Eberswalde University for Sustainable Development

TRANSECT

Centre for Econics and Ecosystem Management

Michael Spies, Henryk Alff, Christoph Raab,
Aksana Zakirova, Mehwish Zuberi (eds.)

Sustainable Food and Biomass Futures?

Localised Approaches to Agricultural Change and Bioeconomy

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Table of contents

Michael Spies, Henryk Alff, Christoph Raab, Aksana Zakirova, Mehwish Zuberi:
Sustainable food and biomass futures? Introducing the volume 4

Sarah Hackfort:
On innovations and inequalities – digitalization and the challenge of sustainable agriculture in the bioeconomy 7

Natalia Ryzhova:
The inclination toward monoculture production in Kazakhstan: Where are the origins of "path dependence"? 11

Huiying Ng:
Cultivating agroecosystems around commodity crops in Thailand: Challenges and propositions for analysis 16

Gulnur Makulbayeva:
Livestock fodder support in Kazakhstan: An implementation deficit? 20

Aksana Zakirova:
Adapting agriculture in crisis: A study of smallholder farmers in southwestern Tajikistan 24

Muhammad Ashfaq, Irfan Ahmad Baig, Javaria Nasir, Jay Punthakey:
Representative Agricultural Pathways (RAPs) for sustainable food production: A participatory approach for small farmers in Pakistan 28

Maíra de Jong van Lier:
Sowing agroecologies: Knowledge brokering in the Brazilian Agricultural Research Corporation (Embrapa) 33

Olga Romanova:
The potential of agroforestry development in Kazakhstan and the need for agroforestry policy 38

Musavvara Shukurova, Zulfiya Davlyatnazarova, Irina Kasparova, Kurbon Aliev:
Sweet potato as a new and promising crop to ensure food security and reduce malnutrition in Tajikistan? 44

Ingrid Bunker, Jana Zscheischler:
Insects as a sustainability solution towards a circular bioeconomy? - The acceptability of insects as feed and manure recyclers in intensive livestock systems 47

Zhengqiu Ding, Karen Hamann, Philipp Grundmann:
Sowing change, reaping value: Cultivating bioeconomy opportunities from grassland residual biomass 51

Sustainable food and biomass futures? Introducing the volume

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The demand for food and biomass is increasing globally, while natural resource overuse and climate change pose additional challenges to their production. Moreover, soaring energy and input prices push agricultural production to the limits. There is a need to rethink existing agri-food systems and develop alternative production approaches with more sustainable trajectories. As one pathway, the concept of 'bioeconomy' (or 'bio-based economy') has been promoted by policy makers to develop more efficient and circular forms of production, but these approaches have also been criticized for their often narrow focus on productivity growth and 'technological fix' that mirror mainstream agrarian policy directions (Backhouse et al. 2021; Eversberg, Holz, and Pungas 2022). However, other pathways are possible and desirable that highlight more systemic social-ecological transformation and draw on the innovative potential of local knowledge and experience on the ground.

Against this background, this volume examines some of the existing and envisioned pathways of agricultural change and bioeconomy, and critically assesses their social and ecological sustainability. Comprised of a total of 11 short papers, it does so by looking at a broad variety of production systems and geographical settings, ranging from sugarcane seedlings in Thailand to grasslands in Central and Northern Europe and agroecology in Brazil. Looking primarily at practices, discourses, and strategies on the ground, the overall research questions addressed by the contributions are:

- How can and should food and biomass production systems look like to cope with emerging crises while ensuring productivity in a socially just and ecologically sustainable manner?
- How can the weaknesses and path dependencies of existing production systems and policies be overcome?
- How can the perspectives and concerns of the often side-lined local stakeholders be featured more prominently in strategy development and policy decisions?

These questions were also addressed in an international conference held on June 22-24, 2023 at the Eberswalde University for Sustainable Development, Germany, entitled "Sustainable Food and Biomass Futures: Localised Approaches to Agricultural Change and Bioeconomy". The conference was organized by the junior research group TRANSECT.[1] With a focus on Central and South Asia, the conference brought together researchers and practitioners especially from the Global South, but also from other regions to critically address the above questions from a comparative and primarily empirical perspective, sharing insights from various case studies and experiences on the ground. All contributions to this volume are based on papers from this conference. Looking at various aspects of food and biomass production and their (un)sustainability, they broadly address four different research themes: Agricultural modernization, Political-economic dynamics and local challenges, Participation and knowledge production, and Exploring alternative production systems.

Theme 1 – Agricultural modernization. In the first paper, *Sarah Hackfort* provides critical insights to the debate on and recent developments in the digitalization in global agriculture. She identifies five dimensions of digital inequalities, emphasizing control over technology development, distribution of benefits, sovereignty over data, digital literacy among farmers, and power dynamics in defining and solving problems. Outlining alternative digital agri-tech innovations that challenge existing inequalities, she calls for more diversity of actors in the agri-food system and a democratization of economic power in technology development. Looking at different aspects of agricultural modernization, *Natalia Ryzhova*'s contribution

[1] TRANSECT – Agrarian Transformations and Social-Ecological Complexities. Local Bioeconomy Scenarios in Central and South Asia (2019–2025). The research group consists of a team of five researchers conducting research in Pakistan, Kazakhstan, and Tajikistan on the social-ecological effects and interdependencies of agrarian transformations, and evaluating potential pathways towards a bioeconomy in the agrarian sector. The conference and the work of compiling and editing this volume was funded by the German Federal Ministry of Education and Research as part of the funding for TRANSECT (Grant Number 031B0753).

explores the persistence of monoculture production in Central Asian countries, particularly in the context of soybean cultivation in Kazakhstan. She argues that the inclination towards monocropping may be attributed to 'path dependence', wherein the historical context of the Soviet Soybean Revolution in the 1930s and subsequent attempts to reintroduce soybean cultivation through industrial technologies limited the ecological benefits of soy cultivation. Focusing on a different part of Asia, *Huiying Ng* explores agroecosystems around commodity crops in Thailand by comparatively analyzing the cultivation practices of two groups: organic farmers and 'modern' government lab scientists working on sugarcane. She emphasizes the materiality of local agroecosystems as the primary driver of decisions made by cultivators, ultimately concluding that research on agroecological transitions should focus on understanding the conditions of their growth to better support such transitions.

Theme 2 – Political-economic dynamics and local challenges. In a case study on the Zhambyl region of southern Kazakhstan, *Gulnur Makulbayeva* takes a critical look at subsidies that the state has implemented to address the fodder shortage that many livestock farmers are facing. Looking at different subsidies and how they are implemented on the ground, she shows how these subsidies largely fail to improve the situation for the majority of livestock owners, particularly small producers. Reasons include bureaucratic barriers and intransparent distribution mechanisms at the discretion of local authorities, which could be overcome by improved regulation and monitoring efforts by the national government. Focusing on nearby Tajikistan, *Aksana Zakirova* in her contribution considers political and economic dynamics more broadly, focusing on how external stressors threaten the livelihoods of local farmers, and the various strategies farmers pursue to cope with them. Her paper delves into the prevailing adaptive strategies that farmers have embraced at a time of multiple crises from 2020 to 2023, such as the adoption of new agricultural technologies, practices of intercropping and sharecropping, and organic farming.

Theme 3 – Participation and knowledge production. In their joint contribution, *Muhammad Ashfaq*, *Irfan Ahmad Baig*, *Javaria Nasir*, and *Jay Punthakey* give an overview about the lessons learnt from a participatory approach applied with farmers in different regions of Pakistan. In their applied research, they draw on the framework of Representative Agricultural Pathways (RAPs) for need assessments of smallholder farmers and thus for the identification of sustainable agrarian futures. This contribution hence provides intriguing insights into farmers' knowledge and practices and the expectations they have towards agricultural decision-makers beyond conventional institutional path-dependencies in Pakistan. *Maíra de Jong van Lier*, in turn, scrutinizes in her contribution knowledge production on agroecology processes in Brazil. On the example of the Brazilian Agricultural Research Corporation (Embrapa), she provides a Science and Technology Studies-inspired glimpse into how innovative knowledge is produced and disseminated within and beyond agricultural extension institutions. *De Jong van Lier* hence illustrates the role of scientific institutions in establishing more sustainable solutions for the development of farming and food systems in Latin America's largest country.

Theme 4 – Exploring alternative production systems. In her contribution, *Olga Romanova* investigates the potential of agroforestry development as an alternative form of biomass production in Kazakhstan and the policies required to further this development. She concludes that by aligning agroforestry practices with the principles of sustainability, biodiversity enhancement, and improved livelihoods, Kazakhstan can pave the way towards a more resilient and ecologically balanced agricultural future. Focusing on Tajikistan, *Musavvara Khaitovna Shukurova*, *Zulfiya Burievna Davlyatnazarova*, *Irina Sergeevna Kasparova*, and *Kurbon Aliev* provide an overview of the potentials of sweet potato as a new crop to ensure food security and reduce malnutrition in Tajikistan. They conclude that sweet potato can be a promising crop for the country as a source for food fortification, starch production, glucose production, and livestock feed. This, however, requires further popularization efforts as sweet potatoes are not traditionally used in the local kitchen. Addressing the question of popular acceptance at an entirely different level, *Ingrid Bunker* and *Jana Zscheischler* present a theoretical-conceptual framework for analyzing the acceptability of bioeconomic innovations in a case study on manure-fed insects as livestock feed. They argue that on the one hand, manure-fed insects may contribute to incremental sustainability improvements and an increased circularity on the level of feed and food production. On the other hand, this innovation may create the risk of a lock-in of the current unsustainable agri-food system. Finally, *Zhengqiu Ding* and *Philipp Grundmann* draw on a value chain approach for grassland residue biomass in the German federal state of Brandenburg to analyze avenues for the furthering of the bioecon-

omy. They particularly focus on the role of niche technologies for business development and thus emphasize the role of innovational processes beyond the tapping of fossil resources, while also highlighting obstacles for more sustainable bioeconomic development pathways.

In sum, the contributions offer, on the one hand, valuable insights into the weaknesses and path dependencies of existing food and biomass production systems, pointing out the inequalities and social-ecological vulnerabilities of current modes of production. On the other hand, they critically discuss possible ways forward, highlighting the need for participatory approaches of knowledge co-production to make the perspectives of farmers more visible, and exploring the potentials of selected innovations to improve the status quo. While the topics addressed by the contributions to this volume are necessarily very selective, they offer fresh insights by bringing together case studies from very different places to shed new light on important questions of agrarian development.

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On innovations and inequalities – digitalization and the challenge of sustainable agriculture in the bioeconomy

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Keywords: digital agriculture, agricultural innovations, inequalities, corporate power, sustainability

Introduction

'Smart Farming', 'Agriculture 4.0' or 'Digital Agriculture' are largely interchangeable terms used to describe the phenomenon of the increased use of data-related technologies in agriculture and food production. These innovations, including big data-based applications, artificial intelligence and automation, digital agricultural platforms and the use of sensors, drones, and satellite imagery, are increasingly finding their way into agriculture around the world (Prause et al. 2021). Digital agriculture has been widely hailed as 'the next revolution' that will change the way biomass and food is produced (Trendov et al. 2019, p. 1). Both industry and political institutions around the world argue that digitalization offers the solution to feed a growing world population while mitigating the negative environmental and climate impacts of (industrial) agriculture.

This picture is mostly positive, generally conflict-free and with few, if any, downsides. However, some civil society organizations are pointing to problematic impacts, such as corporate concentration and social justice (Mooney & ETC Group 2019). These organizations see digitalization as a threat to food sovereignty and smallholder livelihoods, reinforcing the devastating effects of the agro-industrial model. The academic literature paints a more nuanced picture. Studies highlight the social and economic opportunities, while acknowledging that digitalization poses challenges and risks (Regan 2019). They examine the social impacts and distributional dimensions associated with the development and adoption of digital innovations in agriculture (Rotz et al. 2019; Clapp & Ruder 2020).

A number of studies have revealed how digital innovations are tied to old and new inequalities in the field of agriculture. In the following five interlinked dimensions of inequalities are identified (Hackfort 2021).

Five patterns of digital inequalities

First, there are inequalities in digital technology development, whereby corporate actors largely control the development of infrastructure, products and services. There are basically four main groups of actors: giant corporations producing agricultural inputs such as BAYER; new agri-tech players from the software and big data sector such as Google's Alphabet or Microsoft; machinery and hardware companies such as John Deere; and private sector start-ups. The first three groups dominate technological innovation along agri-food commodity chains, driving the development of GMO seeds, or farm management platforms. One expression of this inequality in technology control is the lack of interoperability among different software and hardware applications. This imposes technical lock-ins, barriers that prevent farmers from using technology systems from different service providers in accordance with their needs. Furthermore, some companies (such as John Deere for instance) place 'digital 'locks' on their hardware and software products. Farmers are on the receiving end, struggling to cope with the lack of system's and data compatibility, constrained by lock-in effects which eventually reinforce the existing inequalities and power relations and farmers' dependence on corporate agro-industrial farming models (Hackfort 2023; Rotz et al. 2019a).

Second, there are inequalities in distribution of benefits from the use of the technologies. Most digital technology is developed by industrial agri-tech-firms and is designed to serve the needs of capital-intensive large-scale farms with high investment capacities who follows a productivist farming model. The exclusion of farmers who adopt a different approach contributes to increased inequality not only between farmers and agribusinesses but also among farmers themselves (e.g., small scale vs. large scale, conventional vs. organic). It is deepening the rift between farmers who use digital technologies and those who are unable or unwilling to do so. It reinforces existing economic inequalities, since farmers who lack the capital to invest in digital technologies find themselves further disadvantaged. In addition, the uneven availability and accessibility of digital infrastructure (e.g., internet connectivity) disadvantages rural areas, reinforcing existing spatial patterns of economic inequality (Bronson & Knezevic 2019; Rotz et al. 2019b).

Third, there is uneven sovereignty over data, hardware and digital infrastructure. Large technology providers benefit from using the data provided by farmers, while farmers themselves have limited access to and control over the data they have generated. They may even be prevented from repairing their own machines, under the terms of license agreements designed to increase farmers' dependency on licensed service providers (Hackfort et al. 2024; Fraser 2019).

Fourth, there are inequalities in 'digital literacy' among farmers and between farmers and corporate providers of digital services. Many farmers lack the knowledge and skills required to process digital data and find it difficult to find independent service providers or employees who are able to use and manage digital tools. Here again a spatial divide between farmers in urban and rural areas comes into play. Those farmers who lack the resources or the opportunity to develop digital skills become increasingly dependent on corporate providers not only for decision-making but also for maintenance and repair of farm machinery (Jakku et al. 2019; Bronson 2022).

Fifth, there are inequalities of power and influence over problem definition and problem solving. Powerful corporate actors shape the discourse, ensuring that the productivist vision of digital agriculture remains predominant, while excluding alternative visions of sustainable agriculture. This allows them to shape policies, whereby digitalization in the service of industrial agriculture is seen as the only way to achieve sustainability goals. Alternative problem definitions, for example focusing on food sovereignty, and solutions such as agroecology are excluded from the discourse, widely ignored by policy makers and starved of investment (Lajoie-O'Malley et al. 2020; Hackfort 2023).

Interlinkages and implications

The identified inequalities are mutually reinforcing, e.g., when the acceptance of discourses linking 'precision-led sustainability' to digital technologies allows corporate actors to gain institutional support for their technological developments and to consolidate and advance their structural and instrumental control over agricultural technologies and food production. This acquired legitimacy might prevent critical questions from being raised about actual environmental effects, as well as related social and political issues such as data and food sovereignty, and corporate control over farming practices.

It further contributes to the disempowerment of small-scale alternatives based on low-tech agriculture or agroecology and their marginalization in international and national policy-making arenas, including in the allocation of funding. The focus on high-tech solutions suits powerful actors from agribusiness and AgTech industry, contribute to maintaining the status quo and help divert attention and funding away from initiatives that are attempting to transform agriculture more fundamentally towards less corporate domination and more biological and social diversity. The "overemphasis of high-tech solutions" in food systems (Klerkx & Rose 2020, p. 2) contrasts with the lack of support for alternative narratives and practices inspired by visions of an agricultural future no longer dominated by industrial production (Lajoie-O'Malley et al. 2020).

These patterns raise the question of the extent to which digitalization can be understood as a revolution in the agri-food system towards a sustainability transformation, or rather as a reproduction of existing patterns rooted in agro-industrial modernization with its productivist paradigm. The underlying power relations in the digitalized agri-food system are not new; they are a continuation of what food regime theorists have called the 'corporate food regime' (McMichael 2009), and they are quite stable. Because of its tendency to leave underlying structures untouched, some authors even argue that the so called 'new' digital precision agriculture is still conventional agriculture, and better understood as part of a long-established production systems characterized by rationalization and control (Miles 2019). However, there are some emancipatory initiatives that are developing and applying digital technologies to challenge existing innovations politics and related inequalities and to advance alternative visions of agriculture (Fraser 2022).

