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Soy and Agro-Food Change

Any assessment of agro-food change faces the challenge of the multiplicity of time, space, and agency. These dimensions are closely interwoven, and each includes multiple scales. Consequently, short-, medium-, and long-term perspectives, spatial formations from local to global as well as various human and even non-human agents need to be considered. Agro-food change is thus characterized by an overwhelming complexity that is difficult to grasp. To reduce this complexity without risking oversimplification, we need a clear research focus. In this special issue of the *Rural History Yearbook*, soy as a commodity provides a lens for assessing agro-food change in the era of globalization since the 1870s. Soy serves best as a marker of agro-food globalization in the 'long twentieth century' because it evolved from being almost exclusively an East Asian food crop until the late nineteenth century to representing the world's biggest agricultural commodity since the early twenty-first century. The lens of soy therefore allows us to comprehend intersections of different scales of time, space, and agency.

The articles of this special issue contribute in one way or another to the multiplicity of time, space, and agency in agro-food globalization. Nearly all of them were initially presented and discussed at the international conference *Agro-Food Change through the Lens of Soy: (Sub-) National Pathways in a Global Perspective*, which took place from 14 to 15 October 2024 at Johannes Kepler University Linz, Austria. The conference assessed agro-food globalization through the lens of soy from a historical social science and humanities perspective, aiming to overcome the methodological nationalism of country-focused agro-food studies as well as certain globalist tendencies in food regime research by emphasizing (sub-)national pathways of agro-food change. International scholars from various disciplines addressed the history of soy in and between Europe, North and South America, Africa, and Asia. They highlighted fundamental continuities and changes, important sites and their connections, as well as more-than-human key actors of the global soy complex – not least in light of the current polycrisis. We will attempt to follow the dimensions of time, space, and agency to provide an overview of the contributions to this volume and make agro-food change more tangible.

The multiplicity of time

The multiplicity of time emerges from intersections of different timescales: short-term (e.g., crop cycles), medium-term (e.g., politico-economic regimes), and long-term (e.g., planetary changes). The example of soy highlights the interplay of these different rhythms, ranging

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from the annual growth cycle of the soybean plant through decades- and centuries-long periods of soy expansion within food regimes all the way to *longue durée* phenomena such as soy-driven planetary change. We can thus distinguish three timescales: first, the *crop scale* of annual soy production and consumption cycles; second, the *regime scale*, which frames the expansion of soy as a sequence of path-dependent periods, each with certain modes of capital accumulation (production, processing, trade, and consumption) as well as regulation (nation states, big companies, social movements, etc.); third, the *planetary scale*, in which natural and human history converge in the Anthropocene, as the Great Acceleration of Earth system trends around 1950 and the soy-driven transgression of planetary boundaries reveal (see *Langthaler* in this volume). These three timescales differ in the ways soy is produced, processed, commercialized, and consumed in various contexts, and they may intersect or act in parallel. The contributions in this volume provide a wealth of examples across five continents.

Crop scale: The annual cycle of production refers to arguments about soy as a "miracle crop." Soy has a unique composition of fat and protein, provides healthy nutrition for humans and animals, and also increases soil fertility through nitrogen fixation in symbiosis with bacteria. This timescale also refers to efforts to adapt soy varieties to local conditions through plant breeding, in connection with changes in production and consumption. The "magic bean" was introduced in Austria-Hungary in the second half of the nineteenth century due to its nutritive value – especially its potential to close the protein and fat gap and to provide a low-cost alternative to meat. But for pioneering producers, yield variation and the availability of adequate varieties posed constant problems (see *Martsch* in this volume). Even after World War II, it still proved difficult to find suitable varieties due to Austria's short growing season and harsh climate. Only in the 1970s did research on photoperiodic behaviour, cold tolerance, and weed control increase soybean cultivation for domestic animal feed sufficiently to reduce the dependence on oilcake imports. Moreover, during the 1980s, tofu, tempeh, and soymilk started to become fashionable foods in the growing community of alternative food networks (see *Tober* in this volume). The government of Taiwan envisioned increasing self-sufficiency in soy through techniques of multiple cropping, intercropping, or crop rotation in the same field within a year. These efforts resulted in labour-intensive, non-mechanized and small-scale, but strongly agrochemical-dependent soy production. Domestic beans predominantly served as materials for tofu, soy sauce, and soymilk, while imported beans were mostly used for oil production (see *Chu* in this volume). In the USA and the USSR, different pathways of soy emerged: In the USA, soy developed from a farm input in the form of seed and animal feed to an output in the shape of soy oil and soy cake as cash crops for domestic and world markets. The USSR was looking for oil crops for various industries as well as protein sources for human and animal nutrition. However, disregard for social and natural conditions in the rural areas contributed to the failure of the "soy revolution" and resulted in the perception of soy as a low-quality food substitute (see *Langthaler* and *Ryzhova* in this volume). In Africa, missionaries and NGOs aimed to use soy to improve nutrition, especially for children. Soymeal was added to the traditional staple foods, but whole soybeans required long cooking times and therefore more fuel, which limited consumer acceptance. Plant breeding supported the expansion of soy cultivation, but production levels remained low (see *Baraibar Norberg* in this volume). In South America, it was genetically engineered herbicide-resistant soy which, in combination with the herbicide glyphosate, propelled the *sojización* of the landscape (see *Baraibar Norberg, Gelabert,* and *Mejía* in this volume).

