ETH Zurich Department of Architecture
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Soil, Water, Labour
Fall 2020

Crop Cultivation

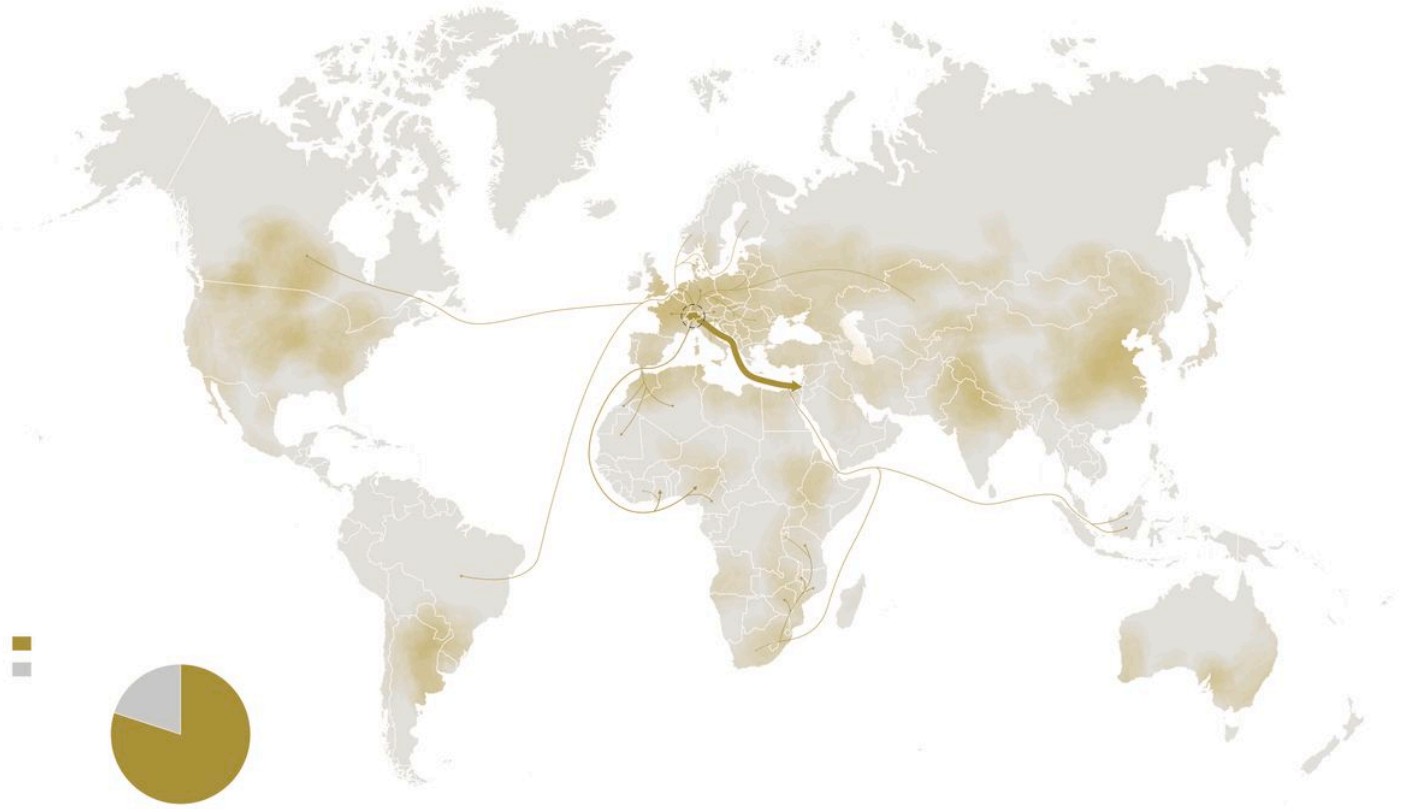
Restoring Soil Fertility

Ronan Crippa, Arianit Ramiqi, and Ekaterina Scholz



The way we cultivate crops today is not sustainable resulting in erosion and loss of biodiversity. Existing soil-conserving cultivation methods are not implemented due to the dilemma between intensification and sustainability. Latter can be bypassed through new multi-scalar implementation models.

Food Crop Or Cash Crop?

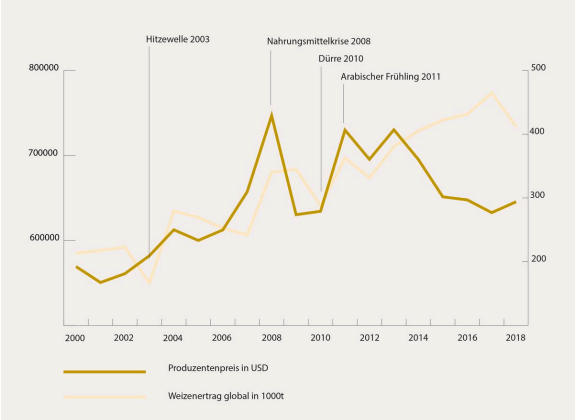


On a global scale wheat grows in the moderate climate zones and among the top wheat producing countries are the EU, China, India, Russia, and the US. If one takes a look at Switzerland it imports 200 times more wheat than it exports. The import is equally distributed between Switzerland's neighbours Austria, Germany, and France as well as Canada and Russia.

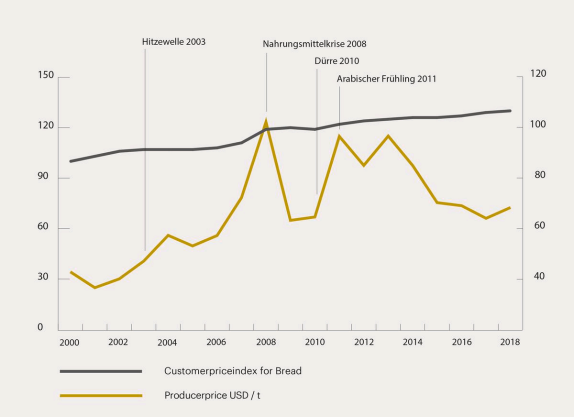
That is different when it comes to export as Switzerland exports around eighty percent of its wheat to Israel because of a trade agreement. Besides the production it is interesting to take a look at the predominant crop use on a global scale as almost the entire northern hemisphere produces more crop for fodder and fuel than for human consumption. The key role of wheat in the past can be showed on various expels. In 1775 in France a revolution started called “guerre des farines”. Due to bad harvest, the price for bread raised suddenly, making it unaffordable to the lower class. The rupture of the Asama volcano in Japan lead to a further decrease of the wheat harvest, caused by a giant cloud of ash. Nowadays the importance of wheat did not lose any of its power. In the past twenty years there have been even two mayor events caused by raising prices. By comparison to the days of the French Revolution, we can notice that during these crises, there has not been a lack of wheat on a global scale. Still the prices have nearly doubled in just a few years. As the price can no longer be linked to the produced amount of wheat, we can observe a strong connection to the value of the US dollar, meaning that no longer nature, but the finance sector is now in charge to define the price of wheat.



Market price



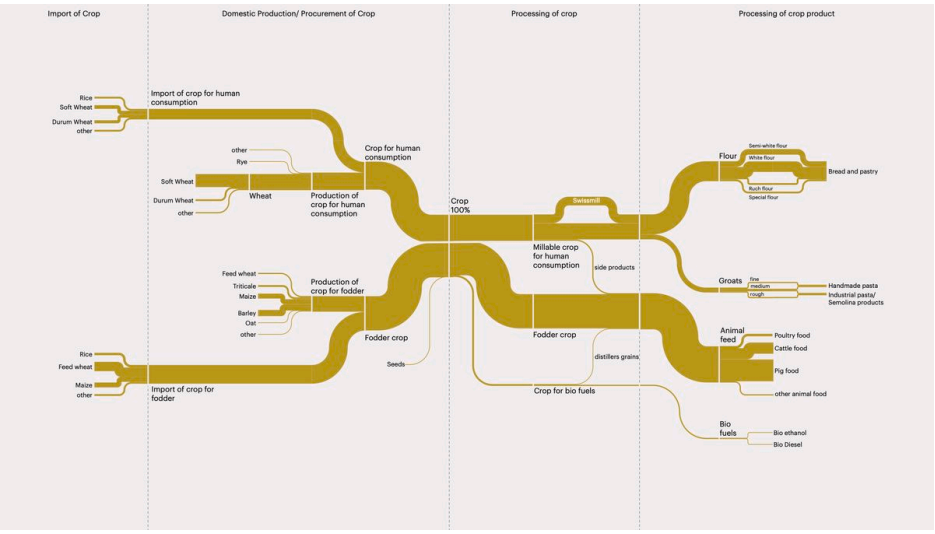
Wheat price



Bread price

The Market Sets the Price.

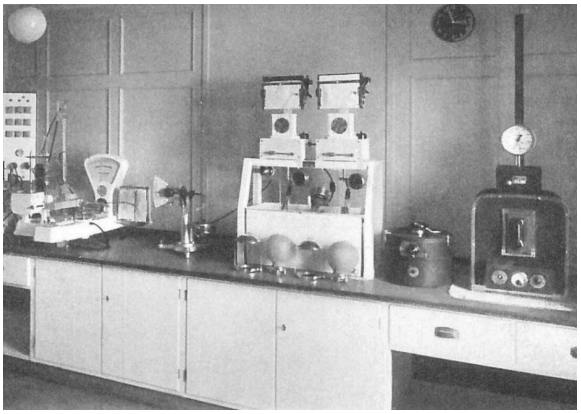
On the scale of Switzerland one can as well observe that more crop is produced and imported for fooder than for human consumption. Also for both, human consumption and fooder, imports make up around half of the amount of crop that is processed further. Among the imported crop types rice is an important one as it does not grow in Switzerland. Among the domestically produced crops wheat, more specifically soft wheat, has the overhand. In the further processing a small amount of both the crop for human consumption and the production of bio fuel goes into the production of fodder. Yet the most striking fact is that a third of the crop for human consumption is processed in the Swissmill. The outcoming products are then further processed. Flour is used for the production of bread and pastry, groats for the production of pasta, fooder for the production of food for different kinds of animals and fuel for the production of biodiesel and bioethanol. So why does the Swissmill has such a predominant position in the metabolism of crop and wheat?



The metabolism of wheat for Switzerland
is about import, fodder and the Swissmill.

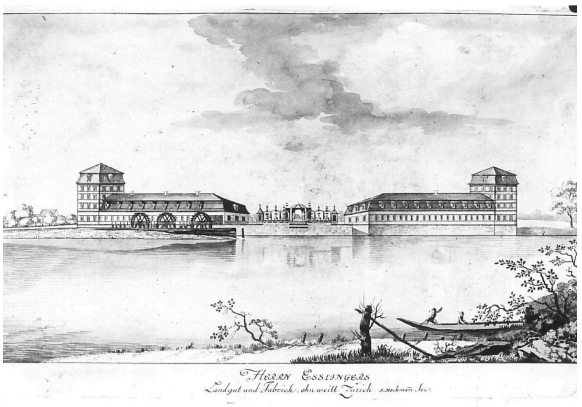
The Rise of the Swissmill to a Symbol of Centralization



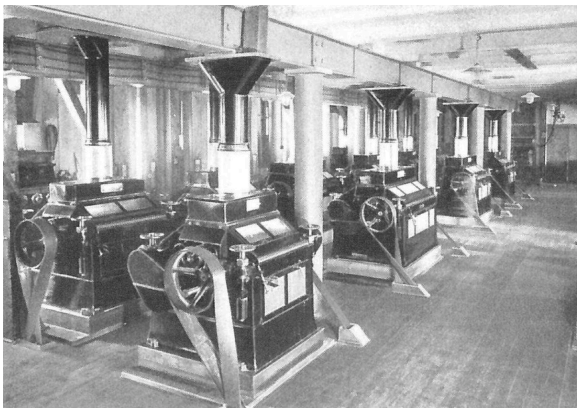




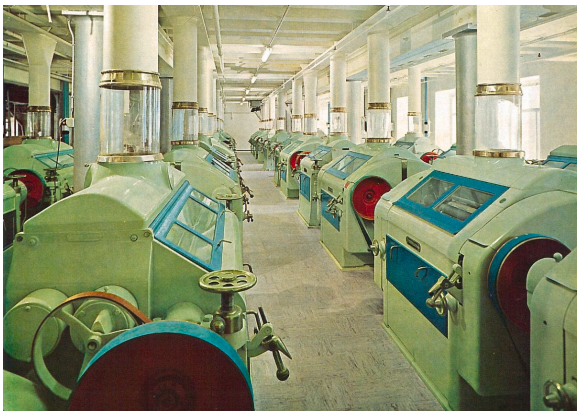




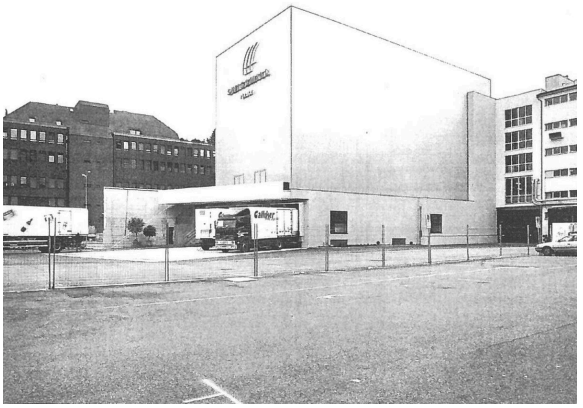
Before the mill. Source:
Baugeschichtliches Archiv Stadt Zürich