Alternative digital agri-tech innovations

In the US, the FarmHack community developed FarmOS[2], a tool which is intended to overcome "technological inequities by introducing greater diversity into the digital agricultural socio-technical system" (Bronson 2019: 4). The free and open platform was developed in close cooperation with farmers, and can be hosted, installed and further developed by anyone who has the capacity (e.g., coding skills) to do so. It enables farmers to stay at least partially independent of large corporations and to regain and maintain sovereignty over how their data is shared. In Germany, the company Rukola Soft[3] offers a farm planning tool for vegetable cultivation customized to the needs of small-scale agriculture. Another example is the open-source software OpenOlitor,[4] a digital platform for CSA administration enabling users to remain independent from proprietary software solutions. Both

[2] https://farmos.org/ (Accessed July 23, 2023)
[3] https://www.micro-farm-planner.com/de/ (Accessed July 23, 2023)
[4] https://openolitor.org/ (Accessed July 23, 2023)

are community driven and developed in close cooperation with farmers and activist from the CSA movement. They facilitate trans-local food movements and the sharing of place-based knowledge for the benefit not only of farmers but also food sovereignty groups promoting alternative, localized, agroecological vision of agriculture.

In addition to these grassroots initiatives, some companies also started to develop digital products tailored to the needs of agroecological, organic and small-scale farmers. The Canadian free and open source farm management tool LiteFarm[5] was co-designed by farmers, especially for the needs of sustainable, diversified, and organic farmers worldwide. In Germany, start-up Zauberzeug is selling its Field Friend[6], a development platform for organic farming, suited for mechanical weed control, inspection and harvest which can be adapted and further developed to meet farm specific needs. And Permarobotics[7] is developing a field robot for regenerative farming, using an open and free data standard to increase compatibility among different systems and applications.

Conclusion and outlook

As the above shows, inequalities and power are often inscribed into technologies, e.g., through technical lock-ins. They are often reinforced by legal lock-ins, property rights over patents or data and further through processes of economic market concentration. Breaking with such patterns and lock-ins requires, first, a different technology design directed towards more diversity on the fields. The presented alternative digital agri-tech innovations are still a small niche, yet they demonstrate that there are alternatives to the mainstream technology regime and that technological and social innovations can support each other in fostering sustainable and fair biomass and food futures. For such niches to grow, political support for such alternative digital agri-tech innovations is needed.

However, sustainable food and biomass futures will never be achieved through technology solutions alone. It needs to be combined with social, ecological and political innovations. This is why, second, we need more diversity with regards to actors in the agri-food system. This requires a democratization of economic power over technology development, food production and sustainability discourses. To achieve that, governments need to implement more effective anti-trust laws to curb increasing corporate power on the one hand and political regulations that strengthens data and food sovereignty of farmers and farming communities on the other (Clapp 2021; Hackfort 2023).

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The inclination toward monoculture production in Kazakhstan: Where are the origins of "path dependence"?

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Keywords: path dependence, monoculture production, the soybean revolution, Kazakhstan

Growing concerns about declining biodiversity and adverse climate change underline the urgent need for systemic change in agriculture worldwide, and Central Asian countries are no exception. Despite overwhelming evidence pointing to the benefits of diversifying agricultural systems on a field scale, the Central Asian countries – like many other post-Soviet and, more broadly, post-socialist ones – retain and even increase monoculture production (Umirbekov et al. 2015; Fehér & Fieldsend 2019; Moldavan & Pimenova 2021; Dębiec 2021). As far as one can judge from incomplete statistics and scattered field studies, the tendency towards monocropping is evident not only in conventional crops like cotton in Uzbekistan or wheat in Kazakhstan, but also in soybean or sugar beet production. The situation is complicated by the fact that the expansion of soybean yields is considered by the Kazakhstan government as a way, for example, to solve the problem of monocropping (Makulbekova et al. 2017). As a result, soybeans intended to be used to rotate and reduce monoculture production become a monoculture themselves.

So, why is monocropping – not the best possible agricultural technology – so persistent? The easiest way to answer this question is to remind ourselves about the economy of scale and the overall effectiveness of monocultural production. However, agronomists now know of other, more effective approaches and are aware, of course, of how monocropping is harmful and dangerous for biodiversity, soil and water. However, farmers continue to use this technology, even in regions with evident water scarcity and fragile soils.

One of the possible explanations for the inclination toward monocropping is the so-called "dependence" of agriculture on a previous development path ("path dependence"). The concept was proposed by economic historians to explain the persistence of (not necessarily the best possible) technology, in particular the QWERTY keyboard layout (David 1985). The idea has since evolved to explain why ineffective technologies and/or institutions become committed to developing in certain, historically-driven ways. There are limited publications on path dependence in agriculture, but scholars have analysed both technologies and institutions. For example, Barnett et al. (2015), scrutinizing six cases from across Australia, explained how path-dependent institutions resist ecological adaptation because technologies incentivise this resistance. In turn, Begg and Meurs (1998) showed that socialist history did not fade away, and ordinary people, and even policymakers, are subject to considerable inertia, which prevents Bulgarian agriculture from market transition.

In this article, I focus on soybean (monocultural) technology in Kazakhstan institutions. I argue that the tendency toward soybean monocropping is caused by technological persistence, which comprises technological approaches to plant breeding and utilizing machinery and the labour force. The introduction of soybean monocropping technology in Soviet Central Asia began in the 1930s (Krokhin 1931, Momot 1932) when communist authorities tried to change the regional agricultural system considerably (Cameron 2018). To do so, they experimented with and introduced different industrial crops – cotton, dogbane, safflower, brassica, rice, sugar beet, sunflower, soybean, etc. (Abolin 1933, Kenarskiy 1931, Kenarskiy 1932, Korolev 1932, Momot 1934a, Momot 1934b, Nusinov 1933, Susarov 1930). Cotton has become the most striking and destructive example of the impact of monoculture production on ecology and social relations in the region. However, there were other "new crops," and although they did not influence the environment to such a degree as cotton, the inertia of industrialisation's necessity never faded.

Besides its introduction and conclusion, this article consists of three parts. In the first, I consider the general context of the soybean campaign ("revolution") in the USSR. In the second, I discuss what technologies were considered necessary for soybean introduction in Central Asia, and in the third, I explain what has happened with this crop in the region.

Context: The Soviet Soybean Revolution

The large-scale introduction of soybeans in different regions of the USSR – from the Far East to Ukraine and the Kazakh steppes – began in 1930. Soybeans were intended to serve as a source of oil for industry, proteins and fats for human nutrition and as animal feed. This versatility of the new plant predetermined an obscure yet now known highly active Soviet soybean campaign in 1930, comparable to the widely known Khrushchev corn crusade from the mid-1950s. The leading initiators, executors and propagandists of the soybean campaign were:

- The *Narkomzem* (People's Commissariat for Agriculture): area of responsibility was introducing the crop to collective farms and other agriculturalists.
- The *Maslozhirsyndicate* (Oil and Fat Syndicate): its institutes and factories were responsible for using soya for food and non-food commodities.
- *VASKhNIL* (Lenin All-Union Academy of Agricultural Sciences): its institutes created new or adapted existing soybean varieties and developed agricultural technologies.

In the 1930s, more than 30 different research institutes conducted experiments on the use of protein in the food industry, the impact of soya on human health, the use of soya in animal feed rations and the potential of soap, olive oil, paints, and ink production from soybean oil. The world-famous academician Nicolai Vavilov – the first president of *VASKhNIL* and director of *VIR* (All-Union Institute of Applied Botany and New Cultures, established in 1924 on the base of the Bureau of Applied Botany, established in 1894) – declared the "soybean revolution", supported the establishment of the Soybean Research Institute and personally participated in an exchange of knowledge and samples of soybean with scientists from the USA and Europe (Ryzhova 2022).

In general, Soviet interest in soybean was greatly inspired by the success of non-Asian countries in introducing the plant, most of all by American agricultural techniques and the Austrian methods employed to process soy protein. The first five-year plan posited: "Of the oilseeds in the first place stands the soy, which has become rapidly distributed in the U.A. States, where this crop is called 'plant of the future'" (Pyatiletniy 1930 – p. 413). In the 1930s, Soviet scientific institutions studied and adapted American cultivation practices, and prepared and published brochures and methodological recommendations for agriculturalists. Moreover, Soviet scientists, technologists and even diplomatic services tried to borrow (even steal) soy meal production technology (RSAE. F. 7486. Inv. 44. C. 1).

The "First" Arrival of Soybean in Kazakhstan. The 1930s

Plant breeding technology. The first Soviet trials for the introduction of soybean to Central Asia took place at experimental stations in Almaty, Frunze (now Bishkek) and Osh in 1929-1931. Later experiments began in many other places, including in Karlag – the Karaganda corrective labour camp – where imprisoned botanists and agronomists attempted to introduce the plant to the Karaganda oblast to provide food to support emerging industrialisation (RSAE. F. 74. Inv. 15. C. 74).

The Soviet breeders believed that they were experimenting with a crop entirely new to the region; however, soybeans were familiar to the Dungans living in Semirechie [*Dungan* is a term used in the USSR and later in Russia and other post-Soviet countries to refer to an ethnic group of Muslim people of Hui origin. This group migrated throughout Central Asia, including across imperial and state frontiers/borders. The Dungan were skilful farmers, growing different crops and vegetables]. Even when the existence of experienced soy farmers became known to the Soviet breeders, the Agricultural Academy of Sciences did not stop trying to invent and introduce other, more industrial technology. Dungan technology thus did not attract the attention of scientists.

What is even more curious is that the Soviet experimenters somehow lost the "Dungan Soybean", which was then "discovered" by Almaty Soybean Experimental Station staff in 1932, in the second year after its establishment. The station undertook an expedition, following VIR recommendations: in order to breed a high-quality, localised variety, experimental station staff needed to find either a wild or a cultivated local plant. In this regard, Almaty station proved to be effective. Then, in 1934, an employee of the Almaty station published a paper about the Dungan soybean variety in the *Central Botanical Journal* in St. Petersburg (Lobanov 1934). In 1935, an employee of the VIR, analysing available samples held by the institute, defended her dissertation on the classification of soybeans, where Dungan soybeans were included. However, later on, this variety disappeared from Almaty experiments and even from the VIR gen bank. I assume this happened because the Dungan soybean was classed as unproductive: it was "green, soft, quickly boiled" and contained fewer proteins and fats than the "industrial" Manchurian bean.

Labour force and machinery. From the very beginning, directives sent down by centralized bodies and research institutes instructed the experimentalists not only to find or produce varieties suitable for the local climate, but also to make the plants suitable for large-scale production. Above all, this meant that it must be a high-growth crop to enable mechanical harvesting, which, in turn, would allow Soviet agriculture to achieve economies of scale, improve labour efficiency and increase productivity. To achieve labour efficiency, in 1936, Soviet scientists studied the possibility of applying the Taylor system in the Kazakh SSR agricultural sector (SARK F. 74. Inv.15 C.70). The Taylor system required breaking down each job into its individual motions and then timing workers with a stopwatch. The elimination of unnecessary motion led the worker to work a-la machinery, resulting in the rise of productivity (Britannica). It is curious that the Taylor system, harshly criticised by Ulyanov-Lenin in 1914 and justified by him in 1918, became a model for Soviet agriculture. The idée fixe was to replace all manual labour with machine labour, even though they did not have machines to process soybean until the 1950s. The lack of machinery, however, did not prevent the abandonment of "Asian"/Manchurian soybean production techniques ["completely unsuitable for socialist farming" – Vul'fson 1936 – p.60], which presupposed mainly manual labour on the beds (the beds, of course, excluded machine processing). This dream about industrialised soybean production may partly explain why the Koreans – skilled agrarians and the only efficient soybean growers in the USSR – after their deportation to Kazakhstan in 1937, were not involved in soybean production: they grew soybeans using exclusively manual methods.

In contrast to Ukraine and the Caucasus, where *Maslozhirsyndicate* and *Narkomzem* organised the mass introduction of soybean in 1926-1934, Kazakhstan avoided this fate. By the 1940s, the Soybean Revolution almost stopped, but trials continued in Kazakhstan until the collapse of the USSR, and they are currently ongoing in the agrarian research institutes that have survived to this day.

Multiple "Returns" of Soviet Soybean

After the Second World War, the USSR again faced a shortage of agro-products, which, as is widely known, led to a new revolution –Khrushchev's Corn Crusade (Hale-Dorrell 2018). Although the main focus of this campaign was corn, soybeans were also present in the new Soviet agricultural uplift programme. Every botanical expedition and secondment to the USA, China, India, Czechoslovakia and elsewhere had to include a corn-related task, but the search for soybean varieties did not stop. Even during the often discussed in scientific literature secondment of Soviet scientists and bureaucrats to the so-called "American corn belt," they also studied soybean and its cultivation, and collected new varieties (RSEA F. 7486. Inv. 22. C. 88). The transborder exchange of knowledge for Khrushchev's agrarian industrialisation programme was not limited to the US, though. At the beginning of 1950, the Ministry of Agriculture organised a series of secondments to countries making up the newly created Soviet bloc. The assigned botanists were tasked to collect new verities, study how plant selection was organised and determine what kinds of machines were used, including for soybean cultivation.

Geographical experimentation on soybean also got a second wind in the USSR. Whereas by the end of the 1930s, it was considered an inappropriate crop for Kazakhstan, by the 1950s, soybean returned to experimental stations (Karyagin 1978). There were two reasons for this change – drought-tolerant varieties appeared but, more importantly, there was a realisation of the importance of crop rotation, in which legumes had a key role to play, as such crops are a natural source of nitrogen. In Kazakhstan, experiments were conducted on the rotation of cotton with soybean, as well as its joint cultivation with corn. In the first case, experiments were unsuccessful due to poor soil quality (resulting in soybean death or very low yields), while in the second case, the lack of machines capable of handling and harvesting both plants led to the programme's failure.

By early 1980, the growth rate in agricultural output had fallen again, especially in crop production. Animal husbandry also required new approaches in the provision of fodder, leading to the introduction of a new food programme in 1982, which did not give priority to one crop. However, authorities again turned their attention to soybean. The Academy of Sciences produced several reports on soybean production and use technologies, mainly relying on old knowledge. The Council of Ministers of the USSR issued recommendations for different agencies on how to use the plant. However, the American Oilseed Industry Report, published in 1982, stated that the USSR did not have the technology to produce and use soybean (Bickerton 1987). This, of course, is not entirely true. The technology had already been developed by 1950, although it was far behind what the Americans had achieved. Moreover, these technologies existed on paper rather than in reality.

Conclusion

As a traditional food source and a green manure crop, soybean has been used by Chinese and Koreans for centuries (Baraibar & Deutsch 2023). However, in the early 20th century, it broke into global markets as an industrial/cash crop. The USSR fully adopted this vision and focused on finding relevant, i.e., industrial, technologies. This perception paradoxically limited the introduction and use of the plant. Each time, path dependence (inertia of the industrial vision) turned good intentions upside down. When soybean "arrived" as a new crop, the "idea" of industrialization thwarted attempts to introduce it, and when it was to be used for crop rotation with corn or cotton (and, in so doing, be used for soil improvement), the absence of industrial machinery prevented its success. When the food crisis occurred, the inability to process soybean industrially prevented its mass production. Finally, soybean is now seen as a soil improver – and is crucially needed for exhausted soil – but the industrial vision is reversing the plant's ecological value and turning this legume from an environmental cure into a soil killer.

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Cultivating agroecosystems around commodity crops in Thailand: Challenges and propositions for analysis

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Keywords: agroecology, Thailand, infrastructures, peasants, transition

I elaborate on the concept of "agroecosystems" around a commodity crop, to relate local trajectories of transition towards non-chemical agricultural approaches. This paper's primary aim is to apply this concept as a framing device for further analysis, to two groups of actors: farmers and government lab scientists. Its secondary aim is to propose an analysis that takes heed of intersecting scales. I demonstrate that the cultivation practices each of these groups take enroll local ecologies and human networks in unique ways, giving rise to forms that may or may not replicate beyond a certain scale. I use "agroecosystem" to define the system of ecological relations these cultivators work with, and use "agroecological" to refer to agroecosystems that include the political dimension of peasant autonomy.

Figure 1: Cultivation practice 1. Mathana Aphaimool holding seedlings she is propagating for sale to neighbouring farmers. Author, 2023

Thailand has long played the card of appeasing more powerful players, since its emergence as a modern nation-state (Baker & Phongpaichit, 2014). From the British and French trying to bifurcate it—the British on the west and the French on the east (settled through a 1896 treaty between the two colonial powers), to the Bowring Treaty between Siam and Great Britain in 1855, to the shock of the British invasion of the Burmese Kingdom, these histories retell the story of Siam coming of age as a nation-state by learning to hold its own between two strong powers. Histories like these influence perceptions of the constraints Thailand navigates, in much the same way it continues to do so today—such as with the US and China.