Regime scale: The annual dynamics of soy are interwoven with expansions (and contractions) of soy cultivation and international trade relations at the food regime scale. Food regimes consist of hegemonic arrangements of agricultural production, agro-industrial processing and distribution, and food consumption coordinated by regulatory institutions at multiple levels. While the literature mostly outlines three global food regimes – the first or British-centred (1870s–1930s), the second or US-centred (1940s–1980s), and the third or WTO-centred (since the 1990s) – a refined periodization distinguishes five regimes (see *Tilzey* in this volume): the "liberal" (1846–1870s), "imperial" (1870s–1930s), "political-productivist" (1930s–1980s), "neoliberal" (1980s–2010), and "neo-imperial" (since 2010) regimes.

From the second half of the nineteenth century up to World War I, soy spread from Northeast China (Manchuria) throughout the Western world, though it remained in an experimental stage with limited production volumes. Various African colonies introduced soybeans from the late nineteenth to the early twentieth century, primarily through experimental stations. Colonial pioneers perceived soy as a valuable source of feed, but also as an answer to the rising European demand for vegetable oils and fats. Soybeans continued to be envisaged as a "future crop" or "food of progress," even when empirical results failed to meet these hopes (see *Baraibar Norberg* in this volume). After World War I, soy flour was propagated as "nutritive, inexpensive food for the starving children of Austria and Central Europe." However, soy and its products did not become part of the food regime in this period, as their introduction in times of scarcity contributed to their negative image as a substitute for animal-based protein (see *Martsch* in this volume). In Taiwan, Japanese colonialism introduced modern processing factories along with large-scale import of soy from Manchuria for fertilizer at the end of the nineteenth century (see *Chu* in this volume).

Between the World Wars, the USA and the USSR announced "soy revolutions." In the United States, extensive European-style mixed farming changed to capital-intensive specialized agriculture with a multi-functional symbiosis between hybrid corn and site-adapted soybeans (see *Langthaler* and *Ryzhova* in this volume). In South America, the colonialism and neo-colonialism of the nineteenth and twentieth centuries introduced or expanded soy monocultures. In the 1940s, farmers from Rio Grande do Sul began to cultivate soy in rotation with wheat production and exported a few tons to Europe (see *da Silva* in this volume).

The era after World War II is characterized by the Green Revolution, a knowledge- and capital-intensive transformation of agricultural production. The technological package of high-yielding seeds, motorized combines, and efficient pesticides made soy the key commodity of the US-centred productivist food regime. Soy oil for human consumption as well as industrial and biofuel use along with soy oilcake for animal feed became the main products. Under the General Agreement on Tariffs and Trade (GATT) of 1947 and the European Recovery Program (ERP) of 1948, the USA exported surplus soy cake at preferential tariffs or subsidized prices (see *Langthaler* and *Ryzhova* in this volume). Austria became a customer for US soy cake as animal feed (see *Tober i*n this volume), and American post-war aid changed beancake from being a fertilizer to serving as animal feed in Taiwan as well (see *Chu* in this volume). Animal feed supported the growing livestock complex in Western Europe and Japan, where middle-class families adopted meat-heavy diets as part of the "American way of life." During the Cold War, cheap soy from North America served as a geopolitical weapon against both world hunger and world communism (see *Langthaler* and *Ryzhova* in this volume). In newly independent African states, governments and aid organizations embraced soybeans to combat protein malnutrition, reduce dependence on animal-based imports, and promote self-sufficiency (see *Baraibar* Norberg in this volume). In Brazil, shortly after the end of World War II, the increased production of soybeans substituted oil for lard. In the 1970s, Brazilian authorities exploited the danger of African swine fever to propel agrarian modernization and the transition from animal fat to vegetable oil for domestic and international markets (see *da Silva* in this volume).