First modernisation phase

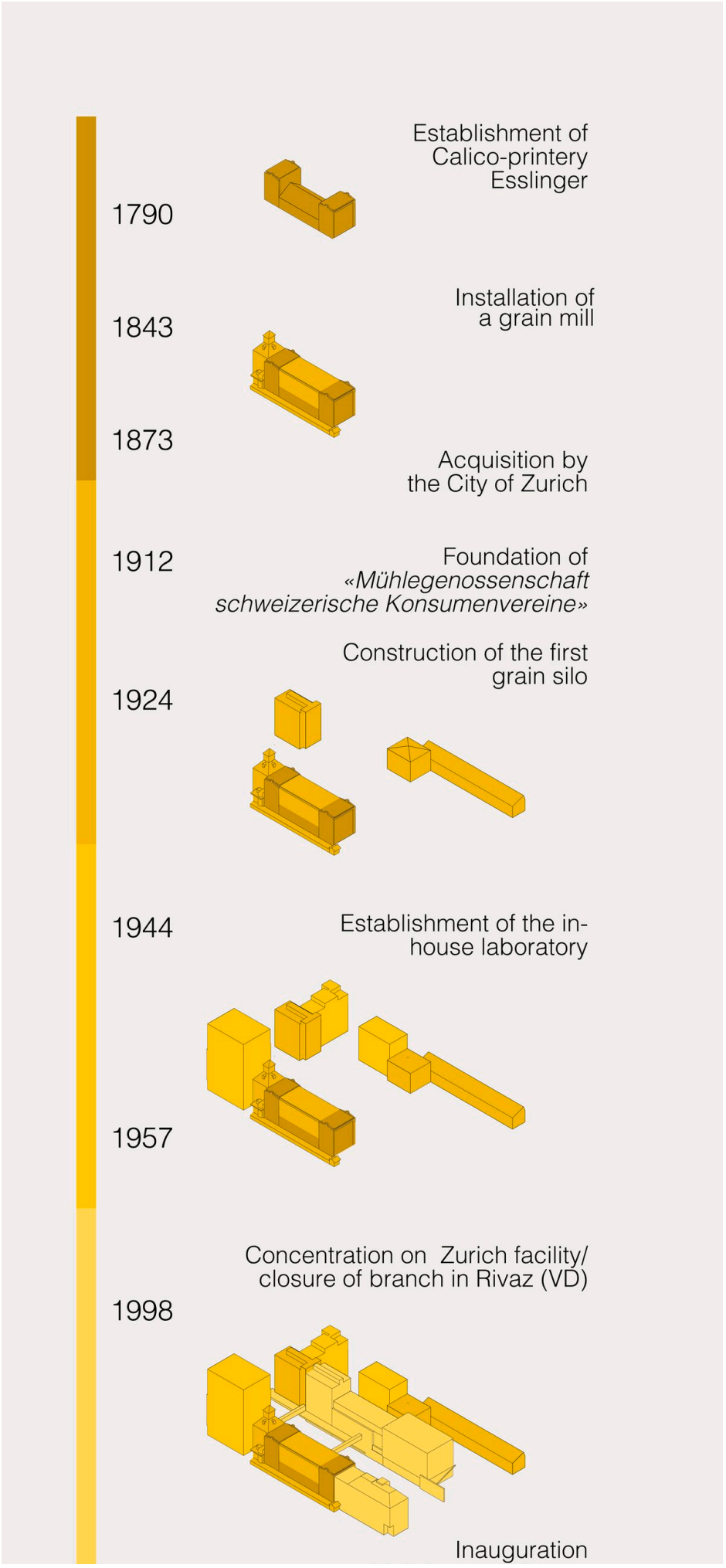


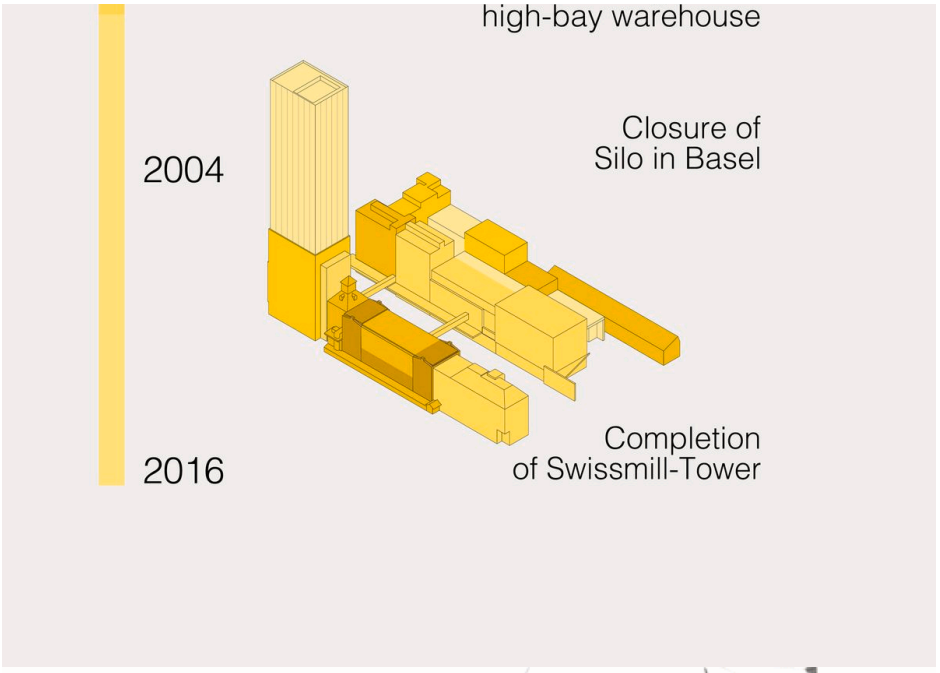
Second modernisation phase



Expansion phase

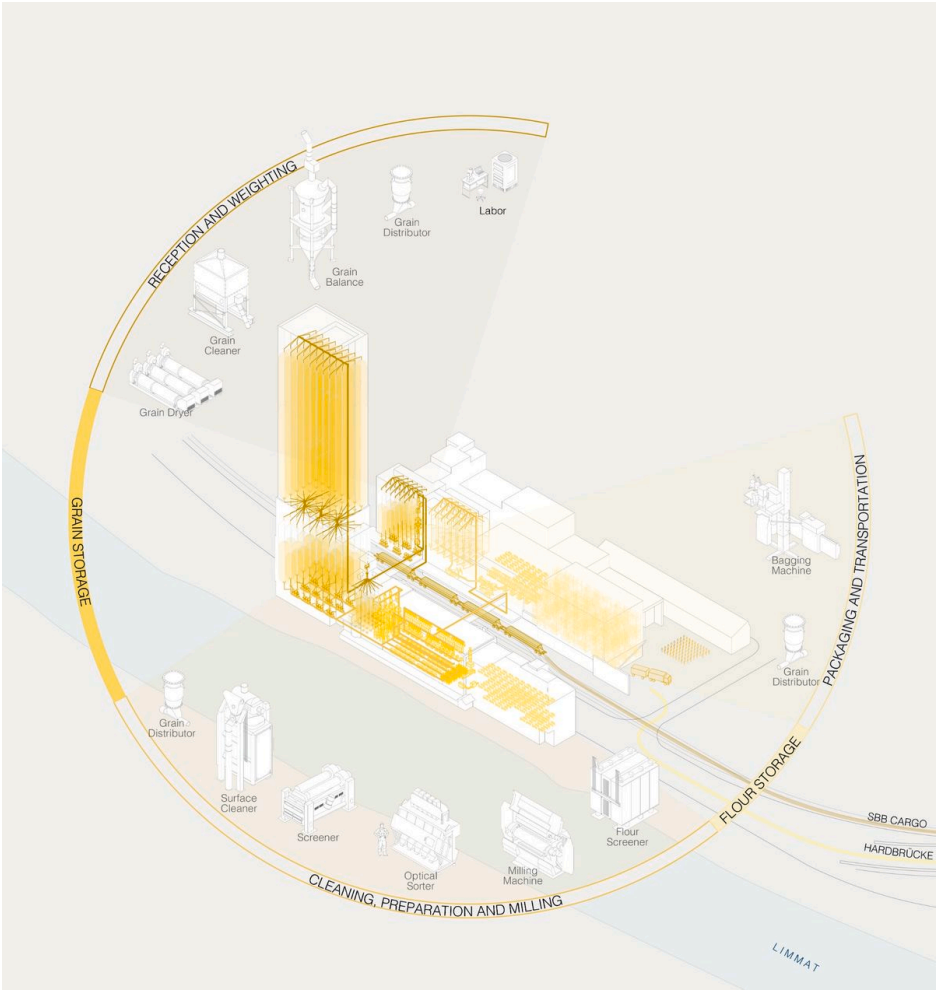
The history of the Swissmill can be roughly divided into five phases. After the Esslinger printery gave up its use and the milling technique advanced with the invention of milling rolls the foundation phase starts. The installation of the first grain mill happened 1843, followed by the aquisition by the city of Zurich 1973 and the foundation of the “Mühlengenossenschaft schweizerische Konsumvereine” in 1912. In the following first modernisation phase the first grain silo was constructed in 1924 and an in-house laboratory was established in 1944. In a second modernisation phase, among other advances the first grain silo on the site of today’s tower was constructed. After that a period of expansion based on fusions started. The mill remained in the property of Coop and the branch in Rivaz closed. In addition a silo site in Basel was sold to Novartis making an expansion of the Zurich location necessary. The most recent expansion period is marked by the inauguration of the high-bay warehouse and the completion of the Swissmill tower.


1790
Establishment of Calico-printery Esslinger
1843
Installation of a grain mill
1873
Acquisition by the City of Zurich
1912
Foundation of «Mühlegenossenschaft schweizerische Konsumenvereine»
1924
Construction of the first grain silo
1944
Establishment of the in-house laboratory
1957
1998
Concentration on Zurich facility/ closure of branch in Rivaz (VD)
Inauguration





A journey to the Swissmill.



The complexity of milling. Source: swissmill.ch

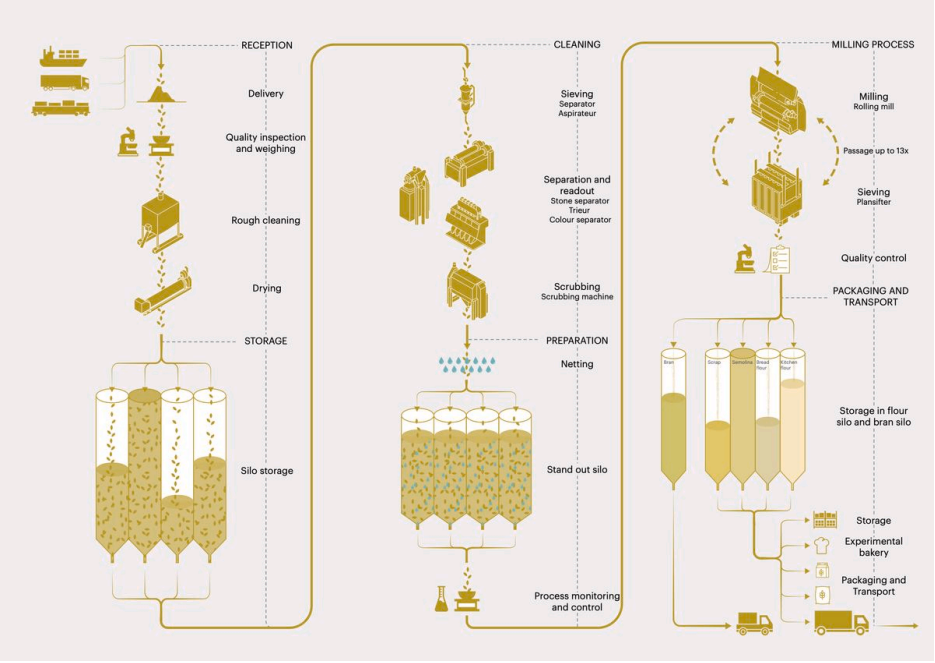
Thus the Swissmill nowadays is a highly modernised mill. The modern milling process consists of several steps, the whole process is highly automated nowadays, yet the core processes stayed the same over the last few hundred years. The reception of the grain starts with the delivery followed by quality inspection and weighting, rough cleaning and drying. Afterwards the crops are stored in a silo. Further they undergo a multi-stage process of cleaning consisting of sieving, separation, and readout as well as scrubbing. In the following the clean grain is enriched with water in the process of netting and stored again in a stand out silo. After the process is monitored and controlled the core process, the milling, starts. During this process the grain is milled between rolling mills and sieved. This process between milling and sieving called passaged can take place up to thirteen times. After another quality control the different types of flour are stored in a flour silo and the bran is stored separately in a bran silo. The final products are then packaged in household packages and sacks, directly transported in a silo truck or treated in an experimental bakery.



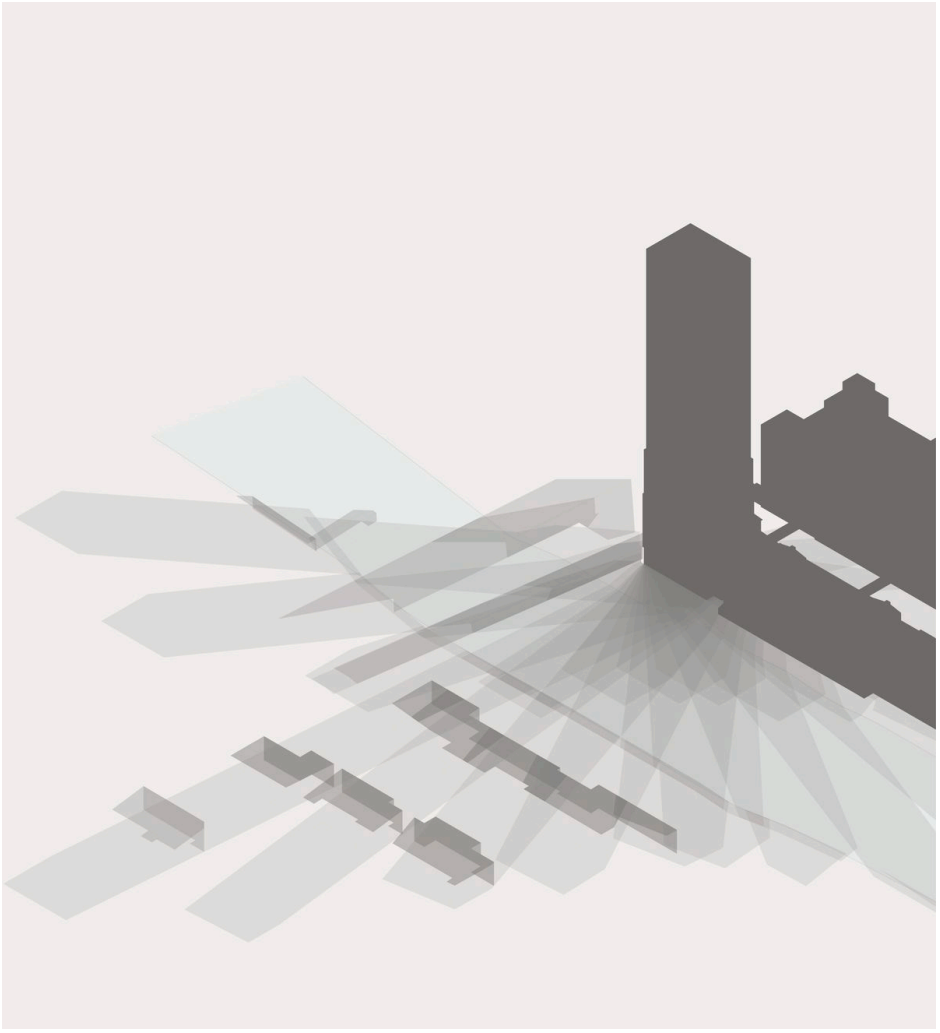
Inside the Swissmill.
Photographs: Landolf Urs, 2020.



Inside the Swissmill.
Photographs: Landolf Urs, 2020.



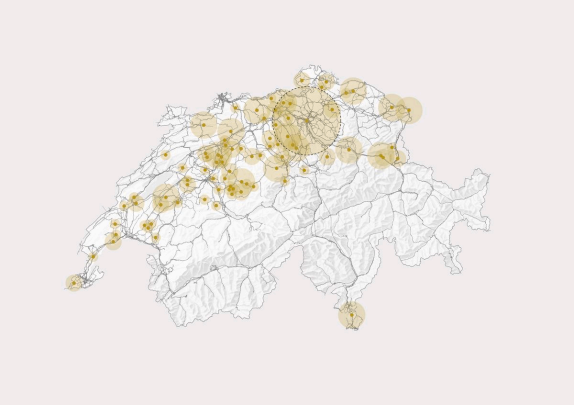
The crop milling process is both simple and automated.



The shadow of the Swissmill provoked a heated debate

The debate around the construction of the Swissmill tower mainly focused on the height of the building as well as the problem that the building drops a shadow on the “Obere Letten”. It was also a question of whether the city is an appropriate location for a symbol of agricultural production or if it has to be placed in the periphery. Concerns were raised that expansion of the site would lead to increased noise emissions and other conflicts in the existing fabric of the neighborhood, especially since supplies were only to be delivered by rail.