Variations of these stories were related to me when I first began fieldwork in central Thailand, amongst tenant rice farmers. I heard similar stories in the north amongst activists working along the Mekong river. While references at the national scale appear during encounters between individuals of different nations, or through trading contracts and agreements, I argue that the materiality of local agroecosystems is the primary driver of decisions made by cultivators, weighed against regional shifts.

Hirsch, Woods, Scurrah and Dwyer (2022) make a similar point in an edited volume on the Mekong region, when they introduce the concept of "capitalisation" to describe three types of social relations people have to land: improvement, commodification, and financialization. As this is a precursor to a more thorough theoretical analysis, I will limit my discussion of the concept to describing the case studies, not to analyzing its fit.

"Capitalisation" is a partial, but helpful description of how two groups of individuals cultivate the agroecosystem around a commodity crop. It is partial because the two groups in question do not fully resemble capitalists in the Marxian sense.

Cultivation practice 1: Germplasm growth niches

In the foothills of a northern province, a community of organic farmers coordinate seedling production (Fig. 1), vegetable and tuber production, pig farming, and agroforest maintenance and non-timber forest product sales at local and regional markets. The time

of non-human growth mixes with the labour-time of peasants, requiring peasants to decide which agricultural approach suits their needs, resources, and energy. Localized and place-based, materials and time are woven by the peasant into the growth of a functioning agroecosystem.

Cultivation practice 2: Lab-grown and capital-dependent

In a provincial field station removed from farmers' everyday lives, government scientists run research projects to solve the problems of sugarcane white leaf disease—a viral disease which spreads through insect vectors. One project plans for clean and healthy seedcane to be cultivated in farmers' fields for propagation, to ensure the sustainability of sugarcane for local sugar mills. Another project cultivates indigenous microorganisms from soil collected in the region, the best strains selected and propagated in the lab. The abilities for these projects to take off, and the social relations that can be created, will be based on what funds are acquired.

Analysis. The first cultivation practice is by second-generation farmers who return to their villages from an adult life in the city, and choose to build a village economy around organic, chemical-free farming despite the skepticism of other cash crop farmers in the village. They create jobs locally, and this local economy has been further strengthened by a collaboration with a supermarket chain which has secured a channel for product distribution. Their work is known nationally, regionally, and internationally through word of mouth, and their choices around what to cultivate and how, are taken simultaneous to the exposure they receive of national, regional and international tastes, through their visitors and supporters.

The second practice is by a group of government employees with secure employment, working in a lab and experimental field station to support the cash crop economy of the northeast region. Their experimental research aims to identify organisms, propagation methods, and biocontrol methods that can improve the condition of farmers' sugarcane agroecosystems, to boost the health of sugarcane plants against plant diseases. Most of their experiments at this time focus on creating clean seed cane, or identifying indigenous soil bacteria that can strengthen the health of plants, as a preventative measure against disease.

Thus, both groups work on improving the condition of the land. However, their approach is different to that of the actors who Hirsch, Woods, Scurrah and Dwyer (2022) track. These latter actors aim at "turning land into capital" (xiii) within the system of industrial farming: by "the addition of various inputs, machinery, infrastructure, and associated knowledge", through "large-scale water infrastructure investment and management" and other "land-use interventions" that "turn upland smallholder rice and other mixed cash-crop landscapes into large plantations through the investment of agribusiness resources" (174). In contrast to improvement for the purposes of chemical-intensive agriculture, the two groups of cultivators described here practise a kind of improvement that looks towards the systemic reduction of chemical practices. In Thailand at least, a shift to non-chemical farming inputs to manage soil and pests is on the rise amongst farmers (National Statistical Office 2014) and companies, a discussion beyond the scope of this abstract.

Peasants in a dominant food regime

Amongst varied definitions (Edelman 2013), I follow anthropologist Eric Wolf's (1969) definition of the peasant. Wolf defined the peasant as "populations that are existentially involved in cultivation and [who] make autonomous decisions regarding the processes of cultivation" (20). Peasants interact with the dominant food regime, and with different agroecosystems. I choose to apply the idea of agroecology widely to also include the agroecosystems of the industrial farmer—though they are not politically aligned with the agroecology movement. Doing so lets me express the landscape of potential and challenge with which an agroecological farmer sees their work, in a world that has been shaped by the dominant, hegemonic food regime (McMichael 2013) today—one shaped by the capitalist logics of industrial techniques, and grown by corporations' interests.

Propositions

The two kinds of cultivation practices described here highlight different social relations. The first is linked to a redistributive network, in support of non-exclusionary, openly interacting, diverse agroecosystems. It includes gift and commodity relations. The second creates product-focused approaches which require the aid of a sister agricultural extension department, and funding from the ministry, to be shared and distributed amongst farmers. It includes state-sponsorship and private investment, and needs further examination through the lens of state-led agricultural development for commerce.

Challenges

The first cultivation practice struggles constantly to balance foreground and background priorities: there is the non-linear time of ecological relationships the peasant observes, and the linear time that urbanity brings (production times, communications, visits). Which scale requires attention, and when? The second cultivation practice provides a technological solution, which will take time to scale, if it is not integrated with farmer lives, and is partial as long as monoculture practices stay. A common question arising from both is that of scale: how will local actions scale without financial support?

Discussion

As one heads north from Bangkok to Chiang Mai, dominant food system infrastructures (cold chain storage and transportation, rice paddy and rice mills) and factories remain, but interpolate with smaller communities and their food and vegetable markets. The north, northeast and south of the country are home to highlands and river networks, and a historically unprivileged administration respectively. They are also home to peasant networks who mobilized and joined forces to hold protest rallies and months-long sit-ins in Bangkok, in the late 1990s and 2000s. The concept of "capitalization" and improvement helps to frame a long-awaited transition towards more ecological, or at least, moderate chemical practices. While the ecological limits of soil are forcing a transition in industrial practices, and a global carbon market is discussed, a Marxian view will predict capital continuing to create new forms of exchange value. Is the object of improvement here the land itself, or soil? Will this view differ amongst companies, state, farmers, and peasants? If land as a movable asset is linked to soil health or soil carbon, which social relations will be strengthened? These questions can be addressed by observing regional dynamics of land use policy, capital flow, and peasant movements.

Food system transitions can be studied as a collective action problem, where knowledge emerges from particular conditions (Douglas 1980). The actors involved at the local scale in building agroecosystems are essential, despite the emphasis given to global policy flows. Focusing on local-regional material contexts fills in blanks hidden to a globalised governance structure. By extension, these may enable an understanding of what the nodes of a supportive infrastructure for agroecology—in Thailand and regionally, are.

Outlook

The existing infrastructure of industrial agriculture is creating a new terrain of global governance mechanisms in which data figures centrally. Data supports processes of "capitalization"—improvement, commodification, and financialization. Yet industrial agriculture is also facing ecological limits, including limits to soil fertility and clean water. Will data monitoring catalyzed by industry concerns shift how value is generated from land? Concerns about the rise of corporate support amongst food system and agroecology scholars point to the coupling of a corporate-state nexus, through which data—generated by specific places enabled to speak empirical "truth"—will be used to manage land for forestry and agriculture. Rather than taking the view that this presents a challenge for the growth of local agroecosystems, this paper asserts that research can follow the scientific and peasant cultivations of another kind of value—ecological relationships within agroecosystems. By analysing the conditions of their growth, such research may contribute an understanding of the challenges they will encounter, and thus better support agroecological transitions.

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Livestock fodder support in Kazakhstan: An implementation deficit?

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Keywords: fodder, subsidy, livestock, arable lands, degradation, Kazakhstan

Introduction

Although Kazakhstan saw a sharp decline in livestock numbers in the 1990s, more recently, the country has experienced a steady increase in this regard (Ferret 2018; Hankerson 2019). Along with this increase in livestock numbers, the demand for fodder has also grown. Thus, the government has introduced new ways of supporting the supply of fodder, such as the provision of fertilizers and fuel at reduced prices, agricultural fairs and direct cash subsidies for purchasing fodder for pedigree cattle owners. It is thus important to examine the implementation of livestock fodder support, as Kazakhstan aims to become a top 10 global mutton- and beef-exporting nation by 2027 and 2028, respectively (Horoshun 2020). To achieve this aim, the Kazakh state has already adopted some new approaches in terms of livestock fodder supply. This study aims to examine how fodder support measures are implemented on the ground by focusing on the T. Ryskulov district of Zhambyl province in Kazakhstan, and how these measures have changed over time.

The literature on livestock fodder in Kazakhstan mostly focuses on the reasons for overgrazing lands and degradation, which are rooted in uneven pasture use by farmers (Robinson et al. 2002; Issayeva 2020). Out of 188 million hectares, only around 80 million ha are utilized for pasture in the country (Issayeva and Bakhralinova 2020). The main reason for this issue is that household and private farmers, who own 60% and 35% of national livestock, respectively, graze their animals on nearby village pastures (around a 5 km radius) (Robinson et al. 2021). Since the collapse of the USSR, mobile pastoralism has reduced harshly, as 60% of all national livestock belongs to small householders who cannot afford the social and economic costs of moving. As long-distance mobility has been reduced and household farmers are immobile, the viability of village pastureland has thus degraded (Robinson et al. 2021; Issayeva 2020; Kerven et al. 2021). Additionally, abandoned pastureland, which is inaccessible to farmers due to distance, is also subject to the risk of losing vegetation diversity. In this regard, Dara et al. (2019) reveal that reduced grazing has led to the growth of dry vegetation in northern Kazakhstan. Likewise, Brinker et al. (2016) claim that "grazing is mandatory to fully restore the original near-natural steppe vegetation" (p. 2544). Other studies focus on fodder production in Kazakhstan (Kantureyev 2019; Ospanova et al. 2022; Robinson et al., 2021), noting that the arable land is shrinking (Ospanova et al. 2022), in addition to the degrading pasturelands. As a result, there is a fodder deficit in the country, which Kantureyev (2019) highlights at 1,366,000 tons per year. Additionally, a hay deficit accounts for 11,017,000 tons per year, a compound feed deficit accounts for 2,186,000 tons per year and silage for 3,965,000 tons per year in Kazakhstan. Likewise, Moldabayeva (2018, p. 26) mentions that Kazakh livestock is undernourished, with the average weight of a Kazakh sheep being 30 kg and cattle 280-320 kg, whereas the world's averages in this regard are around 45-50 and 450 kg, respectively.

The existing literature on livestock and fodder production mainly focuses on pastoralism, the degradation of rangelands and livestock production. However, fodder supply has received less attention, and there is no literature examining state-supported measures at sub-national levels. This study aims to contribute to filling this specific gap. In addition, by examining how these measures are implemented on the ground, this study also aims to provide recommendations to policymakers about how to improve the current situation.

Methodology

This exploratory study draws on qualitative field research undertaken in the T. Ryskulov district of the Zhambyl province. The latter spans over 144,000 square kilometers with around a 1.2 million population, and has one of the largest livestock headcounts in Kazakhstan (e.g., cattle size around half a million; sheep and goats 3.3 million in 2021) compared to other provinces (Kazakhstan Bureau of Statistics 2021). Meanwhile, although Zhambyl province has

one of the highest stocks of livestock in Kazakhstan, it had the lowest stocks of ready-made livestock fodder in 2022, i.e., merely 48,000 tons, as compared to East-Kazakhstan province, for instance, with 72,500 tons (Kapital 2019). As a result, there is a mismatch between the number of livestock and ready-made fodder in the Zhambyl region, and thus it is interesting to look at this province to reveal state-supported measures for farmers. This study focuses on one district from Zhambyl oblast, namely the T. Ryskulov district, which is predominantly rural and has 7.6 heads of sheep per inhabitant (Table 1).

Regarding the respondents, this study purposively selected household owners and family farms, because Robinson (2021) argues that the majority of livestock is owned by households and farming families vis-à-vis large enterprises in Kazakhstan. The author conducted face-to-face (N=6) and online (N=12) interviews with these two types of livestock owners and experts in 2022-2023. In the present study, nine of the respondents are household owners, five family farm owners and four agricultural experts who work in local academia and for civil society organisations.

Findings and discussion

According to the interview findings, as well as the existing literature, the Soviet central apparatus rehabilitated mobile pastoralism in 1941 and provided immense state support due to the state plan to increase livestock numbers. Measures that addressed fodder support included the irrigation of arable lands and feed crops (Kerven et al. 2022), the provision of winter fodder and feed supplements to large farms and households (Kerven et al. 2021; Hankerson 2019) and, most importantly, the provision by the Soviet state of material and institutional support to farmers for mobile pastoralism (Kerven 2004). The main feature was the state support of large state (*kolkhoz*) and collective (*sovkhoz*) farms (Kerven 2004).

After the dissolution of the Soviet Union, de-collectivisation and privatisation of farms took place, which in turn influenced how livestock was raised and fed by farmers. Currently, the Kazakh government has some measures in place to support fodder provision. Findings from the T. Ryskulov district indicate that one of the more common approaches is to provide diesel fuel at reduced prices, with the aim of assisting farmers when harvesting crops. However, one of the respondents argued that the diesel fuel subsidy was ineffective because the subsidised price was USD 0.47 per litre compared with the market price of USD 0.52. Considering when a farmer buys subsidised diesel, they are obliged to pay taxes and environmental fees, as well as disclose information about arable land, which places additional burdens on them. Thus, the respondents overall decided not to apply for subsidized diesel.

Second, the state provides direct subsidies for fodder purchases to pedigree cattle owners (Ministry of Agriculture of Kazakhstan 2019). The amount of the subsidy varies from province to province, but the respondents mentioned that it was USD 22 per cattle head in 2021, reimbursed as a direct cash payment per year. According to the interviews, it is mostly agro-oligarchs who are able to access this type of direct cash subsidy. One respondent, who is a family farmer, argued that local government designed the procedure and rules for this cash subsidy by taking only the interests of agro-oligarchs (large enterprises) into account. Similarly, Robinson (2020) noted that, in general, agricultural subsidies were almost exclusively received by the top cattle ownership quartile, with the most frequent examples being subsidised pedigree bulls and machinery purchase/lease arrangements in Kazakhstan. In addition, the direct subsidy of fodder purchases for owners of pedigree cattle is not transparent, as provincial government, not district-level government, determines the criteria and procedures in this regard, according to our respondents, but nobody knows who receives direct cash subsidies, or why, when and how much. This non-transparency leaves room for corruption and lobbying in the provincial executive body. Thus, the subsidy provided to owners of pedigree cattle is evaluated as unfair and non-transparent.

Nonetheless, another measure of support provided to farmers is the chance to buy fertilizers at reduced prices. One of the household livestock owners noted as follows:

> "Small households do not own arable land; instead, they lease it from the large enterprises. To be honest, as we are not the owners of that land, many of us are not concerned about the soil as much. In 2021, we purchased fertilizers at a 50% discount, which helped us a lot. Otherwise, we wouldn't be able to afford it" (Respondent-farmer 1).

Indeed, household livestock owners acknowledged the worsening quality of the soil on arable land, because they lease it from large enterprises, which in turn lease the land from the state. Consequently, no party is concerned about the quality of the soil, which is why the farmers found subsidized fertilizers effective, as they helped increase harvest yields. Additionally, they also mentioned state supported agricultural

fairs, where they can purchase fodder (e.g., compound feed, hay and grain) at reduced prices, which they found helpful, albeit these were organised very rarely in their district.

According to the farmers, measures such as the fertilizer subsidies and agriculture fairs proved to be effective, but they are inconsistent and conducted only occasionally. One of the private farmers noted:

> "Overall, we really need some support with livestock fodder. The local government ran a state-supported agricultural fair some years ago, but you never know when they will organise the fair again." (Respondent-farmer 2)

This exploratory fieldwork therefore demonstrates that there are some approaches which address the fodder deficit on the ground, but their implementation remains challenging.