Over the last 50 years, the neoliberal and the current neo-imperial food regimes have established soy as a flex crop for global markets. Argentina and Uruguay adopted neoliberal reforms, promoting export-oriented agriculture to serve the rising global demand for vegetable oils and animal feed. Argentina became one of the first countries to approve Monsanto's "Roundup Ready" seeds and emerged as a global leader in no-till farming with genetically modified (GM) soy (see *Baraibar Norberg, Gelabert,* and *Mejía* in this volume). By contrast, Austria positioned itself as a producer of GM-free soy. The growing trend towards plant-based diets opened the domestic market for organic and conventional soy foods. Furthermore, EU integration brought an opportunity to sell GM-free soy in international markets – initially to European countries, but recently also to North Africa and the Middle East (see *Tober* in this volume). Taiwan applied a twofold focus by supporting traditional varieties and organic production as well as large-scale mechanized and agrochemical-intensive edamame farming (see *Chu* in this volume). In Africa, the vision for soy changed from direct human consumption to oil extraction and animal feed, often framed in terms of unlocking underutilized land, empowering smallholders, and securing future export markets (see *Baraibar Norberg* in this volume).

Planetary scale: At the planetary scale, the focus lies on the consequences of soy-based commodity chains in the past and present for the sustainable development of the planet in the future. In the current debate, divergent arguments about soy's role in a sustainable transition have emerged: Soy is framed negatively as a "climate killer" as well as positively as a "climate saviour." The negative framing relates to environmental destruction, such as the depletion of the Amazon rainforest and savannahs in Brazil, as well as to the adverse socioecological effects of GM soy: Soy monocultures lead to homogenization of cropping patterns, loss of biodiversity, degradation of soil and water quality, pesticide contamination, and herbicide-resistant "super-weeds" (see *Baraibar Norberg, Gelabert,* and *Mejía* in this volume). The positive framing argues that GM soy allows no-till cultivation and thus reduces carbon dioxide emissions. Moreover, soy provides an alternative to meat as a source of protein, and may thus contribute to reducing the methane emissions of industrial livestock (see *Langthaler* in this volume).

This discussion includes broader visions of low-carbon, "green," and circular-economic development as reaction to the human-driven Earth in the Anthropocene. Societal demands translate into stricter environmental regulations by nation-states and supra-national organizations for firms operating abroad. Some countries, including the EU and China, promote less resource-demanding and more sustainable modes of production. This leads to changes in the hegemonic accumulation strategy: from capital-driven deforestation to state-led "green capitalism." However, the case of Mato Grosso in Brazil shows that the public–private strategy of ecological modernization over the last decades has delivered mixed results: short-term decoupling, but long-term recoupling of soy expansion and deforestation (see *Langthaler* in this volume). Profound sustainability that privileges social and environmental concerns over corporate interests would require strong institutions backed by a socioecologically responsible state and civil society.

The multiplicity of space

The multiplicity of space emerges from connections linking different spatial configurations. Layers of space – from the local and regional to the national and global – are also transversally linked. The human and non-human relations across space mediated by soy have been extended through scientific improvements such as the exchange of knowledge, appropriation of seed varieties, inoculants to improve nodulation, conventional breeding and genetic engineering, as well as through technological packages of machinery, chemicals, and improved seeds. However, policy programs and market opportunities also played important roles. In the context of the contributions to this volume, two spatial scales are especially relevant: the expansion of frontiers of soy production in certain regions and the extension of transregional teleconnections related to soy.

Regional frontiers: In the USA, soy cultivation increased from the 1930s due to the powerful biotechnological package of hybrid corn and soybeans. The commodity web including beans, oil, and cake spread out from Illinois and proved its viability across the Corn Belt. Initially promoted for hay production or as green manure to support soil conservation, the growing supply of soybeans fuelled demand from the processing industry. Soy oil flowed into the food and other industries; soy cake went to the growing cattle fattening complex. In the USSR, the Bolshevik government's "soy revolution" announced in the late 1920s introduced the crop in suitable territories. Planners envisioned a fourteenfold increase in arable land under soybeans, but the crop failed to become a significant key resource of the Soviet planned economy. A comparison of the USA and the USSR reveals that between the late 1930s and the early 1950s, soybean acreage expanded by 385 per cent in the USA while increasing by only 34 per cent in the USSR, well below the global average of 65 per cent (see *Langthaler* and *Ryzhova* in this volume). In Taiwan, the acreage under soybeans increased by 50 per cent from 1953 to 1958, with production more than doubling due to variety adaptation (see *Chu* in this volume).