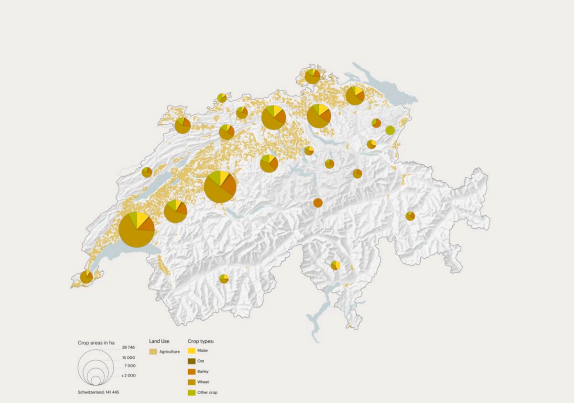
The debate on the Swissmill does not touch on the territorial impact of the further expansion of the Swissmill. Around two hundred years ago there were around 3,000 mills in operation across Switzerland. Through a process of fusions, expansions, and modernisation, nowadays only around seventy mills are in operation. They are located in the northern regions of Switzerland that are suitable for crop cultivation and their size and importance varies, besides one. The Swissmill has a monopoly position in the region of Zurich and is of nationwide importance. That is of interest as the region of Zurich has a very high proportion of agricultural area.



Mills in operation today and the mopoly position of the Swissmill.



The Mittelland is a fertile region for crop cultivation.



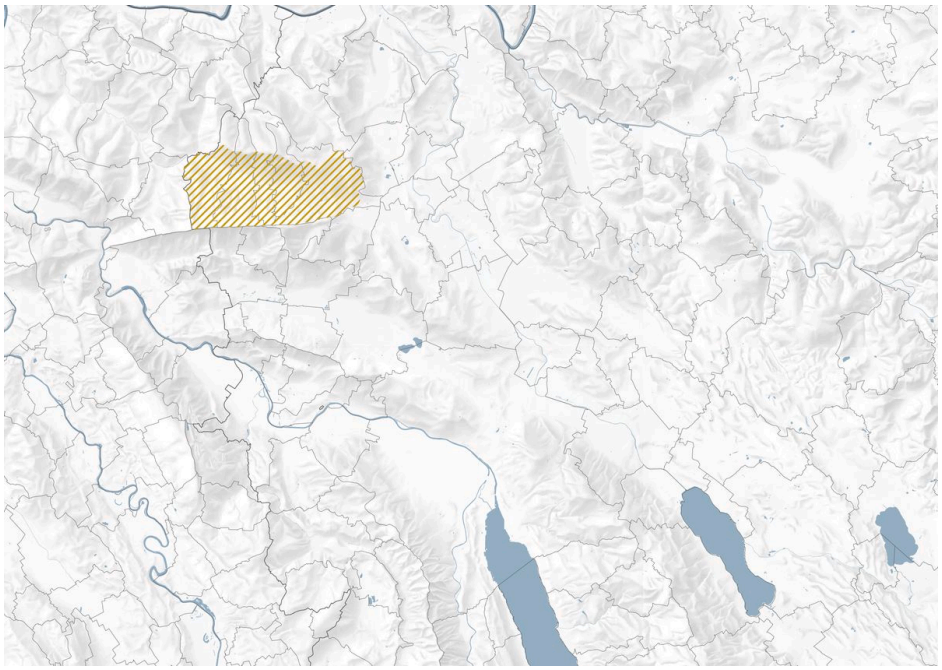
The Mittelland is a fertile region for crop cultivation.

To understand the production of wheat we have to take a look beyond food production for humans. The importance of crop for fodder and fuel production as well as its dependence on the financial market cannot be overlooked. We have to be aware of the fact that through ongoing expansions, modernisation, and fusions the Swissmill gained an almost monopoly position over the processing of wheat in Switzerland which impacts the landscapes that support it.

Force Feeding the Plant and Starving the Soil



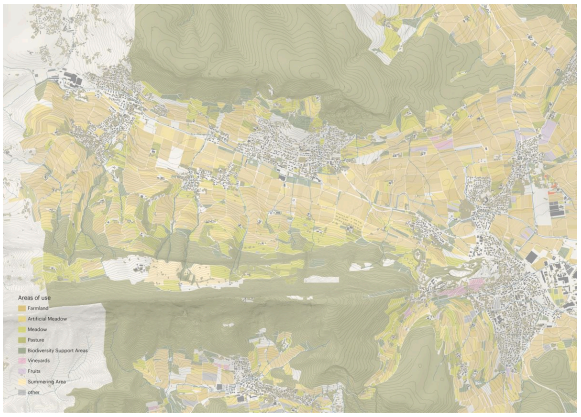
Looking at the Canton of Zurich the Wehntal Valley is an area that is mostly dominated by crop production. Winter wheat and barley are the predominant crops cultivated in the valley. For this reason it becomes our area of research. When planning on which crop to cultivate on a certain field it is important to take the soil suitability into consideration which does not follow any parcelation structure. Every plant has different requirements to the soil and every soil can offer different nutrients to the plant.



Location of the Wehntal Valley. Source: maps.zh.ch.



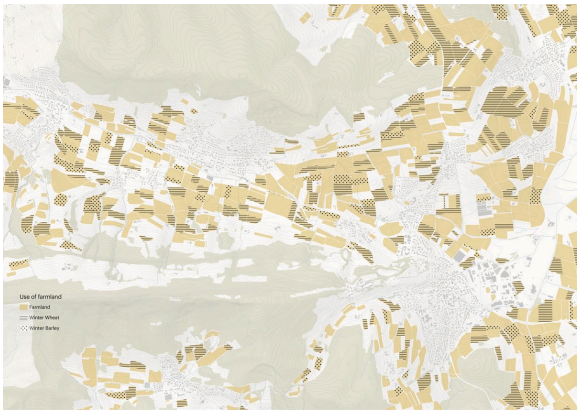
The predominant land use is farmland



A valley dominated by fields.



The predominant land use is farmland



Mainly winter wheat and barley are cultivated

To Each Their Own in the Principle of Crop Rotation

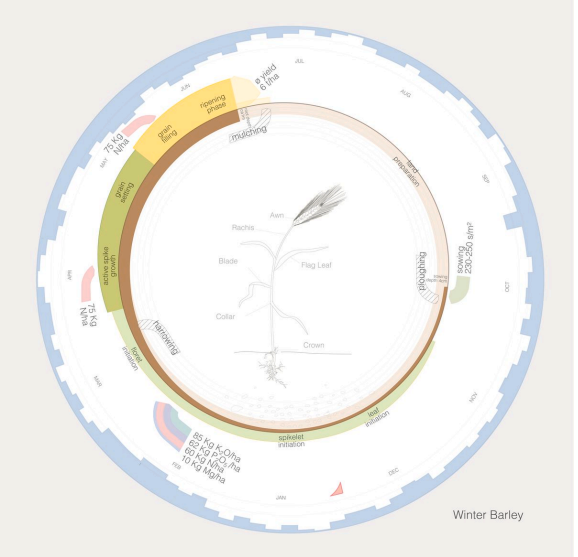
To successfully grow crops today a farmer must know the specific needs of each plant he or she wants to cultivate. On the example of winter wheat, you can see that every work step has to be done at a certain time in the season, depending on rainfall, temperature, and soil quality. As each plant feeds on a specific mix of substances, the soil will become very vulnerable towards pests as there are always some pests, growing exactly on those resources left by the cultivated crop. Therefore the farmer has to balance the nutrition in his soil. Today crop rotation is still the most important tool to tackle this problem, both in conventional as well as in organic farming. By altering the culture the soil can recover and therefore the risk of breeding pests can be reduced. With certain crops the farmer is able to restore certain amounts of nutrition allowing him to reduce the used amount of fertiliser.