Table 1. Population and livestock numbers at different territorial levels, 2021

	Population	***Surface km²***	***Cattle***	***Sheep***	***Goats***	***Horses***	***Head of livestock per inhabitant (sheep)***
Kazakhstan	18,879,000	2,724,902 km²	7850,000	17,751,500	2,307,900	3,139,000	0.93
Zhambyl oblast	1,139,000	144,264 km²	502,000	3,057,081	250,404	151,680	2.68
Ryskulov district	64,700	10,500 km²	37,020	492,712	34,308	22,090	7.6

Source: National Bureau of Statistics of Kazakhstan, 2021

Conclusion and policy recommendations

To conclude, state measures in supporting farmers seeking to deal with the fodder deficit include the provision of fertilizers at reduced prices, lower fuel prices, direct cash subsidies given to pedigree cattle owners to purchase fodder at reduced costs and agricultural fairs. In contrast, the Soviet state offered extensive material and institutional support in the form of winter pastoralism, cropland irrigation and the issuance of arable land. It is worth mentioning here that the current practices of agricultural fairs and direct subsidies reflect some of the policies that existed in Soviet times. For example, similar to agricultural fairs, where small household farmers and private farmers can purchase fodder crops at reduced prices, the Soviet state also offered winter fodder crops and feed supplements to *sovkhoz* (Kerven et al. 2021). The practice of subsidies is directly inherited from the Soviet past, while the current policy of direct cash subsidies given to farmers also reflects the Soviet legacy, albeit with new features, i.e., only pedigree cattle owners are eligible for this type of financial assistance. Additionally, during Soviet times, there was a large, subsidized fodder supply network to supplement grazing in winter (Hankerson 2019), which is not available currently in Kazakhstan.

As the findings show, current measures face several challenges. First, small household livestock farmers are concerned that the local government selectively subsidizes farmers with pedigree cattle. Second, these direct subsidies are non-transparent, and household livestock owners are concerned that procedures remain at the discretion of local governments, which leaves room for corruption and lobbying. The national government should introduce detailed regulations on fodder subsidies and monitor their implementation on the ground.

Moreover, the interviewees raised concerns about the non-transparency and inconsistent features of state support, which is the reason why households and family farmers cannot count on it. These measures should be consistent and digitalised so that each type of livestock owner (large enterprise, family farmers and household livestock owners) have equal access and the opportunity to apply for certain types of support, as well as the chance to observe who has been subsidised – and how much.

As the findings suggest, no party is concerned about cropland and arable land soil. The national government should therefore formalise subleasing, address the irrigation of these lands and create incentive mechanisms for this irrigation. Furthermore, the state should ensure the long-term viability of near-village pastures, by accommodating long-distance mobile pastoralism. Almost half of the pastureland belongs to the state, which is theoretically available for lease, but it is located in remote areas. The government should thus introduce a policy that supports household livestock owners and family farms to graze their animals in those remote pasturelands.

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Adapting agriculture in crisis: A study of smallholder farmers in southwestern Tajikistan

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Keywords: adaptation, decision-making, smallholder farmers, Tajikistan

Introduction

The agricultural sector of Tajikistan has been highly vulnerable during times of recent economic crisis since the beginning of Covid-19 pandemic in 2020 due to the country's reliance on import of agricultural inputs, which exposes it to external factors and fluctuations. The disruptive impact of the pandemic, followed by the increasing input costs associated with Russia's 2022 invasion of Ukraine, had negative effects on the supply of nitrogen fertilizers crucial for optimal yields of cotton, which is considered the country's strategic cash crop under government mandate and supervision (Zakirova, Alff, & Schmidt 2023). Questions of adaptation have subsequently become paramount, particularly in rural communities where agricultural production is essential for farmers' well-being and subsistence, stressing the urgency of comprehensive research in this area.

Despite a longstanding unofficial state mandate that compels Tajikistani farmers to allocate more than 60 percent of their arable land to cotton production (Heyward, Hofman, & Gillin 2022)[8], the adverse impact of external stresses on their food security and income has been particularly pronounced over the last three years (Zakirova, Alff, & Schmidt 2023). In both 2020 and 2022, the purchase price of cotton fell below its production costs as a consequence of the afore-mentioned global crises, leading to significant hardships for farmers, who must sustain their livelihoods amid escalating food prices (Voora et al. 2023). In light of the above, the paper raises the question: How do farmers navigate economic challenges while simultaneously sustaining livelihoods within the context of government-mandated cotton cultivation in southwestern Tajikistan? The case study areas are located in the Khatlon region, encompassing approximately 53 percent of the country's arable land – with 65 percent of it dedicated specifically to cotton cultivation (Tajik National Statistics 2021).

Due to Tajikistan's significant demographic growth since 1991 – from 5.6 million to 9.7 million people, as of 2021 (World Bank 2021) – farmers face increased pressure on their already limited agricultural plots, dealing with an increasing demand for food and various disruptive external factors. While average individual land holdings are about 4 ha (Tajik National Statistics 2021), available arable land per person has decreased to 0.123 ha. In Khatlon, farmers predominantly allocate this land to cotton, while reserving a portion for essential food crops, such as wheat, vegetables, and maize. As several farmers explained in interviews from 2020 to 2022, recent economic and geopolitical events led them to increasingly cultivate higher-yielding and more profitable food crops (Farmer interviews 2020-2022). Although this shift toward food crops stems from unfortunate circumstances, it offers new avenues of development for the local market, which is now in the process of increasing diversification. This paper delves into the prevailing adaptive strategies that farmers have embraced from 2020 to 2023, such as the adoption of new agricultural technologies, practices of intercropping and sharecropping, and organic farming. The data was collected during ten months of field research within 2019–2022 focusing on smallholder farmers, but also interviewing other local agricultural experts, in Khatlon and Tajikistan's capital city, Dushanbe (Zakirova, Alff, & Schmidt 2023).

Subsistence production and crop diversification

Amidst recent crises, acute food insecurity has disproportionately affected rural communities and smallholder farmers in countries with low levels of income (Clapp & Moseley 2020). With the impact of rising inflation and food prices, farmers have found themselves compelled to prioritize the cultivation of essential food crops over cash crops, reflecting a pressing need for sustained food self-sufficiency

[8] https://landportal.org/book/narratives/2022/tajikistan

(Mavroeidis et al. 2022). This situation has been particularly noticeable in Tajikistan, where the country struggles to fully satisfy its demand for staple crops, necessitating the import of wheat, vegetable oils, and animal products. Interviews with several farmers revealed that escalating food prices have compelled them to even deviate from the government mandate for cultivating cotton, opting instead to grow food crops on their fields earmarked for cotton cultivation. Wheat, for example, is a priority crop for these farmers' subsistence to be independent from buying imported wheat, which become scarce during periods of crisis. Notably, the prevalence of wheat cultivation among smallholder farmers in Tajikistan reflects a longstanding tradition of prioritizing this crop as an adaptation strategy, particularly among elderly farmers who experienced food scarcity during the Soviet era (Collins & Dibb 1967).

The strategic choice of crops on the remaining 40 percent of land not dedicated to cotton, especially fodder crops like maize and alfalfa, reflects a critical decision-making aspect in agriculture and is particularly essential for sustaining livestock (Sedik 2009). The southern regions of Tajikistan lack pasture lands, meaning that farmers must grow their own animal feed. Tajikistan has a total of 17.9 million heads of livestock, mainly cattle and sheep. The Khatlon region alone has 5.6 million farm animals, constituting about 31 per cent of the country's total. With a population of over 3 million people, each citizen in the Khatlon region would have, on average, around 1.9 heads of livestock (Tajik National Statistics 2021).[9] These figures suggest that animal husbandry plays a significant role in the rural economy of Tajikistan, as farmers can slaughter animals and sell the meat – or use some of it for their own consumption. The cultivation of maize and alfalfa is necessary to feed an increasing number of livestock, especially during wintertime (Robinson & Petrick 2021), thus highlighting the resilience strategies of farmers who prioritize their basic needs for subsistence and invest in long-term livelihood strategies that help them to cope in times of crisis. This strategy proved its viability especially during the Covid-19, which caused a reduction in remittances and thus increased the pressure on local livelihood sources and food reserves (Holzhacker 2020).

Notwithstanding the innovative approaches adopted by a few pioneering farmers – as I discuss below – the cotton's dominance persists in agriculture. Despite the inherent challenges associated with this practice, certain smallholder farmers are now experimenting with new techniques of cultivating alternative crops like fruits and vegetables in response to evolving markets. These endeavours, however, encounter constraints, stemming from limited resources and insufficient technical knowledge, thereby limiting their widespread implementation.

Technologies and knowledge

With the collapse of Soviet Union in 1991, Tajikistan and other post-Soviet countries gained greater exposure to Western agricultural policies and technologies (Lerman, Csaki, & Feder 2004). As a result, new technologies such as green houses or hybrid seeds are now gaining increasing popularity. In particular, Western international development organizations have laid the foundation for a wider variety of crops, greater yields, and the use of previously unknown practices. Fruits and vegetables, for example, can now be grown in greenhouses during the winter, creating a market niche for farmers. Such practices began to gain ground prior to Covid-19, but proved themselves to be remarkably profitable during the pandemic, as the market demand for fresh fruits and vegetables substantially increased (Farmer interviews 2020–2022).

Some farmers are now shifting from traditional food production towards intensive orchards to meet this growing demand for fruits. This move was bolstered in by legislation encouraging the adoption of this new method by allowing some farmers to transform their cotton-growing areas into intensive orchards. While in traditional orchards, farmers must wait at least five years before their first harvest, intensive orchards can produce yields after one year (Expert interview 2022) – and their fruit varieties from intensive orchards, such as Californian peaches, are better preserved during long periods of transportation. The potential profitability of intensive orchards, then, has incentivized farmers to reduce their cultivation of other fruit crops. What farmers gain in profits, however, they lose in taste. One farmer described these new fruit varieties as looking 'perfect' and 'having no defects' but being tasteless (Zakirova, Alff, & Schmidt 2023). Switching from intensive cotton farming to intensive orchards also raises questions about the long-term viability of the latter, as these developments are so recent, and experts are still unable to pass judgment on the sustainability of intensive orchards. Seeing the benefits accrued by successful farmers, others

[9] This is a rough estimate, and the actual number may vary depending on factors such as the distribution of livestock among different households and the types of livestock being raised.

have also started to adopt such methods, pushing the state to reconsider its legislation for fear that intensive orchards would take away farmers' cotton-growing areas (Expert interview 2020).

Not all farmers, however, can afford to experiment with new technologies. Interviews have demonstrated that it is largely the wealthiest farmers who invest in new technologies and attend trainings and workshops run by international organizations that promote them. Poor farmers, by contrast, are unable to purchase expensive technology but nonetheless adopt lower-cost yield-boosting practices, such as intercropping, in order to maximize land use efficiency and reduce the risk of crop failure. Strawberries and alfalfa, for example, are grown by some farmers between their cotton plants. Strawberries, in particular, produce yields several times throughout the season and are easy to sell on the market: some farmers say that they earn more from strawberries than from any other crop. Nevertheless, both strawberries and alfalfa are highly nutrient-intensive crops, and experts say that growing them in such proximity to other crops may not be wise (Expert interviews 2021). These shifts are largely driven by the need to make an immediate profit, and it is still too soon to tell if these adaptive strategies will be sustainable in the long term.

Sharecropping

Amidst the escalating costs of agricultural inputs, farmers face growing challenges in meeting the financial demands associated with cultivating cotton, a critical factor in securing their land entitlements from the state. The need to display 'productive' land use has intensified, as failure to meet cotton-related obligations may result in the state reallocating it to other individuals. Consequently, farmers have been compelled to adapt to the situation, renting out portions of their land to farmers from different regions as a strategic measure to defray land-related expenses, such as a mandatory land and water tax. While sharecropping has been practiced in Tajikistan long before recent economic crisis (Mukhamedova & Pomfret 2019), its widespread use in recent years highlights a growing trend that reflects the substantial economic challenges farmers face. In fact, the pandemic has given the practice new life, as it offers employment opportunities for Tajikistani labour migrants who were forced to return home, largely from Russia. Sharecroppers seek to maximise profit on farmers' non-cotton-growing areas by growing vegetables and other profit-oriented crops. Their cultivation patterns are now leading to broader shifts in crop selection among Tajikistani farmers, pointing to a broader trend to seek out new crops in times of economic crisis. Not only, then, are smallholders adopting to this period of economic crisis by practicing sharecropping, but also by diversifying their traditional crops on this sharecropped land.

Fertilizer substitutes

Increasing fertilizer prices caused by the crises of recent years have forced local farmers to use their own limited fertilizer substitutes, such as animal and green manure. This adaptive behaviour reflects their ability to manage resources efficiently in the face of adversity, while also reducing their dependence on external inputs. Animal manure is available to most Tajikistani farmers from their animal husbandry, but given its limited quantity, they often mix it with their reserves of nitrogen fertilizers (Farmer interviews 2020–2022). Some farmers also grow fodder crops (e.g., alfalfa or legumes) with the intention of turning them into green manure or bio-humus. A small number of farmers have even stressed their belief in organic farming, although experts are sceptical about its prospects: one agronomist noted that 'in order to shift Tajikistan entirely to organic farming and produce organic fertilizers, we would need so much livestock that it would cover the entire territory of the country' (Expert interview 2022). While organic farming promises reduced input costs and great profit, it also reduces overall crop yields – as investigated in other countries like India and Sri Lanka (Röös et al. 2018), thereby cancelling out its profitability. As agriculture plays an important economic role as a source of income and food security in Tajikistan, many farmers cannot afford to convert fully to organic production, as it entails losses, especially during a conversion period from conventional farming of three years or more.

Conclusion

This study outlines some adaptive strategies employed by Tajikistani smallholder farmers during the period of crisis from 2020 to 2022, highlighting their adaptive capacity and innovation. While the sustainability of these strategies remains uncertain, the findings suggest that farmers are venturing into novel pathways and embracing innovative practices to enhance their adaptability beyond the immediate crisis. This prompts a broader exploration of path dependency, questioning whether the recent crisis could signify the initiation of a new trajectory for agricultural development in Tajikistan. Scholars should strive to ascertain whether these shifts in agriculture denote

short-term responses to pressing issues or enduring transformations in the farmers' approaches to profit, cultivation, and subsistence. Such insights can potentially guide the formulation of policies and interventions aimed at supporting farmers' livelihoods and bolstering their resilience. In essence, further research must adopt a comprehensive perspective on the agricultural landscape in Tajikistan, delving not only into what farmers cultivate but also the contextual factors influencing their agricultural choices. This includes recognizing the significant role played by the government, which hinders farmers from changing their crop choices through the imposition of mandated cotton quotas for arable land districts. Understanding and addressing these governmental influences is crucial for the long-term sustainability of the new innovations and changes within the agricultural sector, especially in the dynamic context of market demands and multiple crises.

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Representative Agricultural Pathways (RAPs) for sustainable food production: A participatory approach for small farmers in Pakistan

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Keywords: RAPs, participatory approach, interventions, socio-economic impact

Irrigated agriculture supported by extensive use of ground water contributes about 90 percent of food in Pakistan to sustain its more than 220 million population (Janjua et al. 2021). Sustainable use of water resources is an important policy objective as set out in the National Water Policy (Government of Pakistan, 2018) and the Punjab Water Policy (Government of Punjab 2018). Pakistan is also subject to adverse climatic stresses overtime, which is making availability of surface water unreliable and scarce, putting extra pressure on available groundwater resources which contribute about 60 percent of the irrigation requirements (Ashraf 2017). Overall, Pakistan's farming landscapes are complex and diversified, in terms of socioeconomic conditions, resources availability, quality, and distribution. On-farm management practices, such as soil management, the use of fertilizer, laser levelling, irrigation methods and the selection of crops contribute in terms of water use efficiency, soil health improvement and water quality impacts. Identifying pathways to move on-farm management towards more sustainable water management is essential for the future of the country.

Representative Agricultural Pathways (RAPs) are designed to extend global pathways to provide the details needed for regional assessment of future agricultural systems. RAPs are formulated under the consideration of representative concentration pathways and shared socioeconomic pathways. RAPs are combinations of economic, technology and policy scenarios that represent a plausible range of possible futures. RAPs are developed to demonstrate the future agricultural production systems in a specific production system. The escalating global demands in terms of food can be tackled with the help of technological advancement for sustainable agricultural production, as shown in Figure 1. We opt for the sustainable development pathways in the analysis. The grey pathway is the Business as Usual (BAU) pathway, which describes the unsustainable use of farm resources while, green pathway describes sustainable use of farm resources and sustainable farm livelihoods. The O1 and O2 describe the current and future adaptations regarding water management that could affect the farm incomes in the current and future time periods.

The RAPs framework is developed on the premise that both bio-physical and socioeconomic drivers are essential components of agricultural pathways. This methodology is based on capturing plausible farm-level improvements, such as concerning climate change and water scarcity that affect the future of farming operations. RAPs are generated from a continuous engagement process among stakeholders such as farmers, policymakers, academia, and researchers that helps to formulate the transformative adaptation and future pathways. Iterative engagement formulates the linkages between potential stakeholders to learn about the specific critical issues using bio-physical, socioeconomic, institutional and policy related indicators. To develop sustainable scenarios for management of groundwater, which is linked with existing issues of the water quality, availability and usage, the RAPs development process is described in Box 1.

