

GLOBAL FOOD GOVERNANCE AND NORMS: A CRITICAL HISTORICAL
ANALYSIS OF THE DEVELOPMENT OF SCIENCE AND POLITICS

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ABSTRACT

GLOBAL FOOD GOVERNANCE AND NORMS: A CRITICAL HISTORICAL ANALYSIS OF THE DEVELOPMENT OF SCIENCE AND POLITICS

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This thesis examines the role of science and technology in the institutionalization of productivist agricultural practices within global food governance. Existing accounts focus on macro-level political-economic processes and international rules and norms in explaining the dominance of productivist paradigm, thus externalizing science and technology. This thesis adopts insights from practice-oriented norm scholarship and the Science and Technology Studies (STS) in order to endogenize science within social analysis. Through a critical historical analysis of the changes in plant improvement practices during the 19th and 20th centuries, it demonstrates the interplay between science and politics in the co-production of technical designs in plant breeding and the institutions advancing them. It argues that scientific ideas and technological innovations contributed to the emergence and normativity of the industrial farming model by simultaneously providing enabling technical infrastructure and rendering it neutral, objective and scientific. This thesis contributes to the critical norm scholarship by confirming the relevance of technical practices in normative change and providing a novel entry point by introducing global food governance. It also contributes to the

critical agrifood studies by providing an extended investigation of the legitimizing role of scientific practices.

Keywords: Global Food Governance, plant genetic resources, practice-oriented norm theory, Science and Technology Studies, international norms



ÖZ

KÜRESEL GIDA YÖNETİŞİMİ VE NORMLAR: BİLİM VE SİYASETİN GELİŞİMİNİN ELEŞTİREL TARİHSEL ANALİZİ

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Bu tez, üretimci tarımsal uygulamaların küresel gıda yönetişimi üzerinde kurumsallaşmasında bilim ve teknolojinin rolünü incelemektedir. Mevcut açıklamalar, üretimci paradigmanın hakimiyetini makro düzeydeki siyasi-iktisadi süreçler, uluslararası kurumlar ve küresel normlar üzerinden açıklamakta, fakat böylece bilim ve teknolojiyi uluslararası politikaya dışsallaştırmaktadır. Bu tez, bilimi sosyal analize dahil etmek amacıyla Pratik Teorisi temelli bir normatiflik anlayışı ve Bilim ve Teknoloji Çalışmalarından (STS) faydalanmaktadır. Tez bitki ıslahı pratiklerindeki değişimleri eleştirel bir tarihsel analizi yoluyla inceleyerek, ıslah teknikleri ve onları çevreleyen kurumlar arasındaki ortaklaşa üretim sürecinde bilim ve siyaset arasındaki etkileşimi göstermektedir. Çalışma bilimsel fikirlerin ve teknolojik yeniliklerin, endüstriyel tarım modelinin oluşumu ve normatiflik yüklenmesi sürecine hem mümkün kılan teknik aygıtlar sağlayarak hem de onları tarafsız ve bilimsellik ile çevreleyerek katkı sunduğunu ileri sürmektedir. Bu tez eleştirel norm çalışmaları literatürüne teknik uygulamaların normatif değişimlerdeki etkisini göstererek ve yeni

alışma alanlarını tanıtarak katkıda bulunmaktadır. Ayrıca bilimsel pratiklerin üretimci paradigmayı meşrulaştırıcı rolüne dair genişletilmiş bir inceleme sunarak eleştirel tarım gıda alışmalarına katkı sunmaktadır.

Anahtar Kelimeler: Küresel Gıda Yönetiřimi, bitki genetik kaynakları, pratik-odaklı norm teorisi, Bilim ve Teknoloji alışmaları, uluslararası normlar





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This thesis took years to complete, and I assume you know how overwhelming the process of writing a dissertation can be. Whatever you're imagining, now multiply it by five and throw in a few existential crises. That's closer to the truth. While I'm no "norm entrepreneur" in the theoretical sense (quite the contrary, as this thesis argues), I seem to have lived up to the title emotionally—spreading stress and anxiety to those around me. Please accept my sincere apologies.