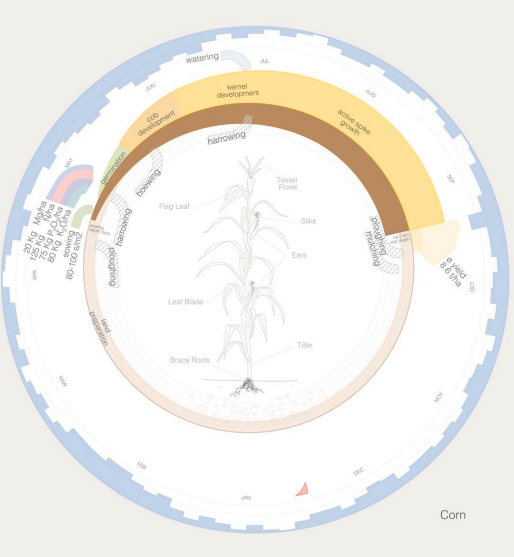


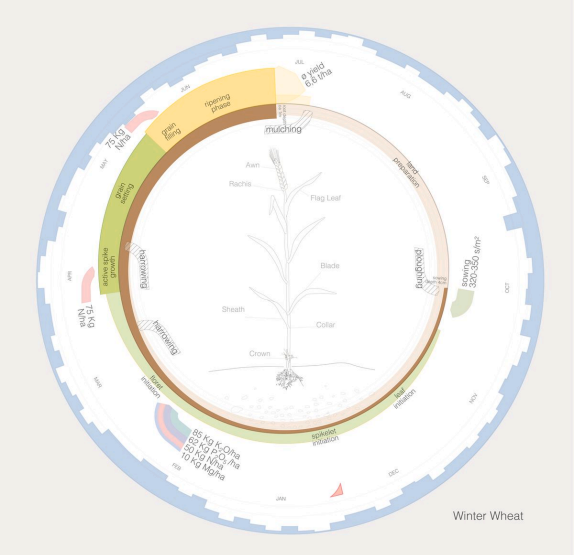


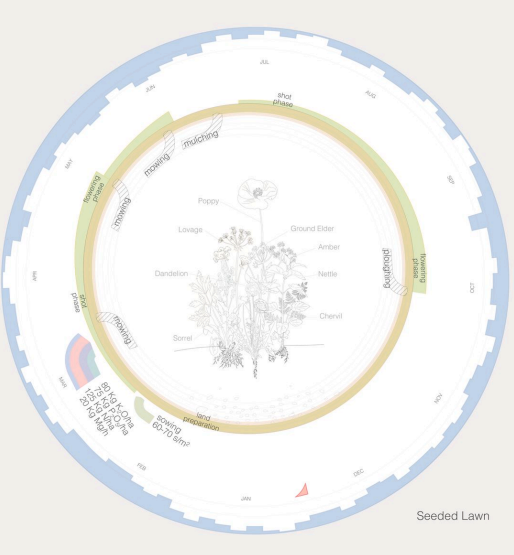


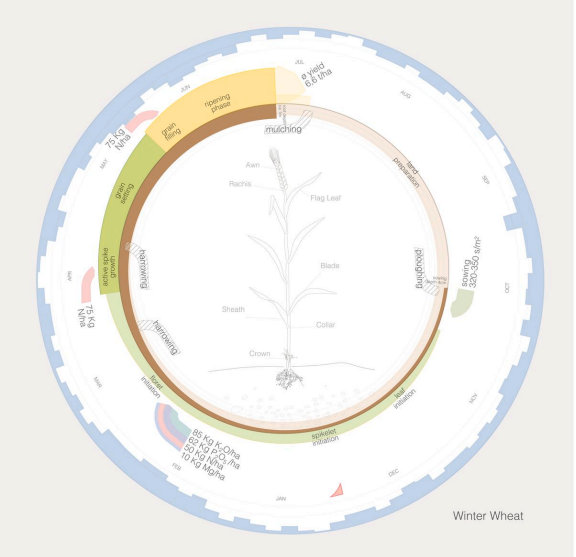



Winter Barley

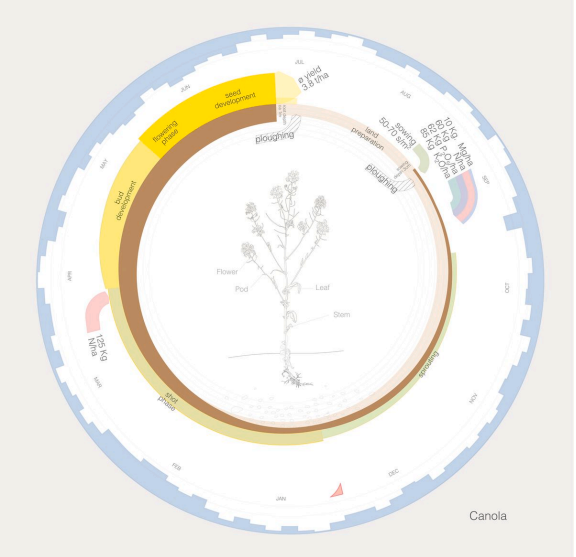

Corn


Winter Wheat

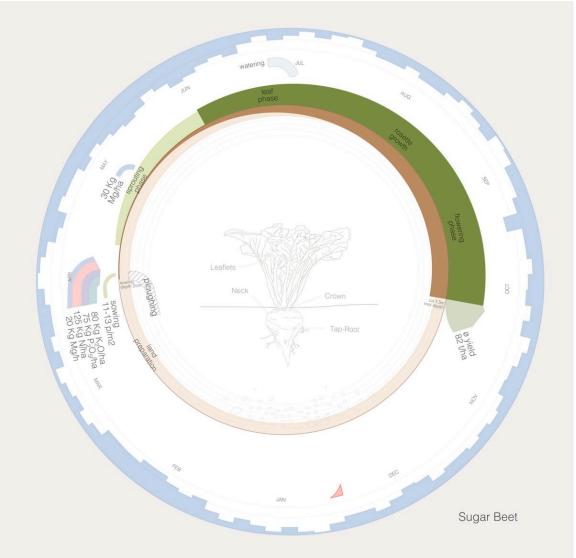

Seeded Lawn



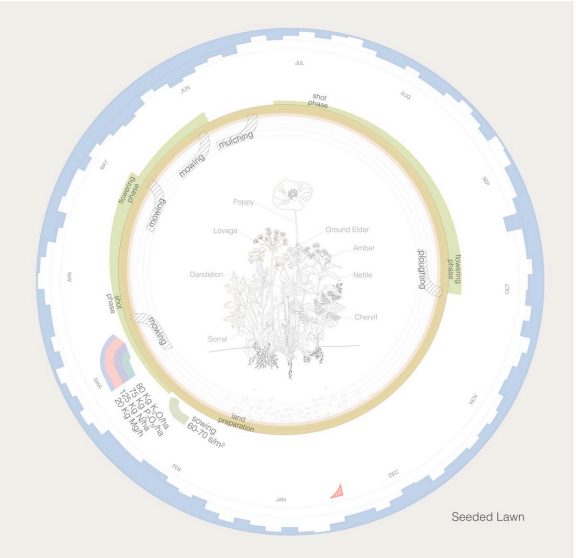
Cereals



Oil seeds



Root crops



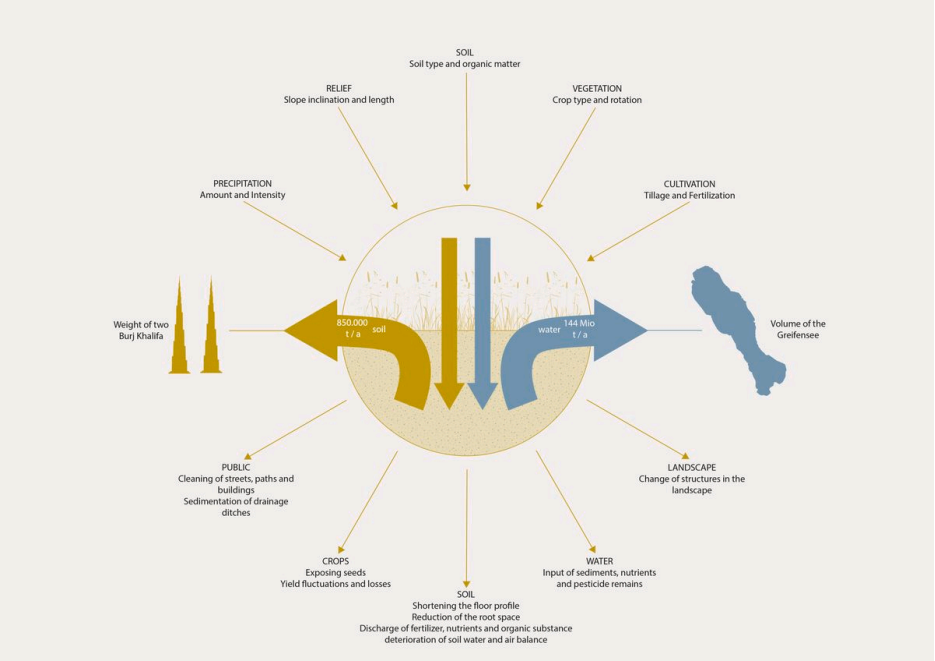
Legumes/Lawns



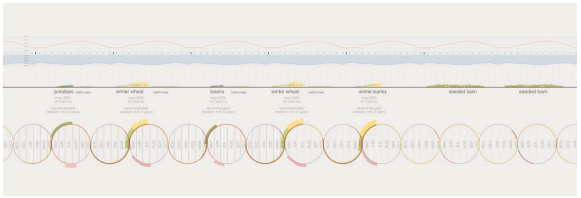
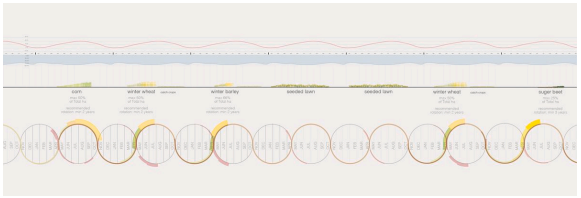
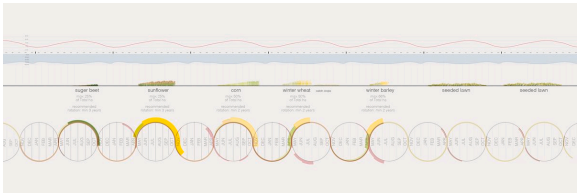
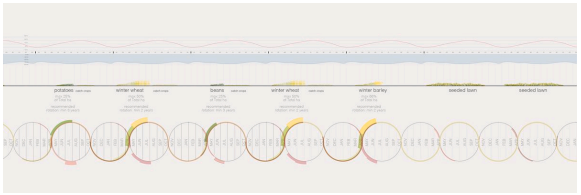
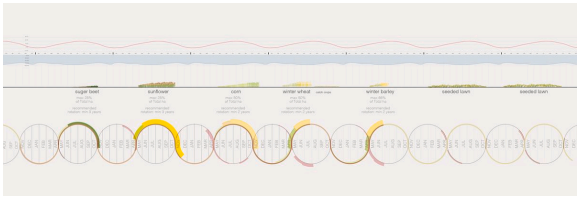
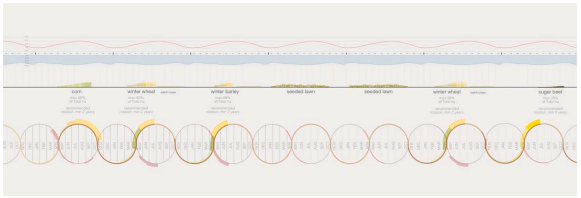




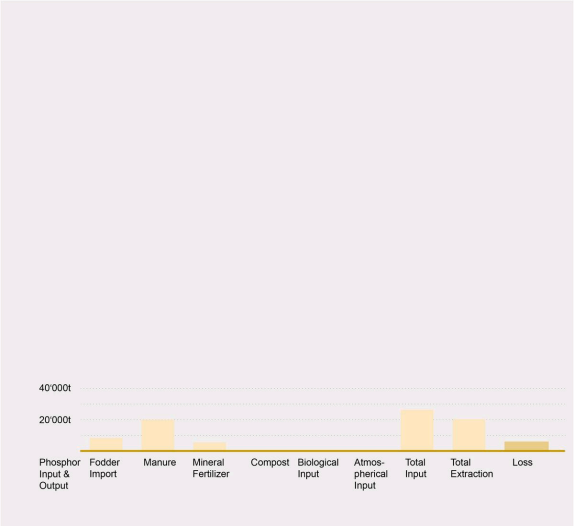




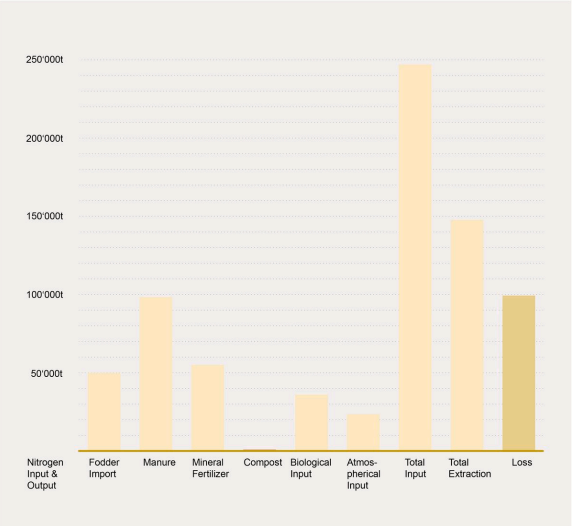
Twice as much soil and water is eroded as can naturally form again.

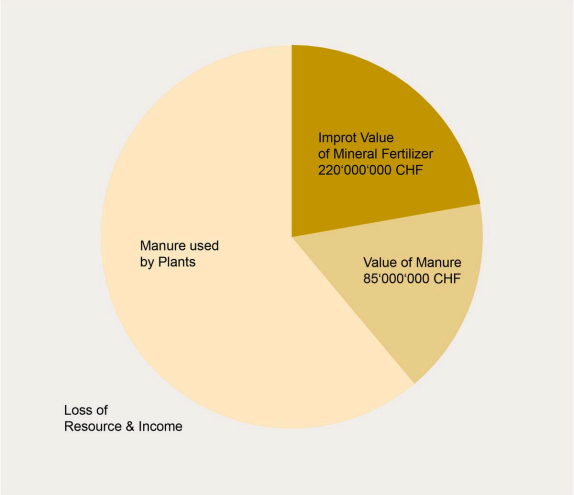
Conventional Crop Cultivation METHods That Are Pulling the Ground From Under Our Feet



The excess of current production.



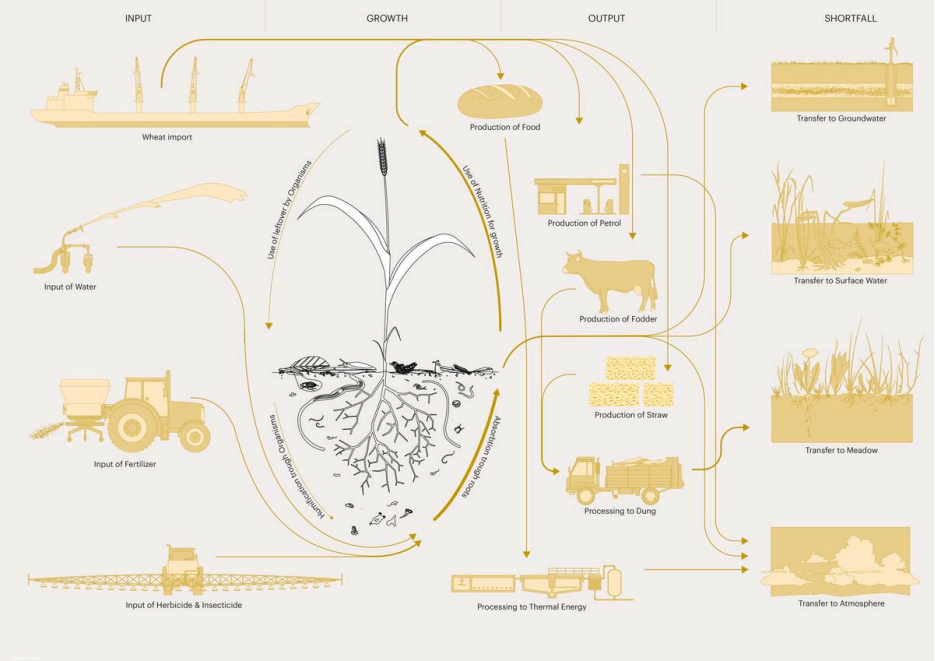
The excess of current production.



The excess of current production.

Even tough the implementation of the crop rotation is able to reduce the needed amount of artificial input, our crops are still heavily fed with different sorts of fertiliser. Because our soils are not capable of storing all of it forty percent of the total input is washed out, damaging the environment.

In general, we replaced the natural nutrition cycle with a linear, artificial one. Not only fertiliser but various resources are now needed to keep up our way of production. We are using most parts of the plant, leaving a lack of nutrition going back into the ground which makes the soil starve. Accordingly, it degenerates into a dense, death mass, unable to store water or prevent the washing out of the nutrition. Consequently we have to steadily increase the amount of artificial input to keep the output on the same level.



Feeding the plant instead of feeding the soil





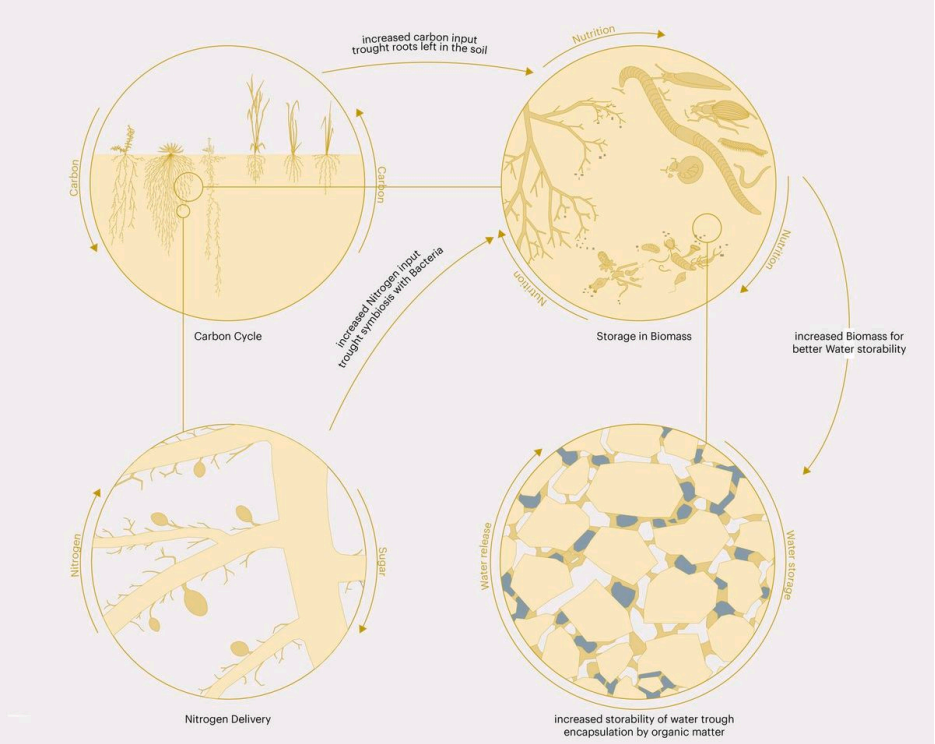


This system is not only inefficient on the long term, but will also damage the fertility of our fields. The amount of soil that is eroded in Switzerland is around twice as much as can naturally form again. As a consequence, Switzerland has to invest a lot of money and effort to build new artificial irrigation systems. Together with given natural conditions conventional agriculture is a main driver of this problem and the negative effects are numerous. Also at our site, the Wehntal Valley, erosion risk is high.
In the following we have to look at existing solutions and the obstacles on the way of their implementation.

Intensification and Sustainability

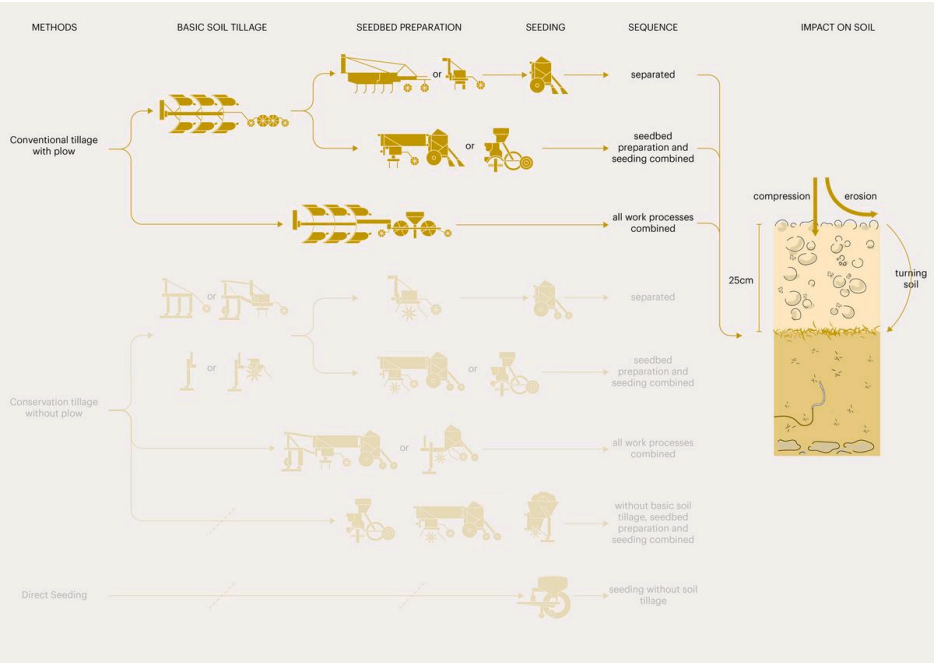


To be able to leave the spiral of high input production microorganisms can be seen as the key element. They are able to store large amounts of nutrition as they need the same substances to grow. As soon as they die the nutrition becomes accessible to the plant. To increase their number it is important to supply them with organic carbon as well as nitrogen. The leftovers of those organisms are capable to enclose water in between the mineral material for storage keeping the soil from being washed out and making it more resilient to droughts.