The expansion of Brazilian soybeans began in the 1940s, increasing the production area continuously until the 1970s as a result of changes in the production chain, the political preference for processed foods to support the industrialization process, and finally the medical discourse condemning pork lard (see *da Silva* in this volume). Later, the change in market orientation from domestic to export production further fuelled the expansion. In 2024, Brazil accounted for 36 per cent of global soy production and 44 per cent of total soy exports. Within Brazil, Mato Grosso emerged as a hotspot of soy expansion, with a state-led colonization offensive developing settlements and road projects that converted large parts of the savannah and rainforest biomes into cattle pastures and crop monocultures. Here, soy experienced three expansive booms: in the 1980s, production increased 32-fold from a low level; between the mid-1990s and mid-2000s, it grew 3.5-fold from a much higher level; and since the late 2000s, it has further expanded more than twofold (see *Langthaler* in this volume).

In Argentina, the process of *sojización* was a result of the "gene revolution" following the approval of Monsanto's "Roundup Ready" soybeans. Within a few years, 95 per cent of the grain and oilseed producers adopted transgenic seeds in combination with no-till farming. By 2024, half of the global soybean-growing area (c. 190 million hectares) employed genetically modified seed, concentrated in a few countries including the United States, Brazil, Canada, Argentina, Paraguay, Bolivia, India, and Uruguay (see *Baraibar Norberg, Gelabert* and *Mejía* in this volume).

In Austria, soy cultivation did not gain a significant foothold between its introduction in the 1870s and the postwar decades (see *Martsch* in this volume). Later, however, the renunciation of genetic modification by way of a referendum in 1997 opened up a window of opportunity for the cultivation of GM-free and organic soy. Consumer changes led to increased demand for domestic soy products and an expansion of soy cultivation. Within the European Union, Austrian soy production became second in relation to arable area after Croatia, and fourth in absolute terms. While conventional GM-free soy is mainly used as oil and feed, a growing share is cultivated organically for human consumption (see *Tober* in this volume). In Africa, the recent increase of soy cultivation in some countries (South Africa, Nigeria, Zambia, etc.) is due to increases in domestic meat production and the resulting need for protein-rich concentrate feed (see *Baraibar Norberg* in this volume).

Transregional teleconnections: The term "teleconnection" has been transferred from climatology to history to describe interactions between distant places in the Earth system. These interactions may involve material and immaterial spatial linkages. Perhaps the most obvious material teleconnections are links via intercontinental trade, especially the use of soy cake as protein feed – first from the USA and later from South America – for the meatification of Europe and East Asia. However, soy played a dual role in the Western diet of the postwar decades: Processed soy provided the cake for meatification and oil for oilification, while unprocessed soybeans emerged as an alternative to animal-based food. These opposing yet interlinked nutritional patterns established transnational soy feed trade connections and more nationally-framed soy food networks (see *Tober* in this volume). In Brazil, the state of Mato Grosso was transregionally incorporated into nation-state and global market dynamics via hierarchical commodity chains and other sorts of asymmetrical connections (see *Langthaler* in this volume). However, it is not always concentrate feed and oil that foster teleconnections. In Taiwan, the import of beancake as a fertilizer from Manchuria and Korea initially connected the countries during colonial times (see *Chu* in this volume).

Besides material trade connections, immaterial knowledge transfers on breeding efforts also established soy-related teleconnections. For instance, soy pioneers in the USA and USSR regularly exchanged knowledge on seed varieties and breeding efforts (see *Langthaler* and *Ryzhova* in this volume). In Taiwan, the Asian Vegetable Research and Development Center allied its agenda with the International Rice Research Institute in the Philippines, and the World Bank founded the Consultative Group on International Agricultural Research. This collaboration assisted in boosting soybeans in Indonesia (see *Chu* in this volume). The Soybean Innovation Lab at the University of Illinois, funded by USAID, became a major hub for breeding, agronomy, processing, and training across Africa. Through certification schemes and regional training, it helped to build capacity and link African producers to global markets (see *Baraibar Norberg* in this volume).

