector, when there is a demand and when the will is strong enough and when you have people who are leading these types of initiatives who believe in it. Who believe, who personally stand by the ideas then obviously you can make a much bigger impact. That's why I think the younger generation is more sensitive to these topics and it is typically more younger people that are plant-based than the older. Yes, there might be a shift but it's like how Patrick said earlier, it is going to take time.
Patrick: I can say something because I'm joining Line completely, in my opinion it will be less the actual social media that will be the real trigger of this shift than the younger generation. We are flexitarians at home, and I have 2 kids, one is 11 and the other is 8 and it is always very surprising and refreshing to hear them speak about nutrition because even if they like McDonalds from time to time, they are also very eager to eat not just meat and they are very sensitive to it. I think this comes and goes to show that true education and communicating nowadays will help and will help speed up the whole process to convert people. But again, I think we are talking about supply, about availability and I think what is very important for people also, a lot of people I talk to, they don't really imagine a dish without meat in it. You need to show them that it's actually absolutely feasible to do a dish that is good where they aren't missing the meat.

Jan: So, we need demonstrations and real experiences.
Patrick: Yeah.
24:20
Jan: Camille, you have an opinion on this?
Camille: No.
Jan: No, you agree?
Camille: [FRENCH 24:29 – 24:31]
I agree.
Jan: Oui, okay.
Gregor: So, now you mention Patrick that the people are expecting like one piece of meat and then a side shift, right? So, if you had something to focus on, one question is what do you as experts think about cultured meat? That is meat that is grown in the laboratory, that is artificial meat which is based on plants like pea protein and then people eat it, and they don't even realise it's plant-based? Just as an entry point to get them into plant-based diets and then later on they can leave this piece of meat and they can eat a bigger variety and discover a bigger variety of plant-based meals but cultured meat as an entry point? What do you think about that?
Patrick: May I? I think they have opened up the first cultured meat burger store in *Inaudible 25:35 (1 word)* something like 6 months ago and it is open to the public. I don't know what to think about it, but I have the feeling, while it is just a feeling and it is not something intellectual it is just a feeling, if people realise that cultured meat is actually something perfectly feasible, I think meat will lose interest enormously in our nutrition and that might be one reason to support this cause. Without having an expertise on it, I don't know if cultured meat is healthy, I don't know of what condition it is done under, and I am not speaking about ethics at all, but I think just for showing people that meat is one piece in our nutrition chain, I think that on a communication level will take the importance of meat away and step back a little. That is my personal opinion.
Andreas: Just one point of what I really have to say is we really underestimate the amount of time that goes into producing a vegetarian meal that tastes like this, compared to frying a steak, frying eggs, frying bacon, within 5 minutes it is done. Throw some soy sauce on, there's taste there, meals finished. A vegan meal is much more laborious and when you first try to go out and do a vegan meal like I did with Stephanie, we went to the supermarket and said right let's go vegan, we bought carrots and celery and some apples and so like what do we do? So, that's a real, you know, thing we have to overcome.
Gregor: Thank you.
Jorg: So, as an organic producer, you know that plant production should be made in a naturally grown soil. So, that is the top law in organic farming. So, there is artificial soilless production of plants also possible, but this needs extra production conditions that have to be constructed which have to be fed with energy and stuff. With meat production, it's the same so technological experiment but it can never replace a natural process. But the growth should not be to replace meat by artificial meat which is already done by several vegan products, but artificial meat and animal cells or stuff like that could be a solution but they have to transmit on the consumers that meat in certain quantities is becoming unhealthy.
Gregor: And it uses a lot of energy, is what you are pointing out.
Jorg: Yeah, it uses a lot of energy, yes.
Gregor: And then we are not against the CO2 balance.
Patrick: That's it yeah, if you have renewable energies and you make an argument like that then okay, but all this would be missing for the other stuff.
29:41
Camille: [FRENCH 29:41 – 31:03]
On the vegan side, I find it a bit of a shame. If it›s the solution for the climate, I understand it, and for those who absolutely want the texture and taste of meat, I could accept it, but I›m a bit sceptical. For 20 years we have been trying to show that it works without meat. You can eat healthy and you can do something for the climate and your health. That›s why I see it critically. The last point is also - as has already been said - health. We don›t yet know what it will do to our health. We may not have any new

diseases, but we will probably have ailments related to our organisms. I remain quite critical of these inventions. Because we already have «meat» textures on «plant-based» products, which are produced on the basis of pea proteins. There are quite a few products that almost replace meat and that are not so bad. But to produce something that just comes out of a laboratory, I remain quite sceptical.