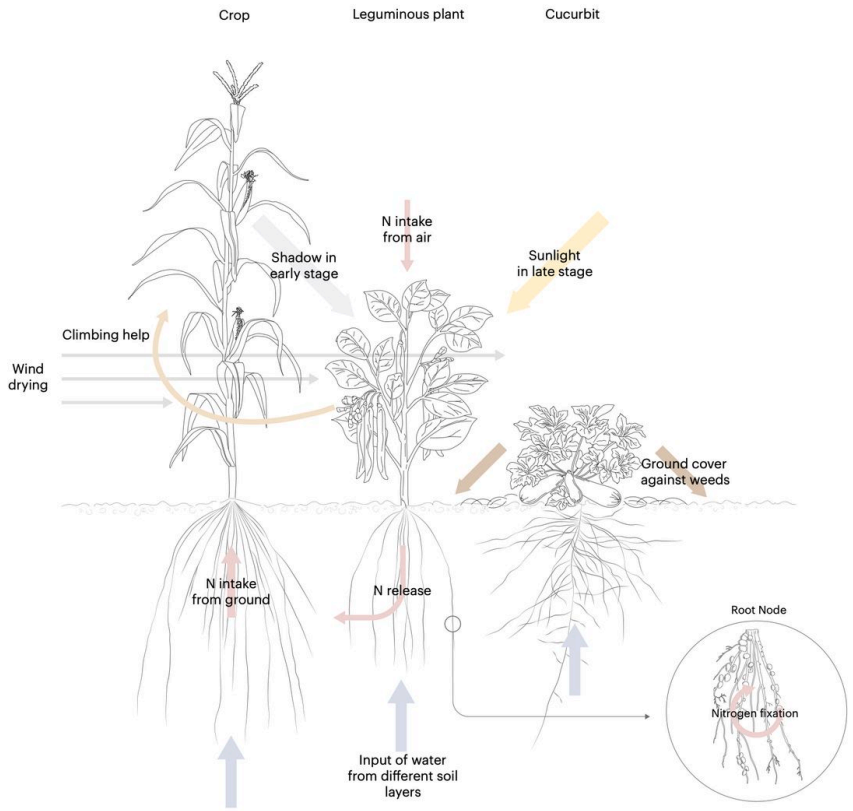
Microorganisms are key

Already today we know a lot of cultivation methods which are able to tackle the mentioned problem. If we look at the different tillage systems for example, one can see that in Switzerland around ninety percent of the methods remain conventional. In conventional tillage the soil is being turned with a plow. There is no organic mass left at the soil surface, the ground is strongly loosened and the biological activity is low. That leads to soil compression and erosion. Yet the advantage is the elimination of weeds. Strip-till and direct seeding are tillage methods that reduce soil and water losses. The reduction of the usual intensity of soil cultivation creates a more stable, load-bearing soil structure that protects against compression and is able to host more microorganisms.

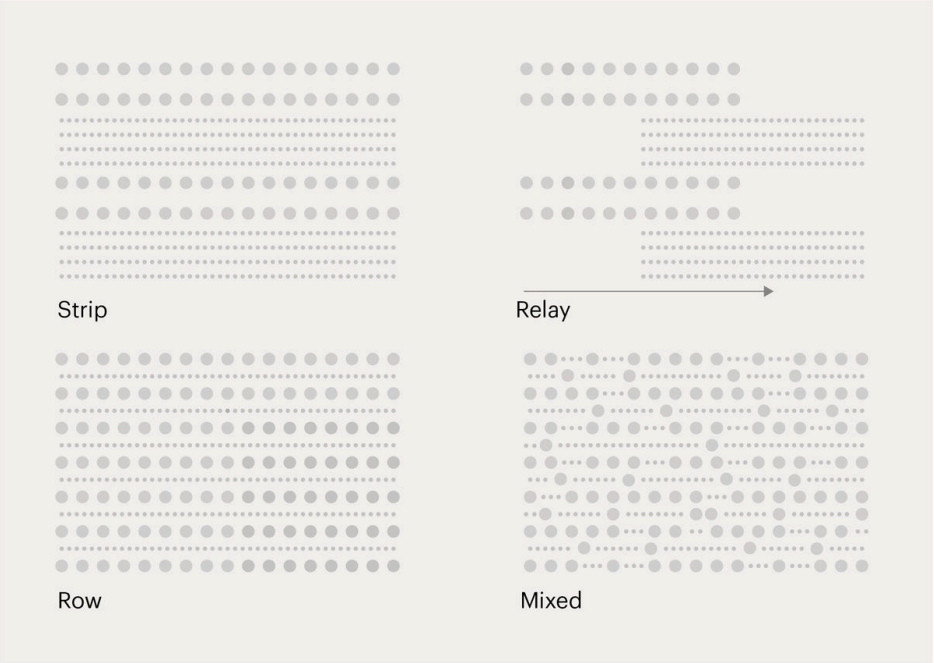


There are several crop cultivation methods that can present alternatives to conventional farming and be integrated in the crop rotation cycle.

Intercropping means planting two or more plants in proximity to each other so that synergies are formed but the plants do not compete amongst each other. Usually a crop and a leguminous plant are combined as latter provides the crop with organic manure. The positive effects are risk distribution, nutrient and water use efficiency, weed and disease control as well as soil stability and increase in organic matter.

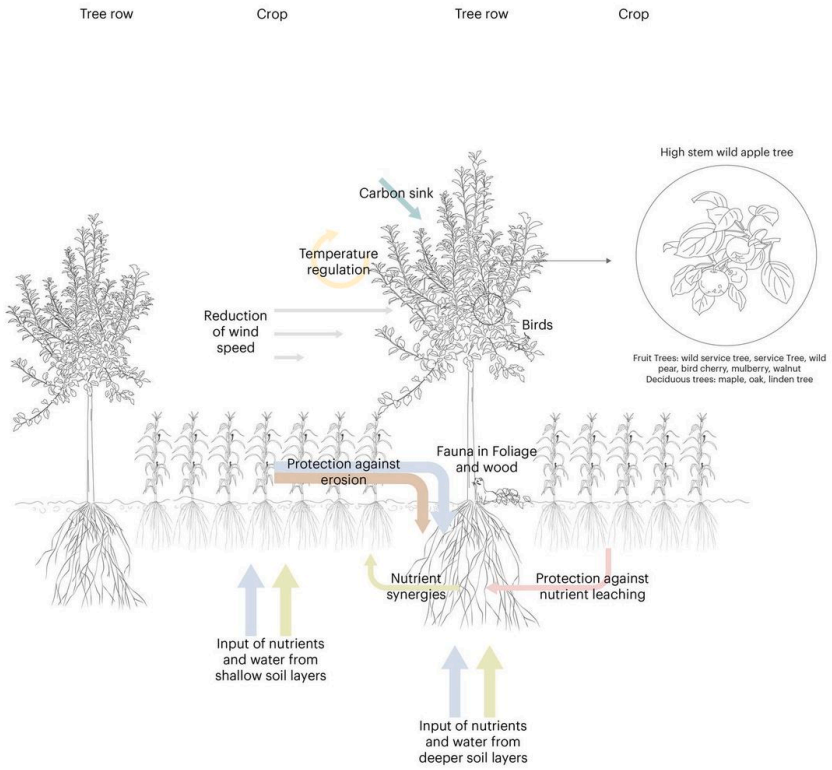


Intercropping—using synergies between plants

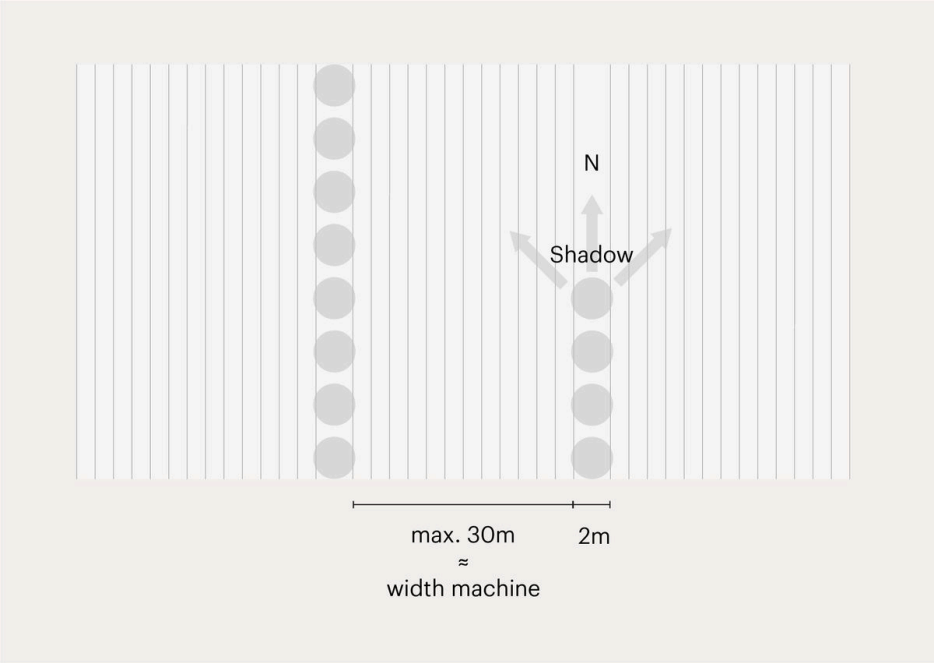


Intercropping types.

Agroforestry is a form of intercropping where synergies between trees and crops are used. Here the positive effects are on one hand nutrient synergies and protection against erosion, on the other hand an increase in biodiversity.

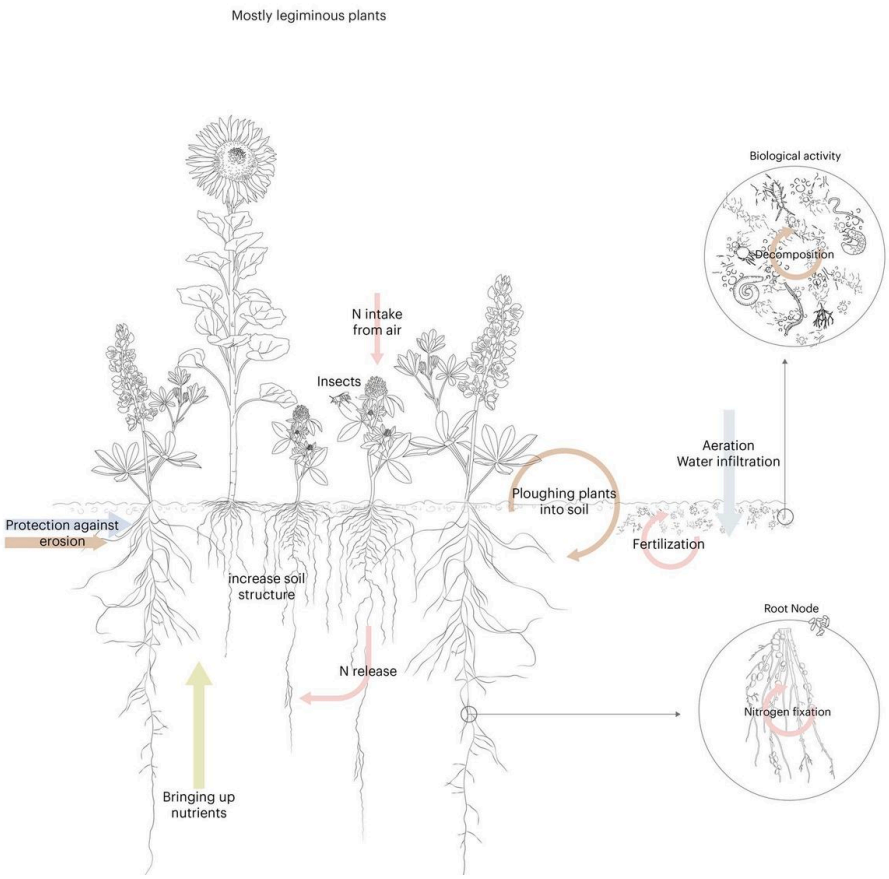


Agroforestry—planting trees as erosion protection

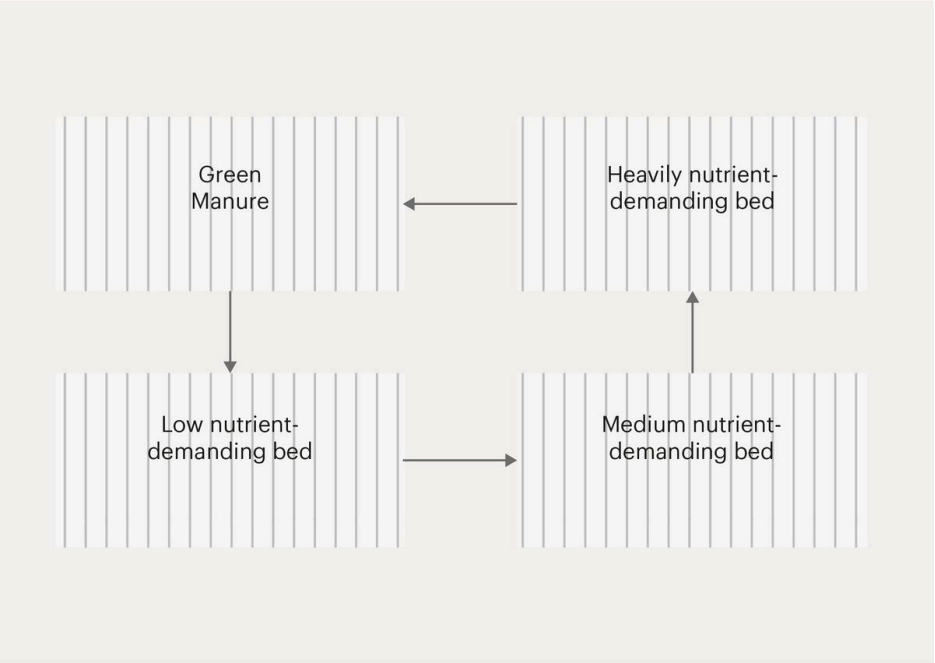


Agroforestry layout.

Green manure is part of the crop rotation. Soil beneficial plants are grown on a field. They are mulched or ploughed under and incorporated into the soil while green or shortly after flowering. Thereby the nutrients as well as the organic carbon held within the green manure are released and made accessible to the succeeding crops.

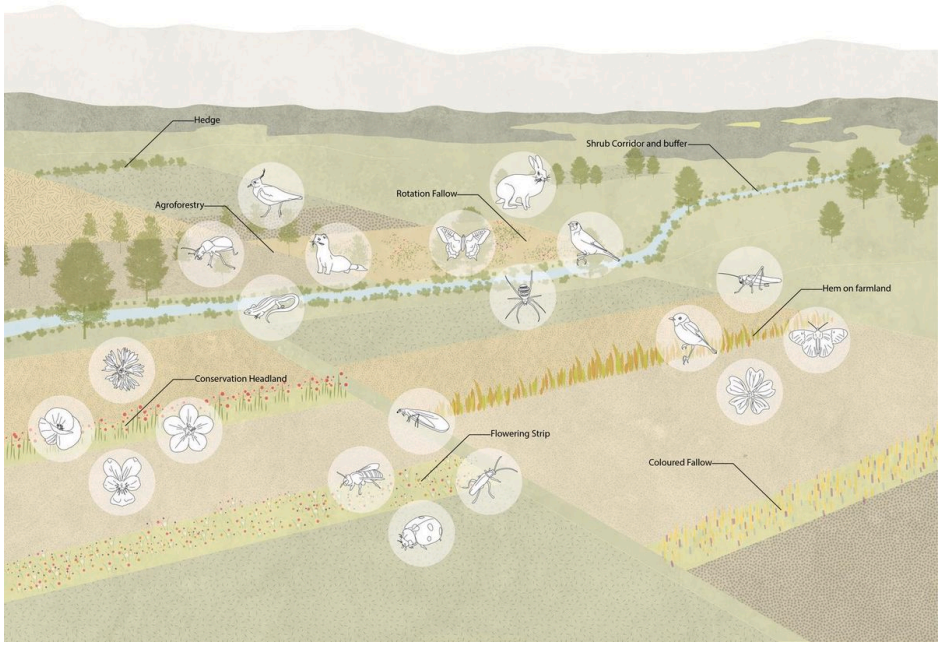


Green Manure—providing nutrients for the succeeding crop.