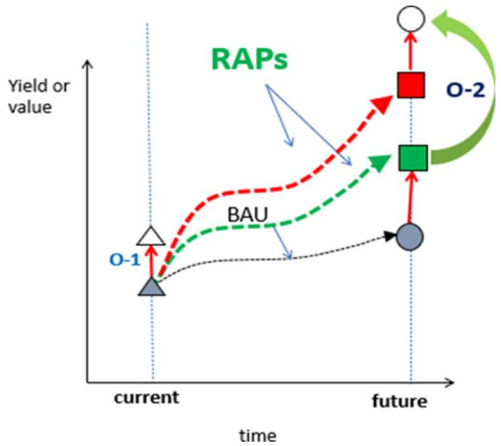

Figure 1: Pathways and future production systems Source: Antle et al., 2015

Box 1: The RAPs Development Process

Step 1: Selection of higher-level pathways and key indicators identification

Step 2: RAPs narratives defined under different shared socioeconomic pathways

Step 3: Key parameters/indicators selection and review with consideration of existing literature

Step 4: Direction and magnitude of change in variables was shared and comprehensively discussed in RAPs meetings

Step 5: The rationale for rate of change and short narrative finalized by continuous engagementprocess with experts

Step 6: RAPs shared with experts for their feedback

Step 7: Feedback from experts and stakeholders in continuous engagement process incorporated in refinement of RAPs

Step 8: Final RAPs drafted in RAP matrix and again shared with professionals for further improvement regarding important variables parameterization in the model

Source: https://www.worldscientific.com/doi/epdf/10.1142/9781783265640_0005

In this study, focus was on the research question whether improved on-farm water management through interventions have impact on poverty reduction through increased water productivity. Adaptation packages were developed and parameterized for three provinces of Pakistan, using feedback from the consultation sessions with stakeholders and review of existing literature.

Selected adaptations were assessed with the Tradeoff Analysis Model for Multi-Dimensional Impact Assessment (TOA-MD Model) (Antle & Valdivia 2011). This is a unique simulation tool that can use the socioeconomic data sets collected earlier in the overall study project and combine them further with macroeconomic data sets of farms and then project the current and future viability of specific interventions. In this study, the model simulated various "experiments" for adaptation of new technology/interventions for their impacts.

Punjab

The adoption of the RAPs approach by the stakeholder forums resulted in three kinds of interventions in Punjab:

- Promoting the cultivation of low delta crops
- Use of water saving technologies
- Improving soil health through the use of organic matter

The Tradeoff Analysis-Multi Dimensional (TOA-MD) model estimated the adoption rate of proposed adaptation based on net farm returns. The two proposed adaptations i,e. High Efficiency Irrigation Systems (HEIS) and substitution of high delta crops, like maize, with low delta crops had positive impact on net farm returns, per capita income and negative impact on farm poverty in the study area.

RAPs was developed for mid-century scenario and simulated separately for HEIS and low delta crops. Results indicated that without adaptation, poverty was 17.72 percent for the survey data, whereas with interventions, poverty rate would reduce by 3.6 and 3.4 percent for scenario 1 (maize replaced by moong bean) and scenario 2 (wheat replaced by sunflower), respectively, as shown in Figure 2. The adoption rate for sunflower and moong bean would be 49 percent and 59 percent, respectively. Results showed that proposed interventions have a significant impact on farm livelihoods.

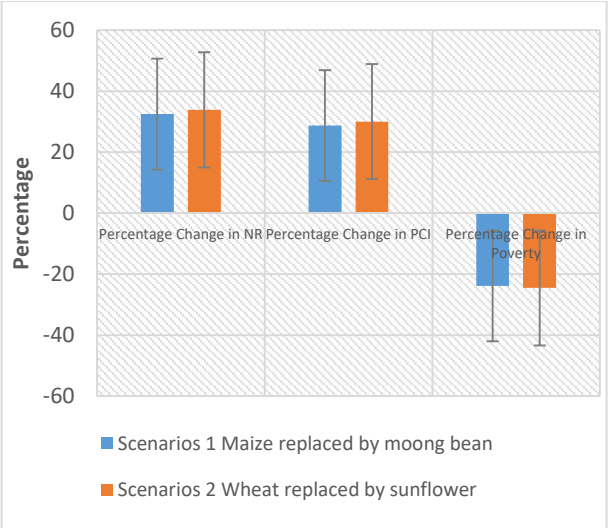

Figure 2: Percentage change in NR, PCI and Poverty due to Crop Substitution in Punjab

With proposed intervention of HEIS (through technology and management), there would be 23 percent decrease in poverty among small farmers and 30 percent increase in per capita income. The adoption rate of this adaptation package is 74 percent and this adoption results in the reduction of farm poverty. Farmers remained the key block of adaptation process with support from institutions and policy makers.

It is recommended that the policy formulation should consider and consult farmer representatives about agricultural and water related issues so that all policies can be coordinated. Participation based solutions are best and all the policies must be formulated for specific zones. The areas with water scarcity must be highlighted and serious efforts should be made to implement the suggested interventions. For the upscaling of the interventions, it is recommended that the current work should be continued in the study area and other agro-ecological zones of Punjab, where the majority of farmers are resource poor, water is scarce, and poverty is high.

Sindh

Sindh province has potential to support intensive agriculture due to fertile soil and availability of farm labor but water is a limiting factor that hinders the growth of the agricultural sector. Currently, major cash crops, which are mainly high delta crops, are dominant due to established markets and processing infrastructure that ensure farm income. However, these crops are of serious concern for sustainable farming practices in the long run due to exploitation of groundwater and natural resource degradation.

This research process brings a holistic approach towards development of pathways and adaptations at farm level. The explicit interventions shared for the study area regarding water management interventions at farm includes;

- High efficiency irrigation system (ridge and bed sowing, drip and sprinkler)
- Substitution of crops (low delta crops like Quinoa)
- Developing the water markets
- Enterprise diversification
- Crop diversification
- Intercropping (sugarcane and wheat; okra and onion)

The economic viability for HEIS for cash crops in the study area was estimated and results showed that water saving techniques like drip irrigation, and bed and furrow would ensure farm returns in the long run. The water use efficiency improvement would increase the crop yields and farm returns substantially in the study area. The impacts of high efficiency irrigation systems on net farm returns (NR), per capita income (PCI) and poverty for mid-century scenario in Sindh is shown in Figure 3.

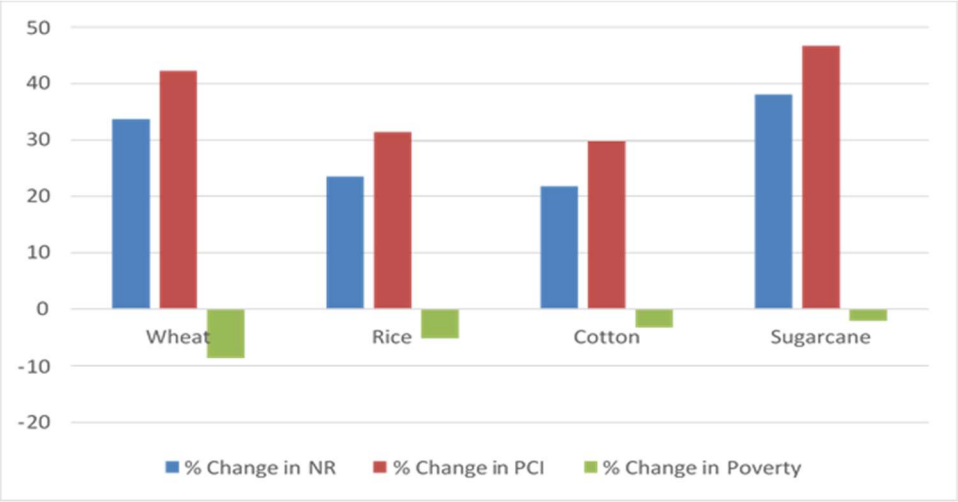

Figure 3: Impacts of high impact irrigation systems in Sindh

Balochistan

The Balochistan province is largely dependent on groundwater for its water requirements either through traditional *karezes* (a system of irrigation by underground tunnels) or tubewells. The number of tubewells has increased from 5,000 to more than 40,000 since the 1970s, with groundwater levels dropping 5 meters per year in some basins (Ashraf & ul Hasan 2020). Groundwater management and reclamation could be improved by social engagement and public sector legislation. The policy domain regarding groundwater is crucial as tubewells and *karezes* are two main sources for irrigation in Balochistan. It is the only province that has implemented a legal framework regarding groundwater management under the notification of the "Balochistan groundwater rights administration ordinance, 1978" and WASA Groundwater Management Act of 1989.

Balochistan could be the leading province in terms of fruit production but due to the lack of good cultivars,

proper marketing and poor infrastructure its agricultural production is not increasing substantially. The results indicated that farmers must adopt sustainable practices regarding groundwater extraction and recharge.

This study used data collected from Kuchlak and Pishin sub-basins of Pishin Lora basin to assess the socioeconomic impacts of groundwater management interventions.

The main interventions suggested by Balochistan stakeholders are listed below.

- HEIS -Drip
- Low delta crops like pistachio, grapes and pomegranate instead of apple production.
- Improvement in the management of existing orchards, for example weed management and plant density.
- Check bunds for water storage.
- Dwarf varieties of apples, and tunnel farming.

The economics analysis for the adoption of HEIS using the TOA-MD model predicted the net farm returns, per capita income and farm poverty for the mid-century scenario (2050). The installation of this infrastructure would ensure efficient water use and increase in the net farm returns substantially. The farm poverty would reduce by 4 and 12 percent in the study area. The adoption rate of high efficiency irrigation systems for apple (48 percent) and grape (42 percent) crops in Balochistan is shown in Figure 4.

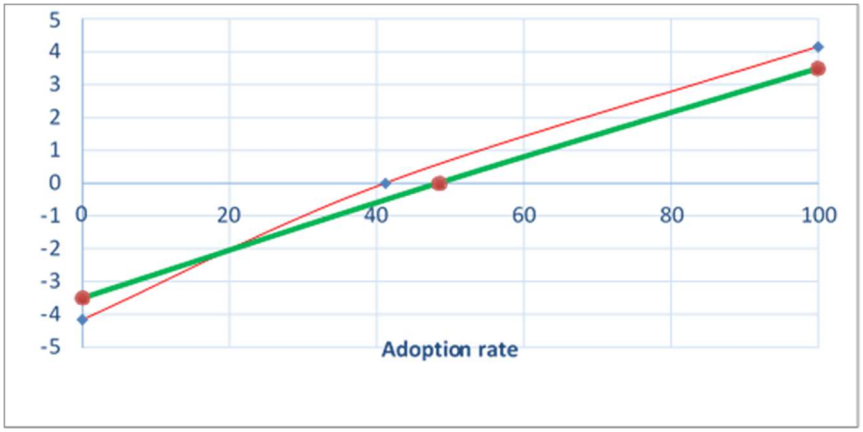

Figure 4: Adoption rate of high efficiency irrigation systems for apple and grape crops in Balochistan

Conclusions

For Punjab province, the impact of high efficiency irrigation system and substitution of high delta crops with Low delta crops had positive impact on net farm returns, per capita income and negative impact on farm poverty in study area. The result further describe that water savings and high net returns are possible by shifting from conventional irrigation to improved irrigation technologies. Overall 75 percent of farmers have economic feasibility to adopt the management interventions.

Results for Punjab indicated that without adaptation poverty was 17.72 percent for survey data, whereas with interventions poverty rate would reduce by 45 and 88 percent for scenario 1 and 2 respectively. Percentage adoption rate for sunflower and moong bean would be 49 percent and 59 percent, respectively. Results showed that proposed interventions such as crop substitution have a significant impact on the farm livelihoods. With proposed intervention of HEIS (through technology and management), there would be 23 percent decrease in poverty among small farmers and 30 percent increase in per capita income. The adoption rate of this adaptation package is 74 percent and this adoption resulting in the reduction of farm poverty.

For Sindh province, the explicit interventions include high efficiency irrigation system (ridge and bed sowing, drip and sprinkler), substitution of crops (low delta crops like quinoa), developing the water markets, enterprise diversification (livestock farming, olericulture, fisheries, argo-forestry), crop diversification (vegetables like onion, okra, chilies, black pepper), intercropping (sugarcane and wheat; okra and onion) and the cultivation of high value crops. Only the economic viability for HEIS for cash crops in the study area was estimated and results showed that water saving techniques would ensure high farm returns in the long run. The water use efficiency improvement would increase crop yields and farm returns substantially in the study area.

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Sowing agroecologies: Knowledge brokering in the Brazilian Agricultural Research Corporation (Embrapa)

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Keywords: knowledge brokering, agroecology, food systems, politics of knowledge, Brazil

Introduction

Global food systems' socio-environmental impacts have prompted growing calls for major transformations from a diversity of actors in research and governance (IPES-Food 2021; Caron et al. 2018; UN-FSS Scientific Group 2021). What pathways are followed toward sustainable food futures greatly depends on the problem definitions adopted and the corresponding solutions that are deemed plausible and desirable (Scoones et al. 2015). This means that these pathways are entangled with a politics of knowledge that produces and reproduces particular values and beliefs, including views on the legitimacy of different forms and sources of knowledge (Milbank et al. 2021).

Figure 2: Organic agriculture sector at Embrapa Vegetables in Brasília.

Accordingly, rethinking the ways in which knowledge is generated and used is seen as a central requirement of food system transformations, particularly the need to recognize and include diverse forms of knowledge (Fazey et al. 2020; Gliessman 2022). Researchers engaging in participatory approaches often play the role of intermediaries, or knowledge brokers, seeking to go beyond traditional roles of science in society. However, such approaches aimed at knowledge co-production need not automatically lead to inclusion. In the worst case, they can inadvertently serve to reinforce existing power structures (Turnhout et al. 2020; Montenegro de Wit & Iles 2021). Turnhout et al. (2013), for example, show that when scientists take on new roles in various knowledge brokering repertoires, traditional patterns of linear knowledge transfer from knowledge 'producers' to 'users' often still persist, as well as assumptions of a 'knowledge deficit' on the part of users. It thus remains important to consider the particular dynamics playing out in different knowledge brokering contexts and their implications for food systems transformation.

Research aim

In this study, I explore the roles envisaged and exercised by scientific and technical staff at Brazil's federal Agricultural Research Corporation (Embrapa) in agroecology-related research and development. In Brazil as well as across the world, agroecology is seen as a promising alternative paradigm holding transformative potential (Van den Berg et al. 2022; FAO 2019), even though its status in agricultural research remains marginal. Whereas social movements are undoubtedly the protagonists of agroecology's rise in Brazil, too little attention has been given to signals from within agricultural research organizations in promoting (different forms of) agroecology. A focus on agroecology is particularly relevant to the study of the politics of knowledge production, as agroecology is itself a contested concept holding different meanings. As a result, it is also prone to absorption into dominant narratives (Levidow et al. 2014; Deijl & Duncan 2021). Indeed, attempts to bring agroecology to scale via formal institutional routes have been criticized for not challenging underlying power structures (Giraldo & Rosset 2018).

Embrapa as a brand is recognized as a symbol of agricultural modernization and is often framed as the force behind technological advances starting in the 1970s which made Brazil into an agricultural powerhouse (Cabral et al. 2022). While Embrapa's main efforts are aligned with the dominant productivist paradigm in global food systems, it hosts a heterogeneous community of experts, including a considerable number of people involved in alternative lines of inquiry such as agroecology (see Embrapa 2006). Filho

(2008) traces Embrapa's engagement in research on sustainable agricultural practices back to the 1980s. Research on non-conventional approaches has mainly focused on organic agriculture, resulting from organics' growing market share. Still, Embrapa staff have also dedicated themselves to the promotion of agroecology, culminating, among others, in the establishment of a research portfolio dedicated to 'ecology-based production systems' (Embrapa 2021). In addition, Embrapa takes part in different networks centred around alternative approaches to food and agriculture, including the Brazilian Association of Agroecology. Finally, Embrapa researchers were intimately involved in the development of Brazil's groundbreaking National Policy for Agroecology and Organic Production.

Analytical framework

To better understand Embrapa's role in transformations toward sustainable food systems in Brazil, I investigate the production of agroecological knowledge within Embrapa and the ways in which different forms of knowledge – in particular farmers' local knowledge (Šūmane et al. 2017) – become part of this process or not. I conceptualize the set of Embrapa staff under study as knowledge brokers: on the one hand helping mobilize local knowings and doings, while also aiming to improve farming practices through techno-scientific knowledge. In doing so, I aim to determine whether and how this fits in with the four knowledge brokering repertoires identified by Turnhout et al. (2013) – pure scientists, science arbiters, honest brokers, and participatory knowledge producers – which represent different forms and levels of interaction between knowledge producers and users.