Jan: [FRENCH 31:03 – 31:09] Interesting point . I find in the supermarkets that every year, every second year the shelves become bigger in the vegetarian sections and I think you will agree with me on this. I think there is a shift going on, can we make this faster? It's again repetitive and maybe I will repeat the same question but with some new ideas during the discussion or maybe there is someone around us that wants to compliment the discussion? I think it›s half past 1, we wanted to stop at 2 but we will see how the discussion goes. Have you had your lunch? Was it nice? Very good, good to see this. So, something to add, do you have another question?
Gregor: I have a former question, when we stand together before a discussion, we already started a little bit actually because there was this question how should we label this diet? Should we call it a vegan diet? Or is it better to call it a plant-based diet? So, we will bring our discussion onto the communication, so how it is best to communicate about a plant-based or vegan diet. Which phrasing provokes least opposition?
Line: Personally, when I speak of my own diet, I speak of a whole foods plant-based diet because that is what I aim for in terms of a healthy diet that I am adopting. To me, vegan sounds a little more dogmatic, it has some positive and some less positive connotations. So, my personal opinion of that is maybe try and yes, find something that creates common ground, to be inclusive rather than exclusive. When we are talking about a vegan diet or a plant-based diet, we often are talking about not eating meat and the things that you are supposed to not eat. The things that people think they are going to miss out on Vs. the things they will gain. People who adopt a plant-based diet, usually their taste buds become more developed. They try to savour things in a different way. There is not the fat and other things that cover the taste, but you try and start to really enjoy the things that you are eating, and I think also from a communications perspective, one should focus on the positive aspects that a plant-based diet brings rather than the things that you have to miss out on. By the way, I think plant-based cooking in terms of cooking is not so difficult, it is just a different way of cooking, so maybe there needs to be some education around that but, yes, I think in a few minutes you can still do a healthy meal.
Jan: Okay.
Audience 2: I remember Gregor once told us about his uncle who believes that not eating meat for one meal even is an unhealthy act. It is unhealthy, you have to have meat in all of your meals, so I wonder as a nutrition scientist, I forget the exact term, consultant, what is your view on lets say, the amount of meat intake that we can have per week and its relation to health. Are there also disadvantages to eating meat every meal of the week is a question I am wondering? And to just explain, the diet shift that we were discussing during the project, was not shifting to a fully plant-based diet but was a gradual shift from one meal per week that is the average today but to one day per week by 2025 and half of the week by 2035 and 6 days a week by 2050. Still there is 1 day a week that meat can be taken as it is. Thank you.
35:38
Line: I think that the key question when we are talking about meat is about the protein because that is usually the question that people ask you. When you say you don't eat meat, the first question that comes about is how do you get your protein? I think one of the key aspects of that is first: where does the protein come from? The protein actually comes from the plants. So, the fact that the animal eats the plants, that is where the protein comes from. So, I think a person who eats a balanced, whole foods, plant-based diet doesn't have any problems in terms of getting enough protein.

That is the first thing. The second thing is that most people think they need a lot more protein than they actually need. Protein is not or should not be the key ingredient of our diet. Carbohydrates, carbs should be and for those who don't like to hear this, I apologise because there are people who think that a low carb diet is healthy. I believe that a healthy diet should have mainly carbs but healthy carbs in it. That means carbs that transform into what we call slow sugars that slowly go into the bloodstream. So, there are many misconceptions about the way the plate should look like, or the food pyramid and we have talked all about this and to give you an example, I think that when I look at the food pyramids or food plates that have become more common, I look for Canada. I think Canada is one of the first countries that makes recommendations that come a lot closer to a plant-based diet than other countries do. For example, in Canada, if you look at their food plate, the majority of their plate is mostly vegetables and then there is some part for protein as well and then they make water the drink of choice and they have taken dairy completely out of their food plate. So, I think there are countries that are further ahead than we are in that perspective. Well, you've got to ask them but when I look at the website for the Canadian, I don't know what its called, what the USDA would be, but they have decided that this is what they recommend Canadians to eat, so there is a politically will obviously attached to it and the momentary aspect is the other angle because then healthier diet, healthier people, less healthcare costs. I mean the implications are vast.
Audience 2: I have another question for our friend from COLABOR, and that is about the metrics that we use, thinking about this project and talking about decarbonisation and carbon metrics but something that is difficult to capture with this outlook is biodiversity and also sustainable water systems. So, water and biodiversity seem to fall in the blind spot when we look from the outlook of carbon. I was wondering as a producer; do you currently work with some understanding of metrics of biodiversity or sustainable water resources and flows? In your produce.