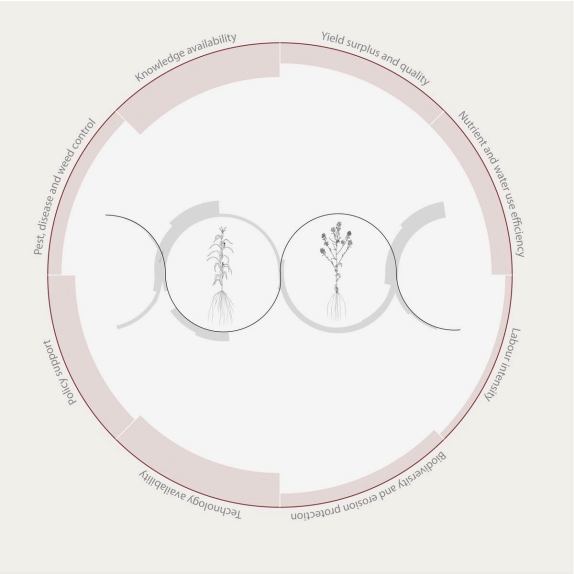
Green manure crop rotation.

There are also several methods to foster biodiversity in crop cultivation. It is convenient to combine linear elements such as conservation headlands with surface elements such as rotation fallows to create networks and synergies.

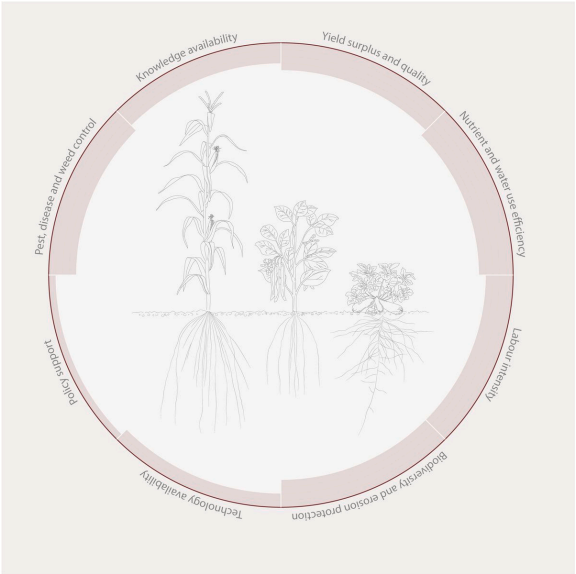


Biodiversity support areas—fostering variety of life that is soil beneficial.

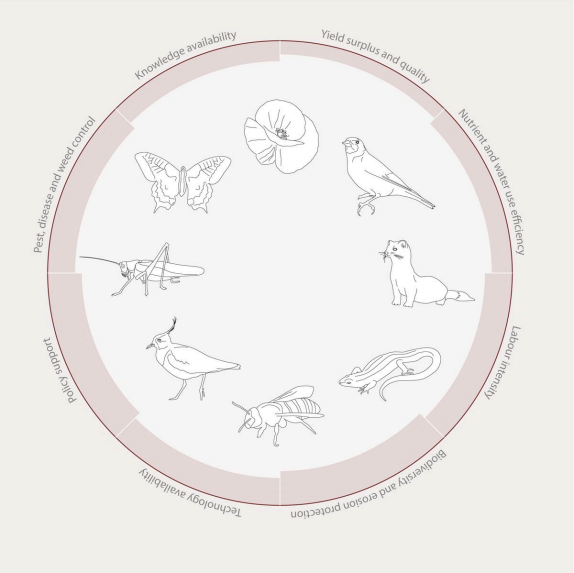
A comparison of the methods shows that, as they differ significantly on certain points, they should be implemented according to the specificity of the site and the social as well as legal framework. If one compares the methods it becomes evident that they share certain advantages. Besides increasing soil quality and biodiversity as well as reducing inputs of fertilisers and weed control, they also lead to higher yields in the long term. Latter is not self-evident as sustainable cultivation methods are often associated with a sacrifice of productivity in favour of sustainability —yet this is not true, especially not in the long term. The reason for this common assumption is based on the fact that sustainable crop cultivation methods were rarely implemented on a bigger scale. However most sustainable cultivation methods are more labour-intensive due to decades of investment in conventional technologies. Also not all methods are legally supported. Yet these disadvantages can be overcome with the right investments and incentives which are not fully developed yet.



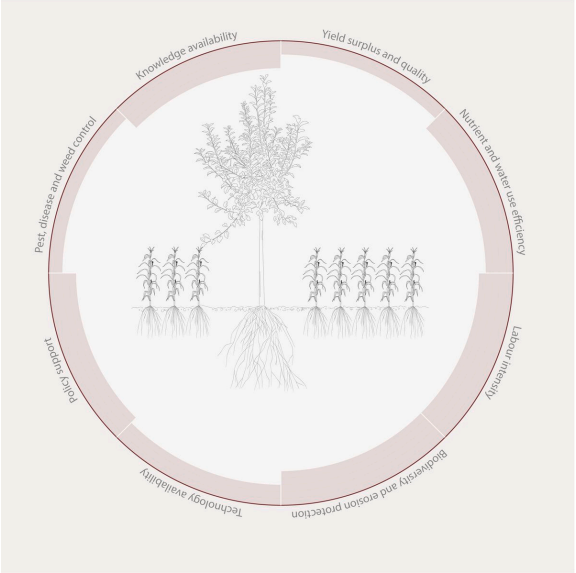
Crop rotation



Intercropping



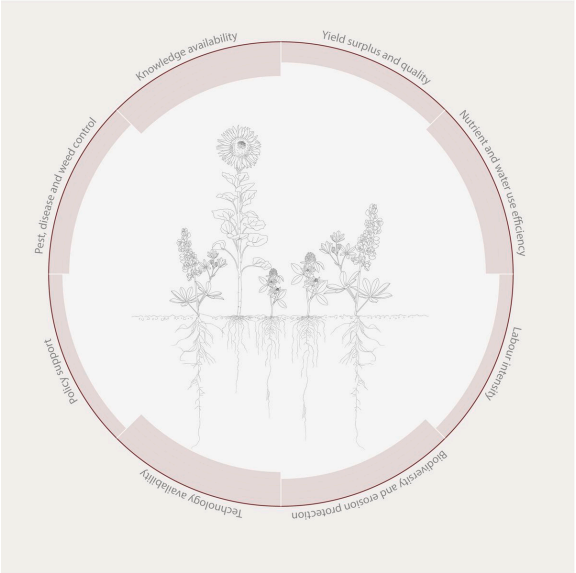
Biodiversity support



Agroforestry



Direct seeding



Green manure

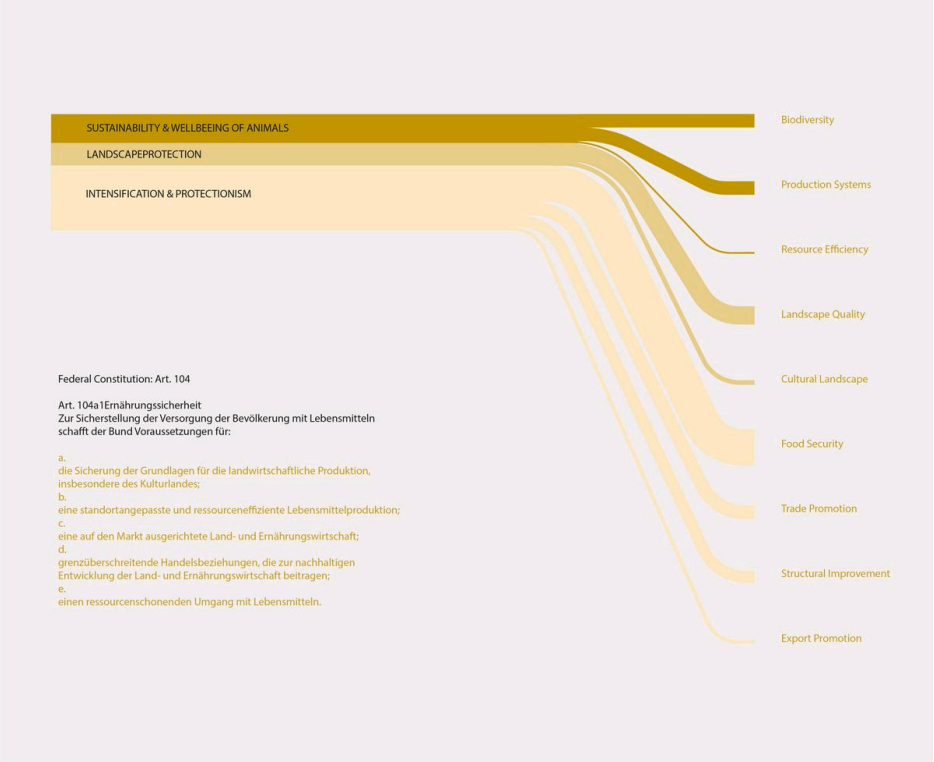
Paralysed Debates, Perverse Subsidies and the Farmer Within

To further understand why those promising methods have not been implemented yet one has to take a look at the agrarian politics, in this case, on the example about regulation of manure. At the moment a farmer has to keep at least three cows on a hectare of land to be able to receive subsidies. At the same time he or she will use this manure to fertilise the same land. If we would want to decrease the amount of manure in favour of nature we would have to lower the amount of cattle per hectare or we would have to redistribute the manure to the lower lands where it would be able to replace the mineral fertiliser. Under current circumstances both solutions could lead to an increased import of products which is seen as problematic by many people. Paralysed by arguing about self sufficiency quotes, the status quo remains, damaging the environment.

This highly ideological dilemma, which is blocking any progress, is not only restricted to the fertiliser, but applies to the subsidy system as a whole.
Most part of the budget is used for intensification, whereas the smaller part, reserved for sustainability has to fix the damage, caused trough our way of producing. Therefore our government invests in biodiversity supporting areas. Those are regulated like a checklist, without looking at specialities of a certain location. Thus it happened that those surfaces are randomly scattered in between the deserts of intensive production. The territorial transcription of this contradictory can now also be observed in the landscape of the Wehntal Valley.



The obsession with self-sufficiency

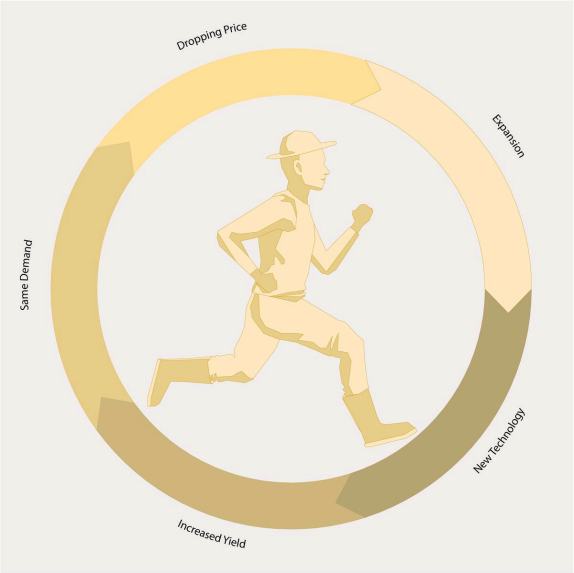


The generalized solution.

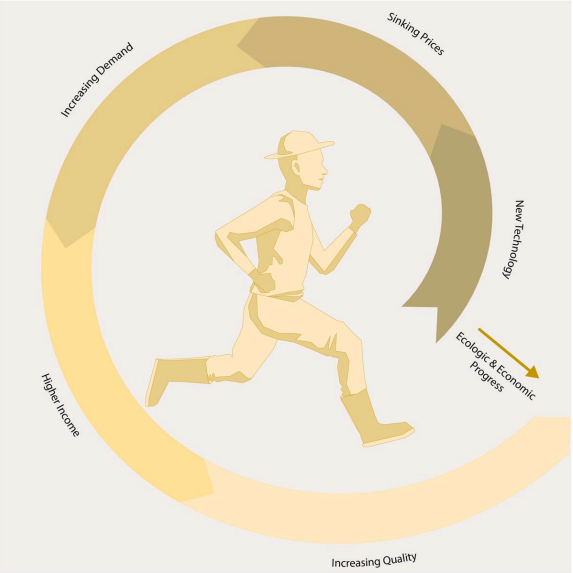








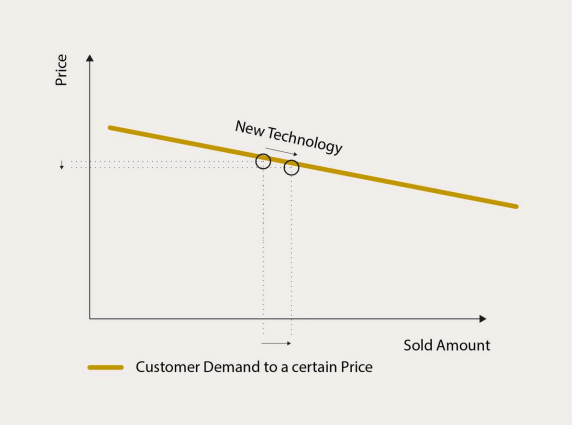
Farmers rat race



The farmers rat race escape



Demand for conventional products



Demand for sustainable products

Most farmers we met, were aware of the current problems, but are at the same time under heavy pressure as the prices of their crops are steadily sinking. For this reason, not only politics but also the situation of the farmer within the economy has to be looked at. New technology often allows the farmer to increase his yield, leaving him some extra income until the point where the others are doing the same. On the long term, he or she then has to lower his or her prices to be able to sell the surplus. Which leaves him or her no other choice than expanding his or her farm, what makes new technology necessary again. The result of this current practice can be seen at the current ownership plan of the farmers we visited. Because they have to buy every piece of land available, their plots are drifting further and further apart, which means more effort in technical and managerial work.

Of course the farmer producing in a sustainable way, has to deal with the same circumstances. But other than the one focusing on intensity, he or she is able to keep the prices at almost the same level, as there is a higher demand on biologically produced goods. This means, if he or she invests in better quality instead of expansion, he or she is able to progress in a sustainable way as well as in an economical way. As a starting point, the farmer needs a certain amount of money to be able to change his or her production system, which is not provided by the government as we saw earlier. Therefore, other sources must provide their support until the politicians proceeds in their discussion.

New Multi-Scalar Implementation Models

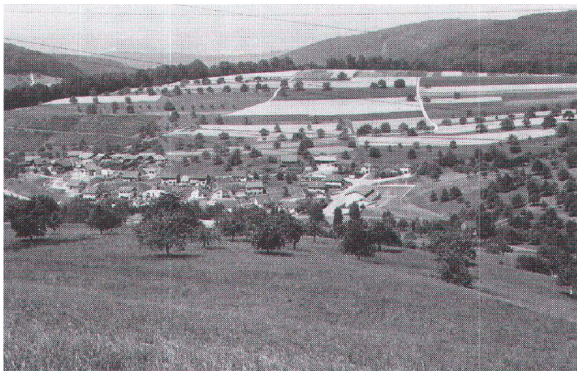


Meliorations in Switzerland where long understood as all land improvement measures. In the 19th century property amalgamation was incorporated into the term. Nevertheless, until the Second World War meliorations were mostly used as a tool to safeguard settlements and improve cultivated land.During and after the Second World War property amalgamations became much more widely implemented and intensified. The goal was an increase in food production with the “Anbauschlacht” and a rational land use in regard to mechanisation. Since the 1970s and especially today the so-called general meliorations try to bring together the interests of agriculture, spatial planning, and especially nature and landscape conservation. The reason for this shift of emphasis was the effect of the large scale meliorations of the past.