Embrapa currently comprises 43 research units spread across Brazil, including its headquarters located in Brasília. The current study is based on fieldwork conducted between May and July 2022, including visits to four Embrapa research units in Campinas and Brasília, participant observation in the Chapada dos Veadeiros ecoregion, and in-person semi-structured interviews with five Embrapa staff as well as 13 non-Embrapa respondents including farmers and other collaborators involved with Embrapa. Additionally, 14 online semi-structured interviews were conducted with Embrapa staff from 8 different units between June and September 2022.

Results

My preliminary results show that agroecology indeed remains marginal within Embrapa. Many respondents pointed out difficulties in getting their projects off the ground. This is partly tied to budget cuts that do not exclusively impact agroecology research, but Embrapa's research management structure does tend to favor projects on technologies applicable to conventional agriculture.

Figure 3: Embrapa scoping visit in the Chapada dos Veadeiros ecoregion in June 2022. An Embrapa researcher (left) and a teacher at a local public school (right) discuss opportunities for collaboration.

Time spent in the Chapada dos Veadeiros ecoregion was particularly valuable as it allowed me to accompany a researcher from Embrapa Genetic Resources in her visits to local stakeholders. This researcher led a large agroecology-oriented project in the Chapada dos Veadeiros area between 2019 and 2022 that involved three Embrapa units. Project execution was very negatively impacted as a result of the COVID-19 pandemic, but through a combination of online trainings and symposia as well as collaboration with partners on the ground, some objectives were still attained. An important partner in this Embrapa project was the regional Pouso Alto agroecology network. Some of the Embrapa staff involved in the project were also members of this network, which serves as a first indication of their embeddedness in the region.

The challenges of pursuing alternative paths within a large agricultural research organization such as Embrapa meant that those doing that research expressed a deep commitment to their work. My Embrapa respondents, while being proud of their institution, also expressed concerns about the lack of support for more participatory action research. Through their accounts, it became clear that programs allowing space for agroecology have been the result of years or sometimes decades of arduous work by a few passionate people – resulting, for instance, in the establishment of the research portfolio dedicated to ecology-based production systems.

As already mentioned, agroecology is a multi-faceted concept. In its broadest sense, it is seen as a science, a practice, and a movement (Wezel et al. 2009). Some approaches have been called into question for leaving out agroecology's political dimension and furthering an exclusively technical understanding (Levidow et al. 2014). It might be expected that Embrapa's work on agroecology would follow such a technical approach. This is however not fully supported by my findings. Rather, Embrapa researchers and analysts interviewed often prioritized a sense of ownership of the projects on the part of farmers and other partners. This usually involved long-standing collaboration with social movements and local agroecology networks, as in the Chapada dos Veadeiros case.

Several respondents had been involved with social movements or worked in close collaboration with farmers previous to acquiring their position at Embrapa. For example, many respondents had taken part in the alternative agriculture movement originating in the 1970s, which is seen as a precursor of current agroecology movements in Brazil (Costa et al. 2015). Other respondents had developed deep bonds with their original research subjects over decades of experience, eventually becoming seen as members of the community. Accordingly, my findings show that this group of people within Embrapa are keenly aware of their position vis-à-vis farmers and other rural dwellers, and actively seek to integrate different forms of knowledge in their work.

In this sense, these findings speak to those presented by Sherwood et al. (2016, p. 11) in their work on agrifood movements in Ecuador: "Far from objective, fact-seeking researchers, in Ecuador we find that scientists are involved in the country's lively actor networks that are organized through processes of translation, where like-minded people from different walks of life work together to problematize experience, normalize behavior, enroll new actors, and mobilize resources."

Nonetheless, Embrapa staff's involvement in lively agroecology networks does not exclude the possibility that conventional practices of linear knowledge transfer be reproduced in these networks, potentially limiting their transformative capacity. For example, some respondents pointed to the importance of identifying demands to ensure the usefulness of agricultural research and development for farmers. This goal of making research more useful easily fits with traditional roles of science in which scientists produce and transfer knowledge and technology to end users. That is, it does not necessarily represent a break from dominant knowledge systems. This is of course not to say that knowledge transfer has no value as part of more participatory approaches. Indeed, a few Embrapa respondents noted that placing too much emphasis on farmers' own knowledge could be received with disappointment and even suspicion as it might make the role of researchers less clear. Being transparent about mutual expectations is therefore essential in dealing with such issues.

Conclusion

Despite Embrapa's limited support for agroecological alternatives, those promoting agroecology within Embrapa seek to engage in knowledge brokering by involving farmers and their knowledge at different stages of the research process. Still, it remains important to consider how these efforts play out in practice and who really benefits in the context of sustainable food futures. This includes critical reflection on what it means to produce knowledge 'with' rather than 'for' farmers, and what are ultimately the goals of the different actors involved.

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The potential of agroforestry development in Kazakhstan and the need for agroforestry policy

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Keywords: agroforestry, assessment, policy, potential, adoption, constraints

Agroforestry as a sustainable solution for the challenges of contemporary agriculture

Present-day contemporary post-industrial agriculture is associated with numerous environmental challenges, including land degradation, carbon emissions, water pollution and the loss of biodiversity, as well as social and economic injustices. Concurrently, the number of individuals experiencing severe food insecurity has risen dramatically, with over 345 million people facing high levels of food insecurity in 2023 – more than double the figure recorded in 2020 (WFP 2023). The growth of the population in Kazakhstan is expected to increase by 2 million by 2030, thereby exerting continued pressure on overall food supply and thus increasing pressure on land use intensification and associated environmental and social challenges (FAO 2022a). Thus, the Food & Agriculture Organization (FAO) has called for the adoption of sustainable agricultural practices to ensure food supply for current and future generations. The establishment of a sustainable food system lies at the core of the United Nations' Sustainable Development Goals (SDGs) adopted in 2015 (Nguyen 2018), including but not limited to goals like "no hunger", "climate action", "life on land" and "gender equality".

Agroforestry offers a host of positive advantages, ranging from its contribution to mitigating and adapting to climate change, to providing a diverse array of environmental services such as enhancing water quality, preventing soil erosion, restoring soil fertility and creating more diverse habitats for biodiversity. Additionally, it can help improve food and nutrition security, alleviate poverty, promote resilient livelihoods and foster gender equality (FAO 2022b; Jose et al. 2022). A growing body of scientific literature shows that agroforestry can contribute to the implementation of nine out of the 17 SDGs (Borelli & Chen 2015; Andersson 2018; Noordwijk 2020), so it holds significant promise as a tool for Kazakhstan to achieve its national commitments under the UN Rio Conventions on desertification, climate change, biodiversity conservation and a diverse range of SDGs.

Agroforestry in Kazakhstan's legislation

In response to climate change threats, there is growing interest in increasing tree carbon stocks and using tree biomass as a fossil fuel substitute to mitigate rising atmospheric carbon levels. In 2023, Kazakhstan approved the Strategy for Carbon Neutrality by 2060, the strategy section on agriculture and forestry of which includes sustainable land use practices, biofuel production from agricultural waste, regenerative agriculture and agroforestry, in addition to carbon emission reduction efforts. The strategy provides a general vision but lacks specific details. No other legislation in Kazakhstan defines agroforestry and agroforestry practices. Only the Forest Code in the 2020 revision mentions tree plantations for the protective melioration of agricultural land (*agrolesomelioratzia*) and protective tree plantations along the roads, which amounts only to a reduced number of agroforestry practices, functions and types.

Efforts toward agroforestry policy development

Agroforestry, despite international recognition as an efficient natural resources management tool, is not yet high on either the official or the private sector development agenda in Kazakhstan. Agroforestry needs to be promoted in corresponding policy development, capacity-building, awareness-raising and technology applications in Kazakhstan for it to its potential as a sustainable food and biomass production system that allows carbon sequestration, biodiversity conservation, land degradation prevention and waterbody protection. In 2022, as the initial step to-

ward agroforestry policy development and promotion, the Kazakh-German University organised the first round-table discussion on the possibilities of agroforestry development in Kazakhstan. A relevant policy brief was produced as a result (Romanova 2022), highlighting the opportunities and challenges for agroforestry, urban and private forestry development in Kazakhstan, and further providing short-term and long-term recommendations (Figure 1).

Four key recommendations as short-term actions include: analysing current practices and projects in relevant fields, reviewing policies, systematizing research and data and evaluating professional education and farmer support systems. The findings and suggestions derived from these actions will serve as valuable guidance for long-term activities. However, even before that, it is evident that substantial governmental support will be essential for facilitating the long-term progress of agroforestry development in Kazakhstan.

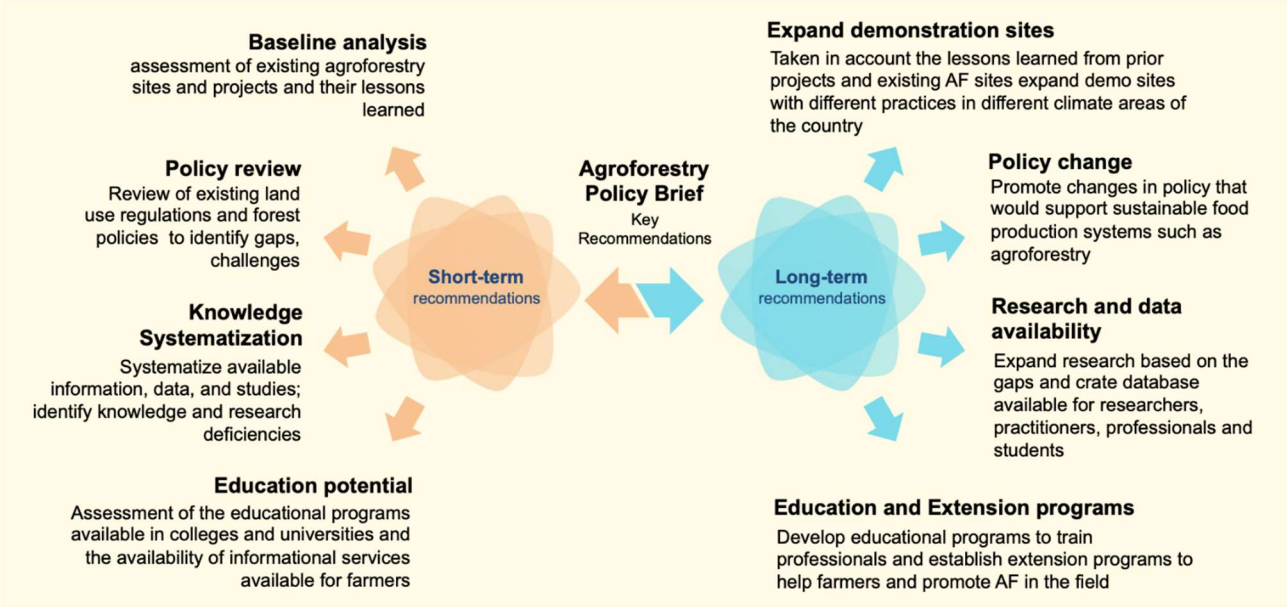

Figure 1. Key recommendations from the Agroforestry Brief for Kazakhstan.

Barriers to agroforestry assessment

The assessment of agroforestry sites and projects in Kazakhstan is complicated due to the absence of an agroforestry concept in legislation and statistical data. In addition, there is an absence of what is meant by the term "agroforestry", not only among farmers and land-users (even if they do practice it), but also among government officials in relevant local administrations, departments and ministries. According to the FAO Global Forest Resources Assessment 2020, which is based on data provided by governments, Kazakhstan had zero hectares dedicated to agroforestry (FAO 2020). However, agroforestry practices such as windbreaks along fields and orchards (both old and newly planted), home gardens with multiple layers of woody species alongside other crops, hay production in orchards and others exist (based on field visits). Yet, these practices are not recognised as agroforestry and are reported separately in agriculture and forestry reports. Due to species complexity and many different agroforestry practices, distinguishing it from other agricultural and forestry systems in existing statistical data is difficult. Another complication arises from the fact that agricultural commodities and forest products have been overseen by different ministries in Kazakhstan since 2019, namely the Ministry of Agriculture and the Ministry of Ecology, Geology and Natural Resources, respectively. Nonetheless, agroforestry has the potential to combine elements of both bodies.

Potential for agroforestry adoption

Public and private forest fund land

According to the Constitution of the Republic of Kazakhstan, all naturally occurring forests are under exclusive state ownership. However, in the Republic, there is an institution of private afforestation, whereby private individuals can establish private plantations on agricultural or state reserve lands. There is significant potential for agroforestry development on both public and private forest fund land. Only 44% of forest fund land (12.9 mln ha) has trees on it, leaving 56% (16.5 mln ha) for afforestation

needs. In addition, there is already 695 ha of land with no tree cover in the private forest fund (UN & FAO, 2019). Self-sufficiency in forest products in Kazakhstan is estimated at 15.5% (UN & FAO, 2019), thus also indicating the need for local timber production that in part can be done in agroforestry systems.

Private forestry development in Kazakhstan has been supported by development agencies such as GIS and UNDP. The GIS project on Integrative Forest Management (ILUMA) highlighted that although a 50% reimbursement for tree plantation establishment costs was introduced in 2012, no private afforestation projects have been approved since then. This can be attributed to the lack of a clear implementation process and a reliable budgeting framework at the national level, as well as the high costs associated with technical forestry projects required for private forest establishment (Ibrayeva et al. 2021). However, these requirements have been revised in 2023 based on the recommendations from GIS experts and feedback from foresters.

State-owned forests outside of SPAs

There is also an opportunity to promote agroforestry practices in state-owned forests to improve self-sufficiency for territories outside of specially protected areas (SPAs). In Kazakhstan, 1,121,800 ha (32% of true forest area) are classed as SPAs, primarily for biodiversity conservation (FAO 2020). State-owned forests under the category "windbreaks," called *protective lines* and *erosion-preventing forests*, together with urban forests amount to 172,580 ha (5% of true forest area), while river buffer forest strips amount to 2,160,300 ha (63% of the true forest area) (FAO 2020) [*there is a probability that remaining forests were lumped together in the latter, but are not river buffer forest, auth*]. True forests with crown cover over 10% amounts to 3.4 million ha in Kazakhstan, making up 1.2% of its territory. Additionally, there are 9.5 million ha of other wooded lands (notably large areas of semi-desert saxaul *Haloxilon sp.* forest) that increase tree-covered land by up to 5% of the country's territory (UN & FAO 2019). Forested and other wooded land is frequently utilized for unmanaged grazing and risking ecosystem degradation, thus missing out on the opportunity for more sustainable silvopasture development.

Agricultural land

There are three main agricultural players in Kazakhstan's agricultural sector:

- large enterprises with over 20,000 ha (Kursiv Media 2016),
- farm enterprises (medium and small) with 1 to over 5,000 ha (Mussayeva 2019) and 57 ha on average (Kekchebayev & Zhakupova 2021) and
- household farms (LPH) ranging from 0.05 to 0.25 ha in an urban area and to 1 ha in a rural area (Land Code of the Republic of Kazakhstan 2003).

Household farms (LPH)

Despite cultivating only a small fraction of arable land (0.4%-0.9%), household farmers play a significant role in the agricultural sector by contributing approximately 41-50% of overall gross production (Mussayeva 2019; Kononova & Qanash 2021). Similar trends can be observed in Russia, where more than 30 million households participate in food gardening, contributing to over 50% of the country's agricultural output (Sharashkin & Gold 2009). In Kazakhstan, LPH have a substantial presence in the following sectors: pome and stone fruits – 34.6%, berries – 92%, nuts – 75%, beekeeping – 79%, potatoes – 53-84%, vegetables – 37-76%, dairy – 71-76% and livestock – 43-68% (MoA RK, 2020; Kononova & Qanash, 2021). These figures highlight the significant contribution of household farmers to the production of various agricultural commodities in the region, especially those that can be (or already are) grown in agroforestry systems.

Even though there is no specification determining how many household farmers use agroforestry practices, it can be assumed that many of them do it to meet their families' food needs and due to the historical tradition of *dacha* home gardens in the Soviet period. Dacha gardens, usually ranging from 0.06 to 0.25 hectares in size, encouraged intensive cultivation and the incorporation of perennial crops, particularly fruit-bearing shrubs and trees, alongside annual crops, often resulting in highly diverse and multi-layered gardens (Sharashkin & Gold 2009). The household farm, or "Personal Subsidiary Farming" (*lichnoe podsobnoye hosyaistvo - LPH*) as defined in the Kazakhstan Land Code, is a type of activity aimed at satisfying personal needs on a land plot located in rural and suburban areas. An LPH owner or renter decides which crop to grow (potato field, multistory garden, hay production, etc.) or to use the land for livestock grazing. Not all LPHs are dachas, while most of dachas are LPHs. Furthermore, LPH may not be counted in the official agricultural economy, but they still make a significant contribution of close to half of the gross agricultural production, primarily for subsistence purposes. As an LPH has a subsistence rather than a market orientation, it is often downplayed by most policymakers and scholars (Sharashkin & Gold 2009). Only recently, in 2021, the

legislation project for LPH was developed and submitted to the lower chamber of the Kazakhstan Parliament. However, it anticipated helping only LPH cooperatives rather than individual farmers, and even this approach did not materialize, as the LPH legislation project was recalled by the Cabinet of Ministers in September 2022. Thus, today, household farmers do not have any preference or subsidies from the government and thereby buy agricultural equipment, fertilizers and seeds at higher markup prices. This calls attention to the need to support LPH in agroforestry policy, thus making home gardens more sustainable food and biomass production systems.