Jorg: Good question so, to water our cultivations we have here in Bertrange We have the rainwater off of the roofs. Just we don't have enough basins. So, that was limited by the environment and we were constructed for the place there that it has to be a certain size. It doesn't respect the real needs, this year we have far more than enough water. The past 3 years, it has been like after about 3 weeks it was all gone. So, we water especially at night-time, we try to water by triangulation, and we work with systems which means we keep the water underground by keeping the grass cuttings like that. So even in the greenhouses we do that. We have another place in Begin, near the outset river. We are not allowed to take water from there, so this is pretty complicated in this country as you construct bigger greenhouses. You also have restrictions such as what you do with the water. The water has to get back into the environment somehow, so the restrictions here are pretty high so I can just agree with you that it is a big problem here.
Audience: *Inaudible 40:56*
40:59
Jorg: Biodiversity? For sure, we do use only 2/3 of our land for the crops and 1/3 of the land for green fertiliser for a rotation system, so we always have a 2-year break in the cultures to revitalise the ground by global crop mixture and things like that. We make flower stripes for insects like that and yeah, we have plants around our cultures to break the wind, we cut the grass around our cultures but just 1 meter so the rest can grow. There is no need to create a golf place like that so yeah. I just want to answer a question concerning the effect of... I have been vegetarian since 88 and there have never been any problems with my health, so I really want to tell you that also.
Jan: Thank you Jorg, interesting. Gregor, you have the last question.
Gregor: Yeah, it is this last phase of the whole project. It should be about pilot projects, so my question to the experts is, what could be the next step of this transition to move to a more plant-based diet? What should be the next step

in your point of view? Should it be a public debate or should it just be more businesses? What is your point of view on that?
Camille: [FRENCH 43:20 – 45:56]
If you look at the statistics here in Luxembourg - and you can in all the countries in Europe - there is a movement now - especially the flexitarians have a lot of momentum. We should take these people and motivate them to go further. Because flexitarianism is well defined, but not by everyone. Some people already call themselves flexitarians if they have nothing against vegans. That›s it. But now we have to take advantage of this momentum to motivate people to go further.
To practice flexitarianism as it is defined. You (Soil & People) have all this in your study. I don›t have to quote anything. And from then on we will have more than a critical mass to move forward. To take the others by the hand. And the rest is good communication. And we›ve already said it: you have to avoid becoming too dogmatic in your terminology and avoid talking about veganism, but about «plant based» and explaining to people the real role of another kind of nutrition. That, in my opinion, is the next thing that needs to be done now.
And I›m aiming here especially at education. It is very important. I am 12-18 times a year in high-schools. I talk a lot with the students and year by year I see a difference. Even teenagers are much more aware and they have an influence on their parents. Above all, we have to invest in education. In particular, we must also invest in gastronomy. We have to tell our gastronomes and our local authorities who are responsible for the «Dëppenfester» (village festivals).
We have 18% flexitarians plus 5% vegans, so that›s more than 20% of people who want to enjoy another choice. And again, it›s maybe more political, but we need to talk more to the community leaders.
We also have certain tools in the climate pact. In chapter 6, there are three points that aim at another kind of nutrition. But I think that they are not paid enough to invest in this, but we should invest in motivating the local authorities.
Jan: Merci. Do you have an idea on what the next step is, what would you do if you were in charge?
46:14
Gregor: That is a question to our communications expert.
Patrick: I think it is a very difficult question because it should be tagged on various points in the meantime, but I think it is important to bring the debate out and not try to convince the convinced. Again, I think convincing the not convinced is by bringing out options and positive messages to a diet shift. I think, going again, I am saying probably the same thing that I said in the very beginning but pointing at people and saying okay, you're the meat guy, I am the vegan guy, and everything opposes us, and I think it is important to try and convince the not convinced ones and to convince them who do not have an opinion yet. These are obviously the kids and build it from the lower. That would probably be the quickest way, but I completely agree, a public debate including all media, not only social media would in my opinion, would be very helpful as a next step.
Line: I think what has been said earlier, we were also talking about a generational gap. So, one angle that personally I look at and speak with my clients about and I look at it with a health perspective obviously, but I have had a lot of times that people start to get more sensitive to a plant-based diet when they start having chronic health problems. I think that is maybe a way to enter it. I think in Luxemburg we are very much focused on reactivity, on reactivity when it comes to our health. When we are sick, we go to a doctor, he prescribes us something and we are treating the symptoms and we are not treating the cause, so I think with the medical body we should be working with them as well. We need to move and go for prevention. Luxemburg suffers enormously from cancer. Cancer rates have gone up quite a bit so I think from that angle, that would be another point we could enter and create a debate in changing a little bit in the medical spectrum, how things work around there.