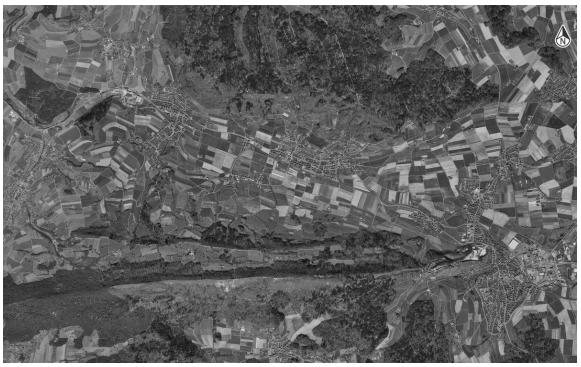
One example is the melioration in Wintersingen, where numerous small structures and thereby biodiversity have disappeared. Accordingly, the Wehntal has undergone similar changes over the decades. We can see it today in the vastness of the landscape.



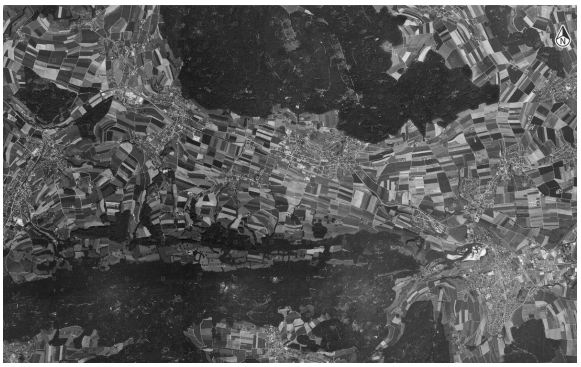






2020



2000



1980













Today the number of meliorations is diminishing. The reason is on one hand a very complicated, long process, on the other hand an interest conflict. The public bears the majority of the costs, almost half of the agricultural land is in the hands of non-agricultural land owners and the amount of farmers is diminishing. As the public and the non-agricultural land owners do not always seem to recognize the long-term benefits of new meliorations that focus on nature protection and sustainability, the process has not started at all.

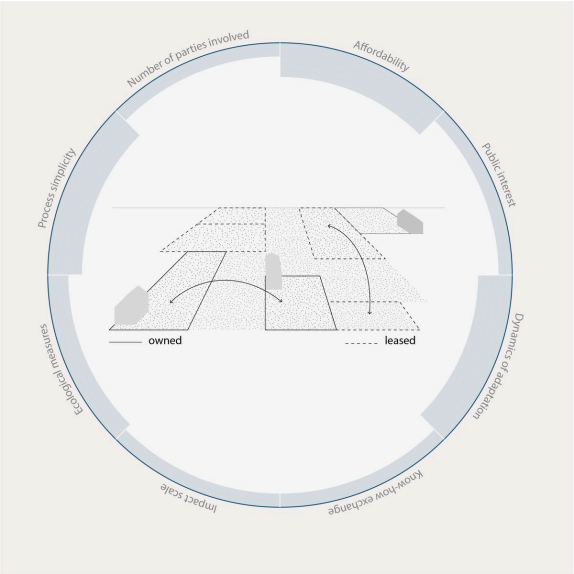
One example for a new melioration with ecological aspects in the focus is the one in Boswil betwen 1999 and 2013. Besides property relocation for a more efficient land use, streams have been uncovered, existing streams have been upgraded, and the landscape has been enhanced with new ecological areas, buffer zones, hedges, orchards, and stepped forest edges.



A melioration with an ecological emphasis. Source: Schlussbericht Moderne Melioration Boswi

Four different types of meliorations can be distinguished. Which one is implemented depends on a variety of factors, from the process duration and complexity to the type of property that is included in the process. Private land exchange as well as voluntary management consolidation are both voluntary including owned as well as leased land and are in terms of bureaucracy the simpler types of melioration. The general melioration often including leasehold land consolidation is the most complex one but also the form that has the largest impact. Here unlike in the other melioration types a change of property is possible.

We see a potential in meliorations with a shift in perspective. Meliorations have the potential to provide large scale improvements, if not only efficiency but also the interests of nature are taken into account. Also the surplus of time and money that is gained from meliorations can be invested in sustainable cultivation methods.



Private land exchange or voluntary management consolidation



General meliorations including leasehold land consolidation

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Integration Instead of Competition as a Potential of Connecting Farmers

Looking at the farmers in the valley, one notices that the cooperation and exchange of experiences and knowledge among farmers is very sporadic. It depends on whether they already know and like each other than on whether they face similar problems and challenges. The only established connection on a regularly basis, is the son of the farmer Egli, who offers certain machine services to farmers who cannot afford their own machines. Another thing we realised was, that the more a farm breaks away from conventional agriculture, the more it is dependent on its own distribution network to generate additional income security on the sales side. Since economic success and farm reorientation depend on how the life plans of family members fit together, this can put lots of pressure on a farmer's family.



Hof zur Au



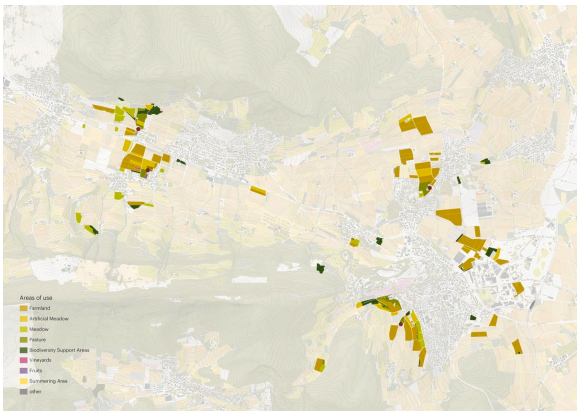
Hof Schellenberg



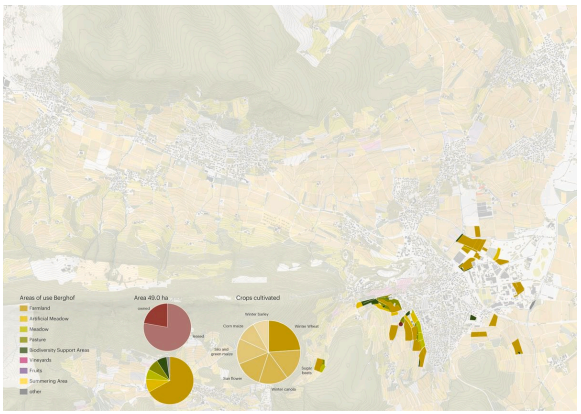
Hof Egli



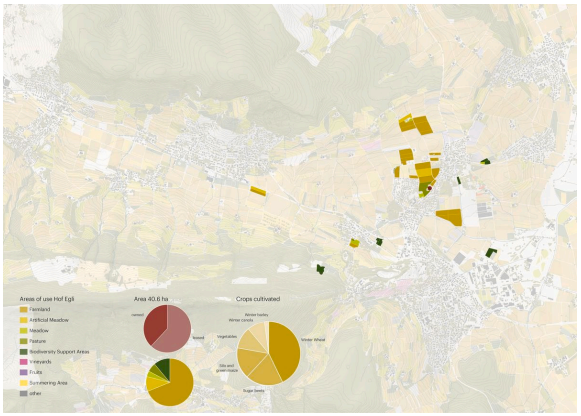
Berghof



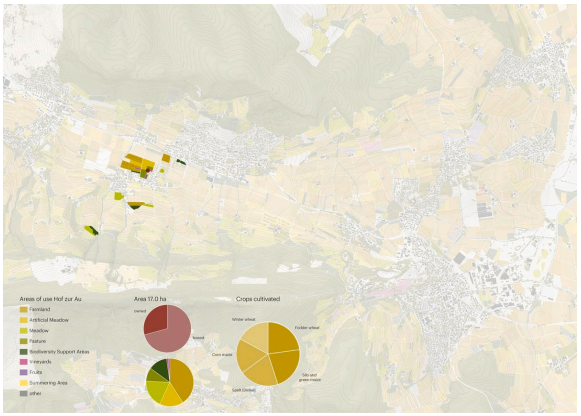
Farms overview



Bergdorf



Hof Egli



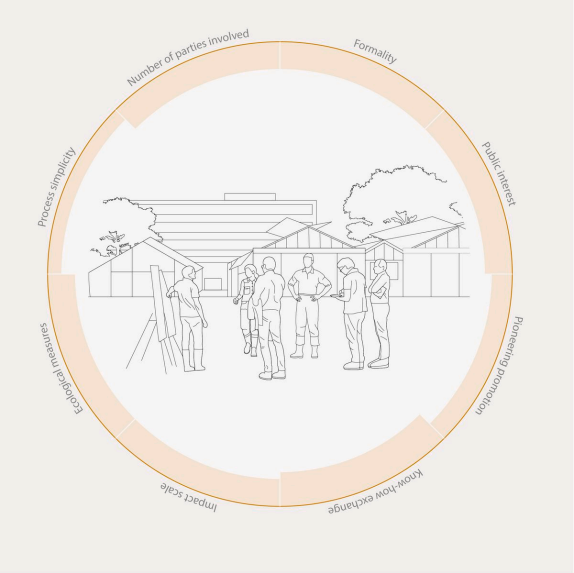
Hof zur Au



Hof Schellenberg

By already providing a network, the economical pressure on the farmer could be decreased to accelerate the shift towards alternative forms of production. Also the pressure on the family could be decreased, as peaks in workload could be solved among the farmers themselfs. Looking in history, there have been various forms of cooperation between farmers. The cooperation thus should not be limited to farmers only, as there are several actors which would profit form from an improvement of the agricultural landscapes and soils. Not only internal cooperations between farmers are possible but also with external parties. Latter might include research or education facilities, the public or commune as well as private actors.

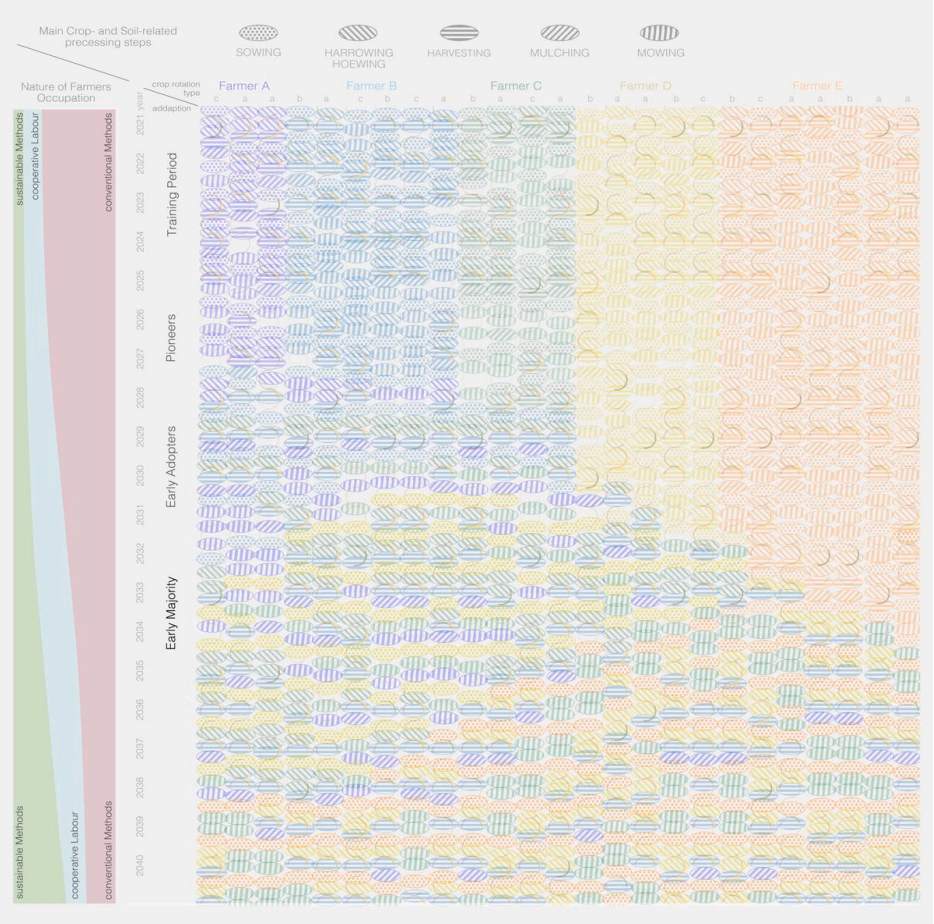
Unfortunately, most of the farmers are currently just focusing on their direct area of interest. Therefore, we need to tackle the problems in a holistic approach, allowing an exchange of expertise, labour, and money.



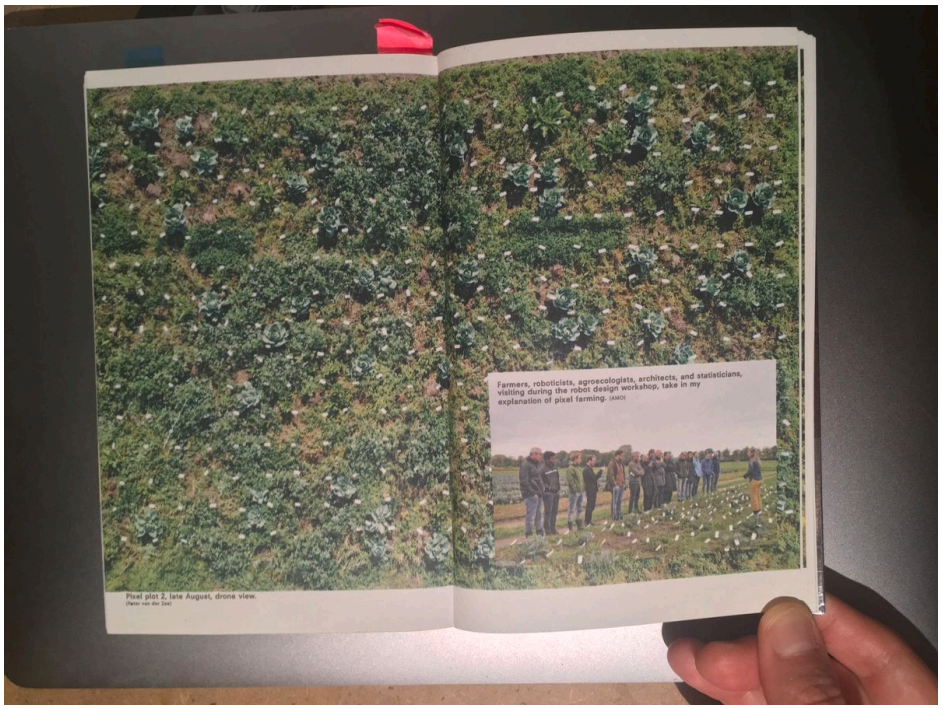
Cooperation of farmers with external party