The multiplicity of agency

In a comprehensive understanding, agency is the ability of human and non-human actors embedded in hybrid networks to affect somebody or something else more or less strongly, regardless of the degree of intentionality. In the contributions to this volume, we can discern different but closely interwoven forms of agency: Some authors address human agency affecting soy cultivation – for instance, the broad spectrum of breeding efforts ranging from the traditional adaptation of varieties to local conditions to high modern genetic engineering. These activities may result in (often destructive) transformation of natural environments or the establishment of dependencies between governments, breeders, farmers, processors, trading companies, and consumers. Non-human agency related to soy cultivation includes the soybean itself along with other organisms such as companion crops, competing products, or weeds and pests. Animate as well as inanimate entities may exert agency, as the biotechnological package of herbicide-resistant soybeans together with corresponding herbicides and no-till cultivation shows. Finally, human and non-human agency interact in convergent or divergent ways and create more-than-human networks around soy (see *Langthaler* in this volume).

Human agency: Success or failure of human interventions depends on the stability of soy networks, as the Austrian case of early introduction exemplifies. Research-led soy cultivation in the late nineteenth century was shaped by an ever-shifting network of diverse actors including experts, publicists, estate owners, farmers, and the educated public. Early enthusiasm was not supported by sustainable institutions or market links, however. Even after World War I, scientific advancements were undermined by insufficient cohesion and coordination among individual actors, institutions, and state policy (see *Martsch* in this volume).

In the United States, a low-modernist pathway embedded in a state-coordinated yet decentralized knowledge network around the US Department of Agriculture, experimental stations, and the American Soybean Association upscaled soy as a pillar of the US-centred food regime. On the contrary, in the USSR, the disembedded high-modernist pathway with centralized direction by the All-Union Academy of Agricultural Sciences and overambitious five-year plans encountered ecological mismatches, weak knowledge transfer to collective farms, coercive collectivization, and repression of scientific expertise, which repeatedly stalled soy expansion (see *Langthaler* and *Ryzhova* in this volume). Similarly, adoption in Africa was strongest where research, assured markets, and processing capacity aligned (see *Baraibar Norberg* in this volume).

Policy actors played leading roles in different contexts. The USA intervened against Austria's autonomy in terms of oil and protein supply in the 1970s. Most important for the later integration of soy into the Austrian agro-food sector were connections between economic actors, civil society organizations, and state policies (see *Tober* in this volume). The EU is currently imposing stringent sustainability regulations like the Anti-Deforestation Regulation (EUDR) and the Carbon Border Adjustment Mechanism (CBAM), which could complicate market access for soy from Argentina and Uruguay. China's demand for imports surged after its accession to the WTO in 2001 as it opened up its markets and became a major buyer, importing nearly 100 million metric tons of soybeans in 2021, primarily for animal feed and cooking oil. Today, China's increasing emphasis on soybean self-sufficiency poses a potential challenge for global soy exporters (see *Baraibar Norberg, Gelabert,* and *Mejía* in this volume).

Non-human agency: In Brazil, the African swine fever virus played a decisive role in the "battle between lard and soy." The government exploited its spread to favour soy at the expense of pork lard (see *da Silva* in this volume). Ecological responses to soy cultivation provide another example of non-human agency: In Argentina and Uruguay, after decades of expansion, ecological feedbacks such as herbicide and pest resistance coupled with other environmental costs are undermining the economic efficiencies that once stabilized the system. Climate change further increases these pressures, intensifying soil-borne diseases and the vulnerabilities of monoculture systems. As nearly all soy production in the region is rainfed, it is highly vulnerable to precipitation variability. The 2022/23 drought in Uruguay, for instance, led to a drop in yield by 73 per cent, and 23 per cent of the sown area was abandoned (see *Baraibar Norberg, Gelabert,* and *Mejía* in this volume).

The transition from the Holocene to the Anthropocene has produced new forms of human and non-human agency that reinforce each other. There is evidence suggesting that the "Soyacene" can be considered a variety of the Anthropocene. The widening of soy's planetary footprint has driven deforestation and global warming, while its deepening has resulted in herbicide contamination and planetary health issues. While human agency has increased to a point that changes the course of the Earth system, non-human planetary agency may in turn change the course of the human species or even extinguish it – for instance, through an increase in adverse weather phenomena caused by accelerated climate warming (see *Langthaler* in this volume). Managing the Anthropocene to safeguard the habitability of our planet for a broad diversity of species, including humans, is probably the biggest challenge of our times.

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