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LIST OF ABBREVIATIONS

CIAT	International Center of Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CWR	Crop Wild Relatives
DUS	Distinct, Uniform, and Stable
FAO	United Nations Food and Agriculture Organization
IARC	International Agricultural Research Centers
IBP	International Biological Programme
IBPGR	International Board for Plant Genetic Resources
IITA	International Institute of Tropical Agriculture
IMF	International Monetary Fund
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
MLS	Multilateral System of Access and Benefit-Sharing
NIEO	New International Economic Order
PPA	Plant Patent Act
PVP	Plant Variety Protection
PVPA	Plant Variety Protection Act
SCOT	Social Construction of Technology
STS	Science and Technology Studies
UNDP	United Nations Development Programme
UPOV	International Convention for the Protection of New Varieties of Plants
USAID	US Agency for International Development
USPTO	United States Patent and Trademark Office
WTO	World Trade Organization

CHAPTER 1

INTRODUCTION

1.1. Background

Beginning with the early 20th century, adoption of modern agricultural practices and the industrial mode of agriculture increased agricultural production.¹ This model of farming and modernization process spread into the developing world during the second half of the century through a process called Green Revolution.² As a result, the productivist paradigm of agriculture, based on intensive resource use and monoculture farming, became the prominent model of the global agri-food system.³ By the mid-century, the agri-food system had come under the influence of capitalist relations of production, then towards the end of the century, it was integrated into the neoliberal economic system through structural reforms that replaced the regulatory role of the state with free market and private actors.⁴ These changes have further integrated food

¹ Jack R. Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology* (University of Wisconsin Press, 2004).

² See Chapter 2 and 6 for Green Revolution. See also Raj Patel, "The Long Green Revolution," *The Journal of Peasant Studies* 40, no. 1 (2013): 1-63; Marci R. Baranski, *The Globalization of Wheat: A Critical History of the Green Revolution* (University of Pittsburgh Press, 2022); John H. Perkins, *Geopolitics and the Green Revolution: Wheat, Genes and the Cold War* (Oxford University Press, 1997).

³ In the context of agriculture and food politics, productivism or productionism refers to paradigm that attempts to increase food supply through maximizing agricultural production with the introduction of science-led technical advances both as a solution to global hunger, and a way for increasing farmers' income. See Nora McKeon, *Food Security Governance: Empowering Communities, Regulating Corporations* (Routledge, 2015), 71-73; Tim Lang and Michael Heasman, *Food Wars: The Global Battle for Minds, Mouths, and Markets* (Earthscan, 2004), 18-20.

⁴ Harriet Friedman and Philip McMichael, "The Rise and Decline of National Agricultures, 1870 to the present," *Sociologia Ruralis* 29, no. 2 (1989): 93-117; Farshad A. Araghi, "Global Depeasantization, 1945-1990," *The Sociological Quarterly* 36, no. 2 (1995): 337-68; Philip McMichael, *Food Regimes and Agrarian Questions* (Practical Action Publishing, 2014).

and agriculture into the global political processes and conflicts. The agri-food system has thus become one of the earliest and most comprehensive agendas of the postwar global governance structure.⁵ Contemporary global food governance, with its rules, institutions, and norms, is argued to be designed to support the dominant productivist paradigm. Moreover, the transnational flow of food and diffusion of agricultural practices has been legitimized under normative visions such as food security, rural development, and sustainable agriculture. In this way, the existing productivist paradigm has been institutionalized as the ultimate solution against the global food problems.⁶

Regardless of its institutional backing and perceived legitimacy, the current agri-food system has failed to fulfill its promises, instead led to additional problems.⁷ This resulted in increasingly consolidated opposition against the existing system demanding its transformation. For example, the concept of “food security”⁸ have been criticized for legitimizing the current paradigm and thereby maintaining social

⁵ D. John Shaw, *World Food Security: A History Since 1945* (Springer, 2007); Matias E. Margulis, “Hunger in a Globalizing World: International Organizations and Contestation in the Global Governance of Food Security” (PhD diss., McMaster University, 2011); McKeon, *Food Security Governance*.

⁶ Kathryn Smith, “Sating Hunger in an Age of Plenty: The Global Food Governance Space and Its Role in the Establishment of an Effective Food Security Regime” (PhD. Thesis, University of St Andrews, 2017); Nora McKeon, “Global Food Governance,” *Development* 64, no. 1–2 (2021): 48–55. For a contemporary case see Carolin Anthes, *Institutional Roadblocks to Human Rights Mainstreaming in the FAO: A Tale of Silo Culture in the United Nations System* (Springer VS, 2020). For a critical analysis of the contemporary global food governance see the special issue in partnership with the Global Policy Forum Maywa Montenegro De Wit et al., “Editorial: Resetting Power in Global Food Governance: The UN Food Systems Summit,” *Development* 64, no. 3–4 (December 2021): 153–61. On the governance of plant genetic resources see Christine Frison, *Redesigning the Global Seed Commons Law and Policy for Agrobiodiversity and Food Security* (Routledge, 2018).