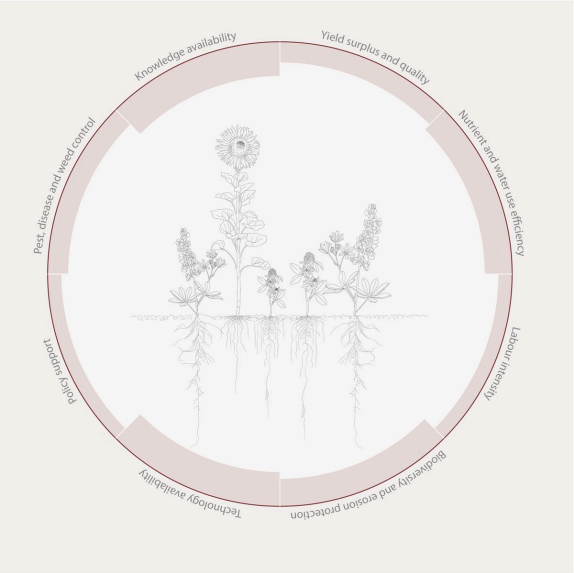
Internal cooperation amongst farmers



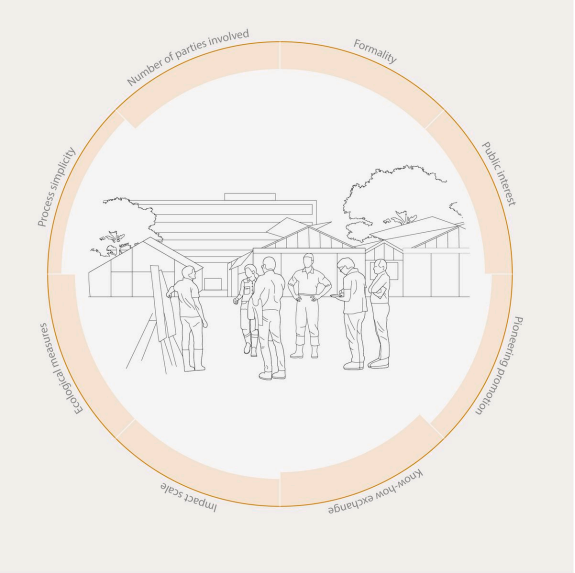
From competition to further integration



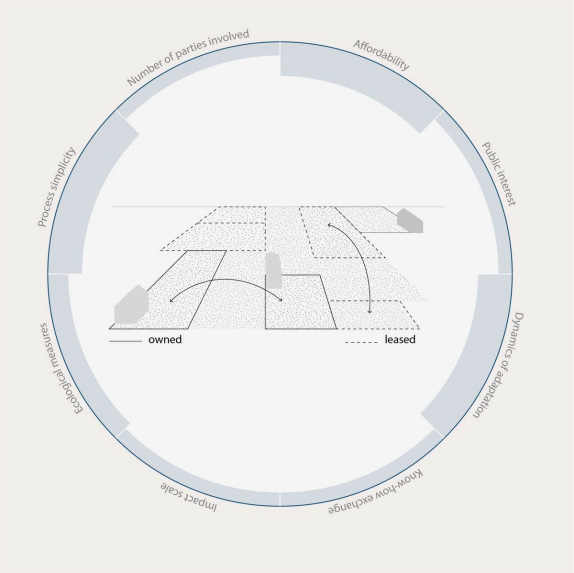
A Network of Interventions - Wehntal Valley



Intercropping

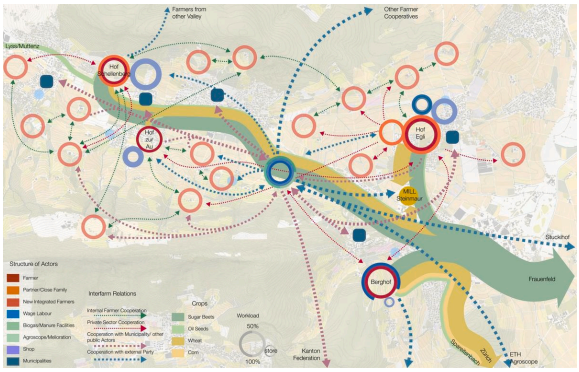


International cooperations amongst farmers

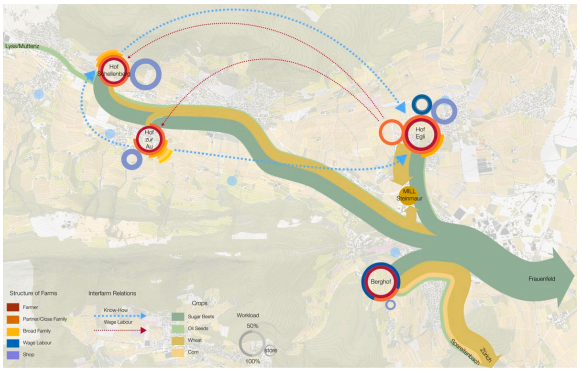


General meliorations including leasehold land consolidation

We could imagine that developing projects with the farmers and other actors in the valley would strengthen the cooperation among them allowing the farmer to access new markets and other actors to solve environmental problems without artificial solutions. By that the farmer's interests and the environmental standards would not be played off against each other but the farmers themselves could develop their own cultivation methods based on the specific needs of their location.



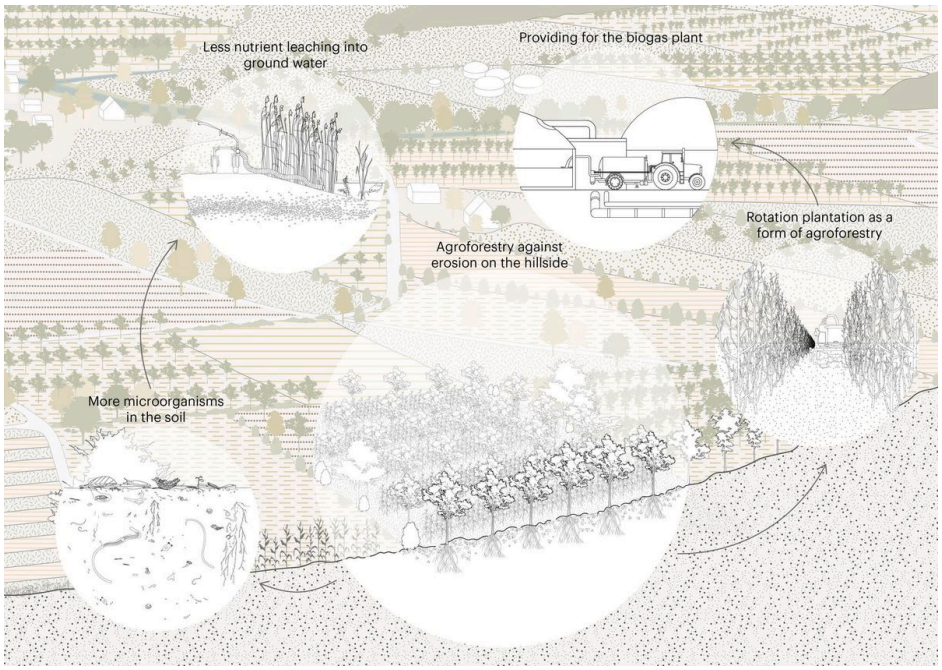
Farmer network in the future



Farmer network now

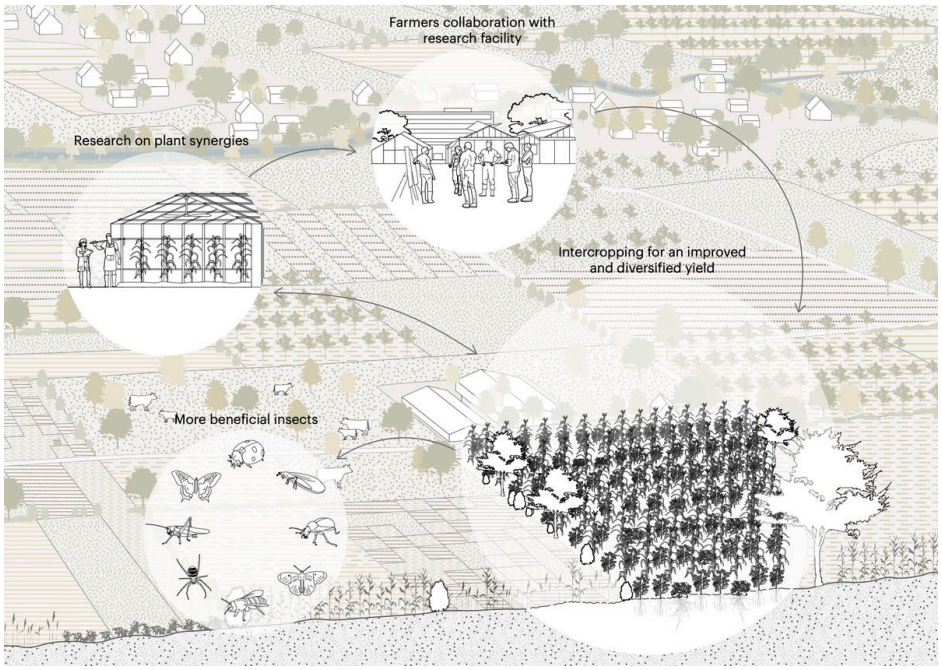
To successfully implement a certain cultivation method, each model has to bring advantages to the farmer as well as the other actors. Of course, all participants are interdependend on each other to a certain degree, but are also able to free themselves from other constraints. In the case of the Wehntal there would be various possibilities to make use of the mentioned implementation models. To further explain some of them, we propose four examples how the alternative methods can be implemented and why different actors should be involved.

In a cooperation with an external actor, a biogas plant could be combined with a rotation plantation. Especially on the hillside of the valley agroforestry would help to prevent erosion. It would increase the amount of organic matter in the soil, accelerating its regeneration. The local department for electricity for example, could produce clean energy, while the farmer could reduce the amount of emissions being released in the air when the manure is distributed on the field. At the same time, ground water, as well as the rivers are less polluted by fertilisers, as the manure, treated in the biogas plant is already less damaging. Not only the farmer but also the local water supply department would benefit as they could spare investing in artificial irrigation systems.



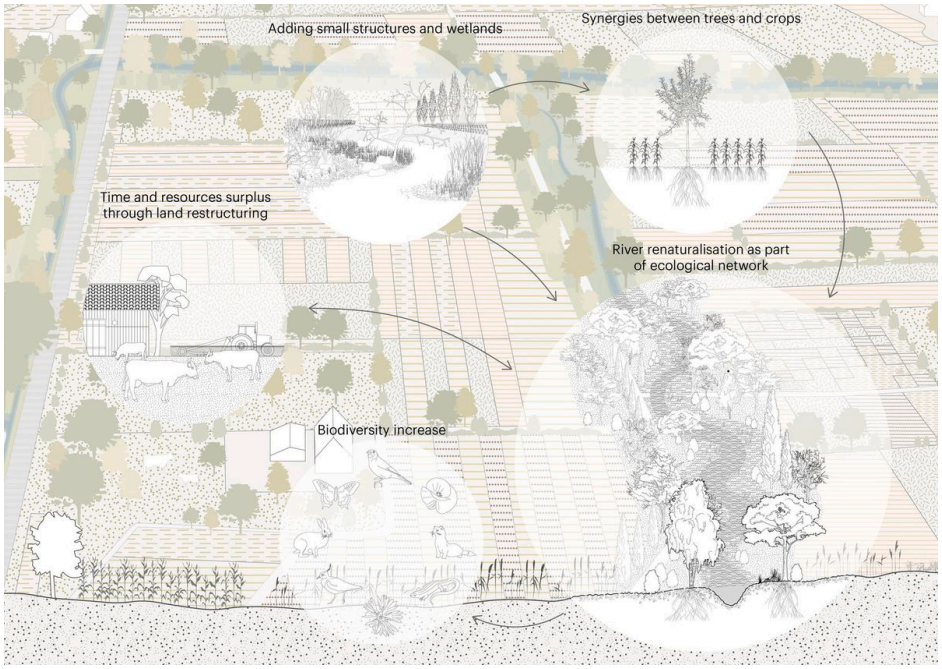
The treescape in the hills–agroforestry in combination with biogas production creating benefits for the commune as well as erosion protection

Through a cooperation with a scientific institution the farmer would benefit from know-how as well as a reduction of risk while testing new sorts of crops or cultivation methods. As a consequence not only the method could be optimised but it would increase the diversity of plants allowing different insects and birds to spread again. Local shops could probably test new varieties and gain an advantage over supermarkets.



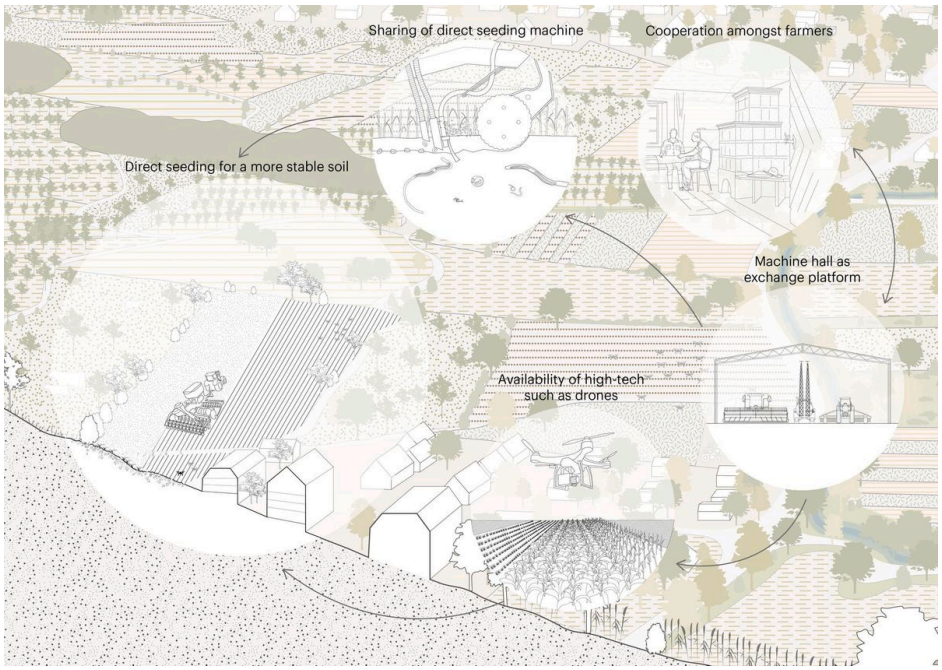
The stripes in the plain—intercropping facilitated through a cooperation with a research facility for a better yield and soil quality as well as biodiversity

With a melioration in the Wehntal Valley the farmer would have more time due to closer fields. If they decide to invest this time into their business they could produce at a higher standard leaving them more income, while the environment would benefit as well. For instance the current location of the biodiversity areas could be relocated where they are needed. In this example the renaturation of the Surb River could provide a attractive promenade in the valley. The farmer could also allow the “Natur und Vogelschutzverein Wehntal” to help them to guarantee the quality of this area.



The renaturation of the Surb River–a melioration not only increasing efficiency but also creating a prerequisite for the renaturation of rivers, ecological corridors, and small scale structures

If the farmers would decide to share their machines, they would have a considerable amount of money left, as about one third of their production costs is caused by their machines. They could invest this surplus into sustainable methods as direct seeding for example. By that they would even be able to increase their yield in the long term protecting their soils against erosion at the same time. With such a common project they would also enhance the flow of know-how among them.



The machine hall—sharing machines as an example of a common project helping farmers to afford costly machines and implement sustainable cultivation methods such as direct seeding

Although these models can be used on their own, it would be most profitable for all to combine them into one system. As most topics are strongly intertwined, different actors could make use of additional synergies on different levels. But most importantly, by tackling the problem at its roots, it could be possible to show that by changing our way of production, self sufficiency and sustainability could coexist.



The valley after the interventions

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