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1s5 Nature-based solutions for circular food systems under climate change

FARM-LEVEL INDICATORS FOR RESILIENCE TO CLIMATE CHANGE STRESSORS

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Mixed farming (MF: animals combined with crops or trees) and agroforestry systems (AF: arable or feed crops mixed with trees) are hypothesised to be more capable to either cope, adapt or transform to changing climatic conditions, compared to mono-activity systems. By exploring the potential of these systems, the EU Horizon2020 project AGROMIX supports the transition towards climate resilient farming in Europe. AGROMIX developed a conceptual framework for resilience in the context of MF and AF, as starting point to explore solutions (Püttsepp et al. 2021). Based on this framework, we drafted a set of 17 indicators (deliverable 1.3) that can assess the level of resilience of an individual farm to climate change-induced stresses and shocks. It can also be used by researchers to compare farm systems with one another. For example, do circular farm systems support a farms' resilience to climate change or does it have drawbacks on certain indicators? The outcome also shows on which aspect in the system and in which dimension (social, ecological or economic) the management can be improved to become prepared against the variety of shocks and stresses from climate change; e.g. a highly circular farm probably scores good for the economic indicator 'Dependencies on external inputs' and may also for the social indicator 'short supply chain' but may still score low on the ecological indicator 'trees and shrubs' since a circular farm does not necessarily integrate trees. The concise set of 17 indicators was the outcome of first listing all relevant indicators related to major shocks and stresses. This resulted in a longlist of 54 indicators, and the shocks and stresses considered are droughts, extreme precipitations, heatwaves, followed by pest and diseases, but also policy and market/economic responses. The indicators were then selected via the application of criteria: An indicator must have a proven, scientific link with resilience; the indicator-score must be changeable by management on the farm itself within 5-10 years; the indicator score can be categorized on an ordinal scale; the indicator is applicable on any type of farm (except for farms without land). The final set covers all three dimensions of resilience (ecological, economic and social) and can show the total farms' resilience performance in an amoeba diagram. Each indicator is provided with a definition, guidance to measure and estimated costs, a target value and ordinal scale to give it a score in order to make it applicable in real-life cases.

Keywords: mixed farming, climate resilience, farm performance, indicators, climate change

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Evaluating the performance of a Subsurface Water Retention System (SWRS) prototype: first assessment of work productiv-ity and costs

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Global warming and climate change are threatening the effectiveness of agriculture in Mediterranean area, which is worldwide considered as a hotspot of climate change. In particular, increasing aridity and occurrence of extreme rainfall events can have detrimental effects on agriculture, therefore there is the strong need of increasing its resilience. One of the possible solutions to tackle this issue consists of applying rain water harvesting technology (RWH), and in particular Subsurface Water Retention System (SWRS). This last consists of applying an impermeable membrane in the root zone, preventing water loss via deep percolation in sandy soils. SWRS has been studied in the recent years, highlighting its effectiveness in increasing several crops yield in arid and semi-arid climate. However, its application is limited only to laboratorial scale, due to the lack of an efficient machinery to set up the SWRS extensively. One of the aims of MediOpuntia project was properly the development of a SWRS prototype. This work represents a preliminary study, in which the evaluation of work productivity and costs of SWRS installation via this prototype was performed. The obtained results are encouraging, indeed the prototype reached target depth of 1 m for the installation of the film. Effective Field Capacity (EFC) of 0.19 ha h-1 was reached, but it can be further improved working in conditions of lower presence of crop residues, which in the studied case caused clogging of the machine being in a very high amount. SWRS installation costs resulted in more than 4800.00 € ha-1. It is however worth to highlight that SWRS is permanent installation and therefore the costs would incur only once. Further studies are needed to evaluate the effectiveness of SWRS to increase crop yield in extensive field trials.

Keywords: climate change, desertification, rain water harvesting, work performance

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A transition towards a circular agricultural economy with a focus on nature-inclusive initiatives

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The Dutch government advocates a transition to circular agriculture, in which nature-inclusive agriculture is one of the important perspectives (LNV, 2019). From the private sector, we see all kinds of initiatives emerging, both from individual farmers and from other parties in the food system. There is a wide variety of initiatives - some very successful, others languishing. A lot is happening at once, with the transition going frustratingly slow for some, but so fast for others that they can barely keep up. That is why we have constructed a conceptual framework with two axes: scaling up and transition range. The framework is filled in with five initiatives in the field of circular nature-inclusive agriculture, from primary producers with a regional focus. We interviewed key stakeholders from these initiatives about the background and the development up to now.

Key concepts are the current regime in farming and niche developments (e.g. Smits et al., 2020). Regime is the dominant, common way of producing, but this can be put under pressure by social developments. Lesschen et al. (2020) state that in the current regime, maximalisation of land productivity is paramount and that this is accompanied by monocultures and extensive use of resources from outside the farm, such as animal feed, fertilizers and pesticides. Niches are new, emerging ways of producing which may be. Niches may scale up or form clusters among each other, but they could also remain small and serve a specific group of stakeholders. When niches develop into generally accepted modes of production, they can become part of the regime. Circular and Nature-inclusive agriculture is still such a niche.

With help of the framework we show that initiatives have developed at different scaling-up levels and transition ranges. Some have reached a stage of a stable niche. However, we do not (yet) see upscaling to a level where the existing regime has been overthrown. Many initiatives remain 'experiments', but there are also initiatives that have already proven themselves and are even being followed. This imitation can lead to changes in the regime depending on the number of followers, such as greater attention to soil quality and manure use. In this sense, it is more a case of evolution (gradual shifts) rather than revolution (the overthrow of the regime).