Small and medium farms

Forestry organisations and small and medium farms should also be supported in the agroforestry policy to adopt practices contributing to the sustainability and diversity of farms and forests. Currently, only 2.3% of farm enterprises (excluding forestry and fisheries) are involved in perennial agriculture, with just 0.5% in tree nurseries (Kekchebayev and Zhakupova 2021); thus, there is enormous room for growth.

Establishing orchards with woody species can be performed on agricultural land with a specific land use destination. In 2021, perennial plantations covered only 0.1% of agricultural land (148,000 hectares), including 99,500 hectares for orchards, 15,800 hectares for vineyards and 32,700 hectares for other plantations of perennial species (nurseries, bush-grown berries, etc.). These plantations were mainly located in agricultural areas (61,800 ha), urban areas (68,200 ha) and reserve lands (16,000 ha). (MoA RK 2021). In 2020, Kazakhstan's mature perennial plantations yielded a gross harvest of approximately 350,000 tons of fruits and nuts (with a net production of 200,000 tons), while fruit and nut imports amounted to about 440,000 tons (BNS 2023). These figures highlight the domestic market demand for fruits and nuts, thereby indicating the development potential for orchards and agroforestry. However, the current area occupied by perennial plantations has not yet reached the levels seen in 1991 (163,200 hectares). Despite subsidies provided for afforestation, orchard establishment and vineyards, the expansion of perennial plantations has been limited (MoA RK 2021). This is partly due to the requirement that financial support is only available for varieties recognised in the National Register of Breeding Achievements (Djanibekov et al. 2016). Other explanations are similar to the challenges faced in private forestry development.

Key needs and barriers to agroforestry adoption

The preliminary result from the interviews with agroforestry practicing farmers and managers of international agencies projects that supported pilots on agroforestry and private forestry highlights (a) the need for awareness-raising and education about sustainable land management practices among farmers (the need for an extension system with professional consultants) and (b) legal recognition being imperative for fostering the growth of agroforestry practices. The key constraints for agroforestry development, apart from a lack of knowledge and legal support, were identified as (a) irrigation deficiency or the high cost of tree establishment and management, (b) the need and high cost of fencing as grazing protection, (c) a lack of zoned varieties of planting materials and (d) the apathy of many residents in terms of environmental concerns, aligned with a desire to see very quick returns on investment.

Conclusion

The challenges posed by contemporary postindustrial agriculture, including environmental degradation, food insecurity and loss of biodiversity, demand immediate and sustainable solutions. Agroforestry emerges as a promising approach to tackling these issues effectively. However, the current absence of recognition, legal support and awareness of agroforestry in Kazakhstan poses obstacles to its widespread adoption. To harness its potential, a comprehensive agroforestry policy is essential, encompassing governmental support, capacity-building and technology integration. The diverse potential of agroforestry across public and private forest lands, agricultural domains and small and medium farms underscores its capacity to revolutionise the agricultural landscape.

Kazakhstan’s agroforestry policy should call for a reassessment of current agriculture systems and offer a vision of sustainable agroforestry practices that can contribute to ecological balance, enhance biodiversity, improve soil health, increase agricultural productivity and provide additional income streams for farmers. The imperative now is to translate these insights into actionable agroforestry policy, focusing on a thorough analysis of the baseline situation, legal frameworks and collaboration across sectors to ensure successful implementation. Overcoming barriers such as irrigation challenges, fencing costs and limited plant varieties requires a combined effort from various stakeholders, which should be reflected in the policy.

Finally, by aligning agroforestry practices with the principles of sustainability, biodiversity enhancement and improved livelihoods, Kazakhstan can pave the way towards a more resilient and ecologically balanced agricultural future.

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Sweet potato as a new and promising crop to ensure food security and reduce malnutrition in Tajikistan?

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Keywords: orange-flesh sweet potato, beta-carotene, food security, malnutrition, Tajikistan

Introduction

Food security is one of the key strategic goals of the Government of the Republic of Tajikistan and is closely linked to the agricultural sector. The socioeconomic importance of agriculture is also a priority in the National Development Strategy of Tajikistan up to 2030 (NDS-2030 2016), in which increasing agricultural productivity plays a special role in achieving the goals of "Ensuring food security". In this regard, scientific institutions, in cooperation with international organisations, contribute to the country's agricultural sector by providing support to local farmers seeking to increase their economic empowerment in terms of producing and consuming nutritious food.

Despite apparent economic growth, Tajikistan remains a low-income country with a high vulnerability to food insecurity, with up to 27% of the population still living in poverty (WFP 2022). Malnutrition remains a critical public health concern, particularly in rural areas among children and women. According to the Demographic and Health Surveys (TDHS-2017 2018), stunting, wasting and anaemia are common indicators of chronic malnutrition amongst this cohort in Tajikistan. Furthermore, it has been identified that stunting and wasting are caused by long- and short-term deficiencies in macronutrients and micronutrients such as vitamin A, iron, zinc, iodine and animal proteins (CIP 2019).

Concept

To address this challenge, the introduction of sweet potato (*Ipomoea batatas*) has been identified as a valuable opportunity to increase food security, reduce malnutrition and provide additional vital nutrients to the vulnerable population in the country. Sweet potato is a non-traditional crop in Tajikistan, and it was first introduced to the country in 1936 (Sulangov et al. 2021), primarily as a food and fodder crop. However, it was soon eliminated due to insufficient popularization and a lack of knowledge regarding its culinary uses.

The introduction of new sweet potato varieties was carried out by the International Potato Center (CIP, Peru), in collaboration with partner institutions, as part of the Potato Production Support and Research to Improve Food Security in Khatlon, Tajikistan - Phase II project and the Feed the Future U.S. Government's global hunger and food security initiative. CIP's project partners were the Laboratory of Molecular Biology and Biotechnology of Plants of the Institute of Botany, Plant Physiology and Genetics of the National Academy of Sciences of Tajikistan (LMBBP IBPPG NAST) and the National Center for Genetic Resources of the Tajik Academy of Agricultural Sciences (NCGR TAAS).

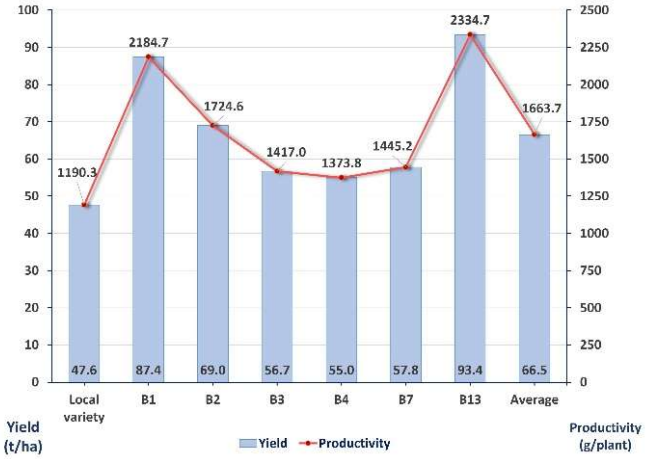
Outcomes

The project had three implementation phases, running from 2016 until 2019. In the first year, CIP provided 15 orange-fleshed sweet potato (OFSP) clones rich in beta-carotene to IBPPG under SMTA in order to develop production technologies. To familiarize the institute's staff with the new crop, an invited CIP programme manager provided training on OFSP's background, its multiplication, adaptation, agrotechnology, pest and disease management and storage. Using a step-by-step rapid multiplication technique, the IBPPG staff produced high-quality sweet potato seedlings, which were disseminated to five smallholders and two schools in West Khatlon for further testing as a new crop in limited demonstration plots and nurseries.

In the second year, sweet potato vines were multiplied in nurseries and distributed to and tested in 12 West Khatlon districts with leading and experienced farmers. After receiving 18,000 sweet potato seed-

lings, they achieved an average yield of 66.5 t ha^{-1} total from local and distributed OFSP varieties (Figure 1). The average yield only for OFSP-tested varieties was 69.9 t ha^{-1}, with a maximum high yield of 87.4 t/ha for the B-1 clone and 93.4 t ha^{-1} for the B-13 clone (Figure 1). This success was replicated over the next three years (2017-2019). In the third year, the sweet potato vines were distributed to local farmers and households who wanted to grow them.

During 2017-2019, researchers from IBPPG and NCGR conducted a joint research endeavour on the collection study of the introduced OFSP clones in comparison with the standard local variety under different agroecological conditions in the Khatlon region (Sulangov et al. 2021). The evaluation was carried out through phenological observations, a description of morphological characters and parameters such as seedling survival, tuber weight, productivity and yield. The assessment revealed that the tested sweet potato clones had high productivity (g/plant) and yields (t ha^{-1}), especially clones B1 (CIP105085.2) and B13 (CIP440136) (Figure 1), and were resistant to high temperatures and pests. These two promising OFSP clones have been recommended for registration



to the State Commission for Variety Testing of Agricultural Crops and Variety Protection under the Ministry of Agriculture of the Republic of Tajikistan as local varieties "Shokhin" and "Somon".

Figure 4: Chart illustrating the productivity (g/plant) and yield (t ha^{-1}) of the sweet potato clones evaluated in the West Khatlon region of Tajikistan. The data includes average values for the years 2017 to 2019. Deciphering the identification designations of sweet potato clones according to CIP are as follows: B1 - CIP 105085.2; B2 - CIP 105086.1; B3 - CIP 106090.1; B4 - CIP 106603.1; B7 - CIP 189151.34; B13 - CIP 440136.

Soil salinity, high temperatures and a lack of water are among the most common stress factors that reduce crop yields and agricultural productivity. These challenges are especially relevant in the Khatlon region of Tajikistan. Furthermore, significant areas of arable land are exposed to salinisation due to the disturbance of reclamation systems, rising air temperatures and increased climate aridity, leading to a deterioration in soil fertility. In this regard, researchers at the LMBBP IBPPG are continuing studies on the selection of sweet potato clones based on their resistance to salinity stress and an analysis of physiological and biochemical parameters in vitro.

Popularization of the sweet potato

Several activities have taken place to popularize this non-traditional crop among the local population, such as the publication of booklets on sweet potato cultivation and the filming of a promotional video (CIP 2019). Also, the Orange Flesh Sweet Potato Festival was organised, with local beneficiaries, representatives of governmental institutions and international and non-governmental organisation delegates attending (CIP 2019). For school students, an animated cartoon was filmed, and orientation training was held about the benefits and nutrients of sweet potato consumption (CIP 2019). Fifteen workshops were held for local farmers on the role and importance of sweet potatoes in solving food security issues, improving growing technologies, storage and processing.

Conclusion

Summing up the activities of the project, we could say that the introduced OFSP is a promising crop in terms of addressing the problem of malnutrition in Tajikistan. The introduced and tested OFSP has received a positive response among local farmers due to its nutritional value and benefits. Additionally, it can be grown as a second crop during the hot season.

The cultivation of OFSP could gain particular importance in the country because it is rich in beta-carotene, which is considered a precursor to vitamin A. All parts of the plant can be consumed, including leaves and storage roots. Moreover, the orange-fleshed sweet potato has been proven to be a cost-effective crop for diversifying diets, reducing vitamin A deficiency and providing additional vital nutrients to vulnerable people in Tajikistan. It could also be used in the national economy as a source for food fortification, starch production, glucose production and livestock feed. Ensuring the sustainable production of OFSP will thus have a positive impact on improving the overall socio-economic growth of local farmers, reducing poverty and improving food security in Tajikistan.

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Insects as a sustainability solution towards a circular bioeconomy? - The acceptability of insects as feed and manure recyclers in intensive livestock systems

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Keywords: acceptance study, innovation, sustainability transformation, human-nature-relations, agri-food system

Introduction

In the search for more efficient resource use, ways to close nutrient cycles, and new productive biological processes, insects as waste recyclers and livestock feed are considered a promising solution within the bioeconomy. One potential application is intensive livestock systems. Intensive livestock systems are characterized by the decoupling of available land from the number of livestock kept at farm and regional levels (Peyraud et al. 2014). In many regions of Europe with intensive livestock systems, this results in a high demand for protein-rich feed imports (protein gap) on the one hand and an occurrence of high nutrient surpluses on the other, with various undesirable environmental consequences for aquatic and terrestrial ecosystems (Wang et al. 2018). Against this backdrop, raising fly larvae on organic wastes such as manure and processing waste-fed insects into protein-rich feed is discussed as a potential solution (Čičková et al. 2015; van Huis 2019). Insects are regarded as a bioeconomic innovation that aims to harness a natural process to offer a more sustainable feed alternative and bring more circularity into the agri-food system.

The insect sector suggests that by 2030 annual European production of insect meal has the potential to reach 1 million tonnes as feed for pets, aquaculture, poultry and pigs (IPIFF 2021). According to IPIFF calculations, this is a scenario in which 1 in 50 chicken meat servings and 1 in 100 pork servings in Europe would come from insect-fed animals. However, the introduction of (manure-fed) insects as feed, as well as many other bioeconomic innovations, depends not only upon technical and economic feasibility, but also on social factors such as acceptability as well as ethical aspects that should be addressed as part of responsible research and innovation processes (Owen et al. 2013; Siegrist and Hartmann 2020). Still, the innovation of insects as feed cultivated on manure is not established and very little is known about its societal acceptability including ethical concerns.

Fournis and Fortin (2017) define acceptance as one of several possible outcomes of a complex judgement process of acceptability. In their review of acceptance studies, Busse and Siebert (2018) present different degrees of acceptability outcomes ranging from opposition and rejection (negative attitudes) to acceptance and engagement (positive attitudes) towards an acceptability object. In arguing for or against manure-fed insects and insect-based feed, a value-based dimension incorporates an inner conviction of what is valuable or desirable for an actor. Value-based argumentation enables a rational discussion pertaining to matters of value as well as fact and logic (Bench-Capon 2003). Values, beliefs and norms constitute a complex system that lays the foundations of the worldviews of individuals or groups (Schlaile et al. 2017).

This paper aims to introduce a theoretical-conceptual framework for analysing the acceptability of bioeconomic innovations and to show empirical results from an acceptability study on manure-fed insects as livestock feed. This also includes insights into the value-based arguments and ethical foundations behind the acceptability decisions of different stakeholders.

Methods

Thirteen interviews were conducted with different actors in Germany along the production chain, as well as with experts/scientists and civil society representatives (see Table 1). Pork makes up approx. 60% of meat production in the German livestock sector (Deblitz 2022), therefore pig farmers are likely to be important potential customers for insect-based livestock feed. Due to the heterogeneity of e.g. business models, challenges, ideologies, regional influences etc. found within farmers, proportionally more pig farmers were interviewed than other actor groups. A

semi-structured interview guideline was used and each interview followed the same basic format. To identify which problems are important to actors and how they are framed, interviewees were asked what they perceived to be the biggest challenges facing the livestock sector. They were then presented with information on the innovation of using insects to recycle manure and produce protein-rich feed. The conversation that followed centred on the interviewee's attitude toward the innovation, with the interviewer guiding with questions, where necessary, about e.g. perceived benefits and risks, willingness to use the innovation and the potential as a (partial) solution to current and future challenges. The aim of this interview format was to be able to identify values and beliefs around (manure-fed) insects as livestock feed specifically as well as livestock farming in general by analysing interviewee's statements.

Table 1: Overview of actors interviewed. N indicates the number of interviewees in each actor group

Actor Type	**N=13**	**Why this actor group?**
Livestock Farmer (LF)	5	Potential direct use of the innovation Economic actor A selection of pig farmers with farms of different sizes and in regions with different livestock densities
Insect Breeding and Production (IBP)	2	Potential direct use of the innovation Economic actor Knowledge of insect breeding and production, nutritional quality of insect-based feed
Feed Production and Retail (FPR)	2	Potential direct use of the innovation Economic actor Knowledge of physiological needs of livestock, feed prices, feed laws
Non-governmental organization (NGO)	2	Non-economic actor (governance/societal level) NGO1 (animal rights): knowledge of animal rights, advocacy for a plant-based diet NGO2 (environmental): knowledge of bioeconomy and manure management from an environmental perspective
Scientist/Expert (SE)	2	Non-economic actor (governance level) SE1 (entomologist): expertise on insect breeding and insect pathology SE2 (veterinarian): expertise on risks regarding livestock, particularly pathogens and further harmful substances

Results

Several interviewees showed positive attitudes towards manure-fed insects as livestock feed (FPR1, FPR2, IBP2, LF1, LF2, LF3, LF5, see table 1). These actors stated that they expected insects to provide high-quality feed to pigs and poultry. The topic of effective waste management and increased circularity was seen as a potential benefit of using manure as a feeding substrate. It was also argued that insects feeding on manure is a natural process, and as such expressed little concern over the technical process and were optimistic about feed safety (FPR1, FPR2, IBP2, LF1, see Table 1). The economic viability of the innovation was particularly important to livestock farmers interviewed and also mentioned by insect production and feed production.

Some interviewees expressed neither overly positive nor negative attitudes toward the innovation (IBP1, LF4, NGO2, SE2) This group recognised certain potential benefits, such as the likely good quality of insect-based feed and the innovation being an opportunity for circularity. However, feed safety concerns and the lack of knowledge over potential risks (of raising insects on manure and feeding manure-fed insects to livestock) were raised by IBP1 and SE2 (see Table 1). Concerns were also raised by some actors over the environmental footprint, questioning whether this feed product would be more sustainable than conventional feed (NGO2, SE1, see Table 1).

Those showing negative attitudes toward manure-fed insects as livestock feed (NGO1, SE1, see Table 1) emphasised that this innovation should not create an incentive to uphold or even intensify animal husbandry and manure production. Insect welfare was addressed in particular by the animal rights NGO, which stated that not enough is known about insect sentience and more research is needed on this topic. Additionally, the animal rights NGO could not recognise any ethical reasons to exploit insects.

When discussing livestock farming in general, differing values between actors were observed. For example, farmers state that ethical considerations are a key part of animal husbandry and they work to achieve good animal welfare. While the animal rights NGO interviewed stated that animal husbandry in itself cannot be ethically justified and the current livestock system causes large-scale suffering of animals. Several livestock farmers stressed that they are interested in doing more for environmental protection and better animal welfare, but that the pressures from the current system make it difficult to move away from the path of intensive livestock farming. Interviewees also highlighted the importance of sustainable management of natural resources.

Discussion

Our results illustrate the complexity behind judgement processes and subsequent acceptability decisions. Actors with positive attitudes towards manure-fed insects as livestock feed showed faith in technological progress, and when discussing the importance of sustainable management of natural resources, most interviewees brought forward arguments based on an anthropocentric viewpoint (i.e. natural resources should be protected because we as humans depend on them, rather than these resources having an intrinsic value in themselves). These views are in line with the paradigm of weak sustainability (Michelsen et al. 2016), and are a form of sustainability that seeks (mainly technological) solutions that can ensure a continuation of current production and consumption systems and established economic practices (Chaminade 2020). Those actors showing negative attitudes toward manure-fed insects brought up concerns over insect welfare and emphasised the risk of such an innovation upholding or even intensifying current livestock production. Such views move away from looking at particular innovations as solutions to specific problems, and focus on a broader perspective around the innovation while also discussing system change (Chaminade 2020).

When discussing manure-fed insects as a more sustainable alternative to conventional protein-rich feed, several aspects should be considered. Insects raised on higher-quality substrates such as grains appear to have an equal or higher environmental impact compared to conventional protein-rich feed (Bosch et al. 2019), while using manure as a substrate has the potential to reduce the environmental footprint of protein-rich feed production, particularly in terms of land use (Smetana et al. 2016; Bosch et al. 2019). However, under current EU law, it is prohibited to cultivate insects on organic wastes such as manure. Should manure be authorised as a feed substrate for insects in the future, using manure in this way may be beneficial in livestock-rich areas such as Lower Saxony in Germany, were excess manure for fertilizer use leads to nitrate pollution in soil and groundwater. However, there may also be a risk of resource competition, as manure could be diverted from other processes such as bioenergy production (van Zanten et al. 2015) or fertilizer use in areas with low livestock densities. Another aspect to be considered is whether or not the amount of manure will suffice for large-scale insect production without compromising its other uses. On the one hand, manure-fed insects may contribute to incremental sustainability improvements and an increased circularity on the level of feed and food production. But on the other hand it may risk a lock-in of the current unsustainable agri-food system. Should manure-fed insects be allowed as feed in the EU, their contribution to a sustainability-oriented transformation of the agri-food system is likely to be limited.

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Sowing change, reaping value: Cultivating bioeconomy opportunities from grassland residual biomass

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Keywords: grassland, residual biomass, value chain, development, circular bioeconomy

Introduction

The pursuit of sustainability necessitates a strong focus on socio-technical systems, as proposed by Geels (2004). These systems incorporate various theoretical frameworks such as strategic niche management, multi-level perspective, and technological innovation systems, which serve as foundational tools for comprehending and facilitating sustainable transformations within society (Markard et al., 2012). Several empirical studies (Giurca & Späth, 2017; Hansen & Coenen, 2017; Hellsmark et al., 2016) have employed the technological innovation system framework to investigate the potential of lignocellulosic biorefinery systems. These studies emphasize the crucial role of improved coordination among actors and the integration of actor networks within the innovation system. This integration, often referred to as convergence, is regarded as a critical phase in the development of sustainable innovations within the strategic niche management framework (Schot & Geels, 2008). It emphasizes the formation of networks, convergence of efforts, and alignment of actors' expectations (Caniëls & Romijn, 2008).

Moreover, when value chain development is centered on a specific group of actors, using an actor- or network-based definition can provide a more coherent conceptual framework. Similarly, when the model emphasizes the business environment, it's better for analyzing the different actors' participation in the value chain and identifying specific areas for improvement involving political, legal or business engagements; new links between actors and potential markets can also be identified (Donovan et al., 2015) The value chain approach is employed to foster coherence within the bioeconomy and gain insights into the fundamental activities and challenges faced by various actors (Singh et al., 2021). To maximize the effective utilization of grassland biomass resources, it becomes crucial to bridge the gap between niche technologies and business investments by formulating a comprehensive cross-sectoral vision that encompasses the entire value chain.

The integration of actors and their activities within the technological innovation system is identified as a crucial factor in achieving convergence, network formation, and alignment of expectations. The value chain approach offers valuable insights into the bioeconomy by promoting coherence and understanding of essential activities and challenges. Ultimately, bridging the gap between niche technologies and business investments is vital to effectively harnessing the potential of grassland biomass resources. The transition from a fossil-based to a bio-based economy relies upon the expansion of bio-based value chains and the development of new ones according to the current demands. As can be seen, process integration along the value chain proves to be a critical point in the development of bio-based industries. Still, there is a lack of research on sector-specific barriers and enablers. This paper addresses this gap by exploring challenges accompanying the emergence of novel grass-based value chains. To help resolve the technological and socioeconomic challenges of this shift, local biomass resources can be exploited through a value chain approach. In total, 15 expert interviews with different value chain actors ranging from farmers, technology developers, regional and local authorities, industry partners and NGOs in each demo site have been conducted using an explorative case study approach.

To contribute to the existing body of knowledge, this research aims to examine the obstacles hindering the successful implementation of novel grass-based value chains. The study will focus on the first research question, which aims to identify the techno-economic challenges that impede the development and expansion of innovative grass-based value chains in rural areas, where traditional agro-food value chains are prevalent. This analysis will be conducted within the framework of the strategic niche management conceptual

framework, providing insights into how these challenges manifest and influence the dynamics of value chain development.

Theoretical foundation

Common value chain activities have been typified in the literature as follows: i) biomass production (e.g., underused grassland biomass); ii) bio-based processing to transform biomass into bio-based products; iii) industrial applications to utilize the bio-based products as inputs for other existing industries; iv) research and development on novel biotechnologies for biomass processing and support the bio-based industries; v) the end users who consume the final products (Mac Clay & Sellare, 2022). Based on the bio-based value chain concept, we have illustrated our conceptual framework for analysis in Figure 1. Furthermore, our analysis will encompass an examination of how institutions, regulations, traditions, and practices influence the evolution of novel grass-based value chains. This will encompass the establishment of markets and the identification of environmental concerns associated with these value chains.

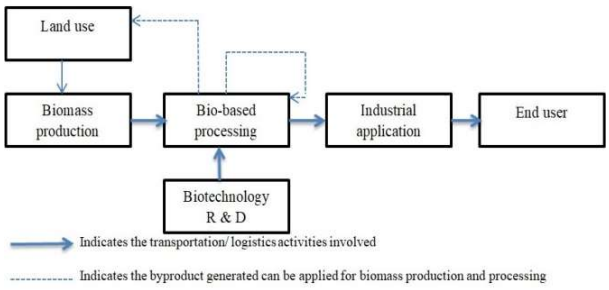

Figure 1: Conceptual framework for value chain using the underused grass biomass

Strategic niche management has gained recognition as an analytical framework for understanding niche experiments in sustainability transition (Raven, 2005). This paper characterizes three value chain cases: organic grass protein, grass-based paper, and biochar production from grassland systems, as strategic niche experiments with the potential for sustainable circular bioeconomy (Schot & Geels, 2008). The strategic niche management framework encompasses three interrelated processes: articulating expectations and visions, establishing social networks among relevant actors, and fostering learning activities for change. Radical sustainable innovations emerge in protected technological niches (Schot & Geels, 2008) allowing experimentation despite limited initial competitiveness (Smith & Raven, 2012). The value chain cases are currently in the pilot project phase, with technology development in the early stages within controlled environments.

Our empirical data in this research was based on in-depth interviews with 15 stakeholders using purposive sampling to select from national and regional agencies dealing with bioeconomy; government representatives responsible for policy and support interventions along the different stages of novel value chains; research institutions who can contribute to biotechnology development; and industry actors who can validate the relevance of potential policies and interventions from market perspectives, primary biomass producers as well as different NGOs. These informants have good knowledge about the GO-GRASS research project and high educational levels that ensure the reliability of the responses. In addition, two workshops with the purpose to discuss the challenges and opportunities on the emerging grass-based value chain development with participants from academia, regional and local authorities, industry and NGOs in each demo site were held between 2020 and 2022 in Sweden, the Netherlands, Germany and Denmark respectively.

Preliminary results and discussions

Immediate actions to overcome the lock-ins

Developing novel grass-based value chains for the transition towards a circular bioeconomy is an urgent need to address the growing concerns caused by the linear model of production and consumption. However, the shift to more sustainable processes is often limited by the status quo. It can be difficult for rural farmers and companies to embrace innovative methods of production and consumption due to their reliance on established systems on grasslands. The adverse impact associated with the case study on the production of biochar from late-harvested grass to complement the current value chain on grassland is particularly significant, as per our findings. Despite the crucial mandate for change, the preference for business-as-usual persists because of the high financial cost of adopting new methods that require developing supporting technology and infrastructure in rural areas (Bugge et al., 2019) and the institutional path dependencies (Boeger & Corkin, 2017) When this happens, it creates a lock-in situation where the existing practices and technologies become entrenched, making it difficult to shift towards more sustainable alternatives (Pannicke et al., 2015). To achieve a circular bioeconomy, there is a need to overcome lock-ins, and the institutional path de and promote transitions by adopting conceptually novel means of providing services that prioritize sustainability. This approach is crucial because bioeconomy innovations cannot rely solely on technological ad-

vancements. Still, they must also address the economic and social factors that influence market opportunities for long-term sustainability ambitions.

Grassland management change creates opportunities for rural farmers

Late-harvested grass from areas managed for landscape purposes is a biomass resource that is mostly neglected. Combining ecosystem services in nature conservation areas with biomass production for a growing bioeconomy is often considered a compelling strategy (Herrmann et al., 2014; Krenz & Pleissner, 2022). The cattle farmers who manage these grasslands are facing economic losses and a lack of competitiveness, and in some cases, the grassland remains unused (Ketzer et al., 2017). Therefore, both climate change mitigation and innovation policies will enhance the integration of the upstream of the novel grass-based value chains into the sustainability aspect of bioeconomy development (Petig et al., 2019). Private grassland owners are the ones who decide on grassland management practices, but they are often left out of bioeconomy discussions.

Integrating traditional agricultural value chains into emerging bio-economic value chains provides small-scale farmers with expanded market opportunities beyond selling individual products directly to rural consumers or local traders. By participating in these value chains, farmers can gain access to a broader range of markets. However, to ensure successful participation in these value chains, it is necessary to pay attention to early engagement with local farmers. This involves identifying their interests at the local and regional levels, and encouraging their involvement in a collective learning effort. Furthermore, knowledge resources and gaps must be identified, and efforts made to determine who can fill these gaps and how (Schmidt et al., 2020) It is important to engage them with local politicians and other relevant stakeholders at the earliest possible stage to ensure that their voices are heard and that social network is established Encouraging collaboration and forming suitable partnerships within the farming community can be an effective approach to promote and enhance these novel value chains. To achieve this, it is crucial to analyze the motivations of all parties involved. Ensuring that all stakeholders involved receive mutual benefits from collaborative endeavors is crucial, and it is equally important to gain acceptance and support for such initiatives from the wider community. This point has proven to be highly pertinent based on the case studies we have examined.

Market competition for emerging grass-based value chains

The issue of market competition is a recurring theme across all of the cases studied; nonetheless, it holds particular relevance to the case of grass paper production. The market competition for the emerging value chain that produces paper from roadside grass is becoming increasingly fierce, especially as it aims to substitute traditional wood cellulose paper. To remain relevant, businesses in this industry need to compete on both prices and functionality. Developing a niche marketing strategy that highlights the unique characteristics of grass-based products, such as their eco-friendliness, sustainability, and potential for high quality and functionality is crucial. It is also important to change the public's perceptions of grass-based products and emphasize their potential as a viable alternative to traditional wood-based products.

Monitoring and evaluation of the environmental challenges

In this study, the cases analyzed with regard to the development of grass-based value chains demonstrate a strong interrelation with ecological systems. The relationship between the bioeconomy and ecosystem services is an area of research that requires more attention, particularly in terms of comprehending the effects and interconnections of various bioeconomy activities (D'Amato et al., 2020) By considering the long-term effects of the grass-based product on the ecosystem services, the LCA is a valuable tool for identifying steps that can be taken (D'Amato et al., 2020). In light of a comprehensive assessment of the environmental implications inherent in these value chains, it becomes evident that a favorable outcome holds the potential to significantly influence their broader promotion and allure among prospective stakeholders.

There is no "one-size-fits-all" solution to the challenges of value chains

The achievement of successful implementation of a novel grass-based value chain cannot be attributed to a single factor, as evidenced by the cases presented herein. Rather, a confluence of interventions at multiple levels is required to effectively address the complexities of value chain development processes. Specifically, the facilitation of innovation processes and the enhancement of effective linkages necessitate a suite of policy measures, development programs, and technical capacity-building initiatives targeted towards value chain actors. Such efforts are critical in promoting the involvement of small-scale farmers in

burgeoning markets and their engagement in novel grass-based value chains.

Conclusion

In conclusion, the transition towards a circular bioeconomy requires immediate action to overcome the lock-ins that prevent local farmers from adopting more sustainable processes. The achievement of successful implementation of a novel grass-based value chain cannot be attributed to a single factor, as evidenced by the cases presented herein. Rather, a confluence of interventions at multiple levels is required to effectively address the complexities of value chain development processes. Specifically, the facilitation of innovation processes and the enhancement of effective linkages necessitate a suite of policy measures, development programs, and technical capacity-building initiatives targeted towards value chain actors. Such efforts are critical in promoting the involvement of small-scale farmers in burgeoning markets and their engagement in novel grass-based value chains. The findings of this study will have significant implications for the formulation of targeted strategies and policies aimed at promoting the integration of actors and activities within the specific type of value chain under investigation. These strategies and policies should be tailored to address the unique challenges and opportunities associated with the identified value chain.

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Sustainable Food and Biomass Futures?

Localised Approaches to Agricultural Change and Bioeconomy

In recent decades, the global demand for food and biomass has been increasing, while natural resources continue to deplete and are further stressed by the impacts of climate change. Additionally, rising energy and input costs have pushed agricultural production to its limits, placing farming communities in an increasingly precarious position. This volume presents a collection of papers that challenge us to reconsider existing agri-food and farming systems from a local perspective, and to explore alternative, more sustainable production approaches.

The volume is structured around four key themes. The first theme scrutinizes agricultural modernization, with a particular focus on technological innovations and monoculture-based agricultural production. The second theme centres on the political-economic dynamics and local challenges. The third theme assesses participatory methods for knowledge production on processes of agrarian change across various regional settings. Finally, the fourth theme explores alternative production systems that are socially and ecologically sustainable, offering potential solutions for reshaping agricultural systems under pressure.

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