Keywords: circular agriculture, nature inclusive agriculture, transition, initiatives

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Seaweed extracts to boost crop productivity under stress conditions

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In the coming decades our world will face several major problems: climate change and a growing world population, combined with an increased welfare. Together with increased temperatures, we will face increased drought and salinisation, with negative effects on crop growth and productivity worldwide. How to combat these seemingly inevitable effects, besides attitude change? Based on an extensive literature review combined with our own experimental results, we show that seaweed extracts have promising biostimulant properties on crops both under stress and non-stress conditions. We will give an overview of effects of seaweed extracts on productivity and growth both under stress (drought and saline) and non-stress conditions, and shortly discuss putative underlying mechanisms of improved growth and productivity, and the seaweed extract compounds that might be responsible for this. We will show our own results on crop productivity under salt stress conditions and how we want to address the 'mode of action'. Finally, we discuss the impact seaweed extracts might have on specifically enhancing the protein content of crops to meet the growing food demand in terms of quality and quantity.

Keywords: seaweed extracts, biostimulants, crop production, abiotic stress

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How transformative adaption is making its way in the Dutch water system

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Climate change is causing more extreme weather and so far commonly accepted reactive, and preventive adaption strategies seem no match to future predicaments. Therefore, a window opens for new transformative trains of thought. The transformative adaptions approach adopts a fully long-term perspective of up to a hundred years. Functional use of land is based on the natural system by which natural resilience is strengthened. For example, rivers are given more space and the functional purpose of rural landscapes are rethought in conjunction with natural conditions. This does not only serve the natural environment, but also stimulates spatial planning to look for pairing opportunities, like promoting aquaculture in particularly wet environments or adjusting crop systems to increase drought resilience.

A true transformation is usually not clearly steered by any particular actor. There are often different people in different positions who 'sense' the challenge of change and work on it. The mobilisation of these change-makers is often a result of some substantive trigger. A good example is the NL2021 project, a long-term scenario for the Netherlands (Baptist et al., 2020), which is centred on the natural system and its capacity. To learn more about how presenting a thought provoking image of the future can instigate a possible transition, researchers from Wageningen Environmental Research are currently monitoring four regional project-driven alliances aimed to set transformative adaption in motion from the perspective of the Dutch water system.

So far six relevant areas of consideration have been identified: 1) drought as a game changer in the acknowledgement of climate change, 2) the 2120 scenario as an eye opener to a future vision, 3) a change of discourse in which the natural system is used as the starting point, 4) embracing integral paths towards sustainability, 4) timing and presentation, 5) small wins by local initiatives and 6) the recognition of natural systems as a self-contained actor. This year, the continuation of the research has been aimed to provide more insights on the process. Not only by consistently following the course of co-creation, but also by going deeper into the tensions that could come with governing towards transition.

Keywords: Transformative adaption, natural system thinking

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Circular waste management

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The global pursuit of sustainable development is an irreversible social trend, also in engineering our future. This has an effect on the work of engineers. New insights resulting from new research and developments can change the situation for which an engineer is developing a solution. Innovation, through research and development, continuously provides new insights. These can be used to develop the best engineering solution. As engineers, we are able to adjust our solutions to the changing situation. One of the most important tools we use to find comprehensive sustainable solutions is our sustainable design principles. Witteveen+Bos developed several analytical, consultancy and engineering methods to accelerate the transition towards a circular and bio-based society. With the increasing depletion of finite natural resources as the world further advances and progresses, circular economy and climate resilient measures have become a crucial topic for which used streams from one party could be re-used as a valuable resource by another party. Symbiosis between these parties to create circular opportunities in our projects is the basic principal. Our aim is to strengthen the robustness of the current system and further optimize the scarce resources by exploring integrated innovative solutions.

A first step in this transition is the scan of streams by material flow analysis (MFA) and identification of sustainable and cost effective circular measures. For different projects, Witteveen+Bos executed environmental, technological and economical impact analysis to determine hotspots, recommendation and engineering solutions to accelerate the circular economy. By not only quantifying the substance flows, but also mapping the overall CO2 impact of these substance and energy flows we can determine their impact and importance: where are the largest and therefore also the greatest opportunities for integrated sustainability and closing cycles?

Based on data analysis of operational flows for water, energy, residual streams and related building materials and chemical use and the carbon emissions we map the use and emissions of these streams to identify hotspots with losses and interactions. From this moment we link parties and/or streams for the development of (biobased) products/service. To solve these hotspot we make recommendations for interventions and develop the technical measures focusing on existing and developing technologies for renewable energy, water and resources reuse and biobased solutions. These technologies can be; various treatment options for solid wastes, sludges, waste oils and sewage

waters; but also green chemicals and building materials and carbon capture and utilization. For organic waste streams we make use of our tool, called the Biobased AtlasTM. The Biobased Atlas is a tool from W+B where we bundle experiences from previous projects in the field of useful and circular applications of residual flows, techniques and processors. Besides various treatment options for solid wastes, sludges, waste oils and used waters were assessed for implementation to increase the circularity.

Witteveen+Bos will contribute to the session at circular@WUR presenting their experiences and knowledge gained during the Material Flow Management at WUR, the Circular Industrial Parks Symbiosis and circularity studies for waterboards.

Keywords: '- circular design, - material flow analysis – MFA, - data analysis, - Impact measurement