⁷ Vandana Shiva, *The Violence of the Green Revolution: Third World Agriculture, Ecology and Politics* (Zed Books, 1993); Jennifer Clapp and William G. Moseley, “This Food Crisis Is Different: COVID-19 and the Fragility of the Neoliberal Food Security Order,” *The Journal of Peasant Studies* 47, no. 7 (November 9, 2020): 1393–17; Peter Rosset, “Fixing Our Global Food System: Food Sovereignty and Redistributive Land Reform,” *Monthly Review* 61, no. 3 (2009): 114–28. For a recent brief contribution see Jennifer Clapp, “Only Politics Can End World Hunger,” *The Conversation*, 12 February 2025, <https://theconversation.com/only-political-will-can-end-world-hunger-food-isnt-scarce-but-many-people-cant-access-it-248736>.

⁸ The concept of Food Security was defined at the 1974 World Food Conference. The definition aligned the problem of hunger with lack of food supply, thus promoted productivism. See Jennifer Clapp, William G. Moseley, Barbara Burlingame and Paola Termine, “Viewpoint: The Case For a Six-Dimensional Food Security Framework,” *Food Policy* 106 (2022): 2–3.

injustices it brought, initiated calls for its revision,⁹ or replacement with entirely distinct paradigms, such as food sovereignty, right to food and agroecology.¹⁰ Yet, despite its failures and criticisms, existing agricultural production model and food policies continue to dominate global agenda. The productivist paradigm managed to remain the globally agreed solution to feeding the world through generating new actor-alliances, discursive tools, technologies and institutional mechanisms, thus proved to be capable of co-opting the critical voices or their ideas.¹¹ Despite ongoing efforts, rights over food, land and seeds are yet to be recognized within the scope of fundamental human rights. Therefore, a critical examination of the agri-food politics, and the global governance processes around them is still relevant and urgently needed in order to explain the persistence of contemporary agricultural paradigm.

1.2. Research Gap

In the broadest sense, this thesis examines the emergence and institutionalization of the productivist paradigm throughout the 20th century with a focus on scientific developments and their political contexts. Two research groups have offered explanations on the emergence, institutionalization, and normalization of the existing productivist farming practices. Some of the highly influential analyses are put forth by critical agrarian studies, adopting a macro-level international political economy perspective that begins with the consolidation of capitalist relations of production at

⁹ Clapp et al., “The Case For a Six-Dimensional Food Security”.

¹⁰ See Chapter 2. Also Stephen R. Gliessman, *Agroecology: The Ecology of Sustainable Food Systems*, (CRC Press, 2006); Priscilla Claeys, *Human Rights and the Food Sovereignty Movement: Reclaiming Control* (Routledge, 2015); William D. Schanbacher, *Food as a Human Right: Combatting Global Hunger and Forging a Path to Food Sovereignty* (Praeger, 2019); Eric Holt Giménez and Annie Shattuck, “Food Crises, Food Regimes and Food Movements: Rumbblings of Reform or Tides of Transformation?,” *Journal of Peasant Studies* 38, no. 1 (2011): 109–44; Lucy Jarosz, “Comparing Food Security and Food Sovereignty Discourses,” *Dialogues in Human Geography* 4, no. 2 (2014): 168–81; Michel P. Pimbert, ed., *Food Sovereignty, Agroecology and Biocultural Diversity: Constructing and Contesting Knowledge* (Routledge, 2017); Francis Adams, *The Right to Food: The Global Campaign to End Hunger and Malnutrition* (Springer International Publishing, 2021).

¹¹ Eric Holt-Giménez and Miguel A. Altieri, “Agroecology, Food Sovereignty and the New Green Revolution,” *Journal of Sustainable Agriculture* 37, no. 1 (2012): 90-102; Geoff A. Wilson and Rob J. F. Burton, “Neo-Productivist Agriculture: Spatio-Temporal versus Structuralist Perspectives,” *Journal of Rural Studies* 38 (April 1, 2015): 52–64; Maywa Montenegro de Wit and Matthew Canfield, “Feeding the World, Byte by Byte”: Emergent Imaginaries of Data Productivism,” *The Journal of Peasant Studies* 51, no. 2 (February 23, 2024): 381-420.

the national agricultural systems, and follows their extension through political, economic and legal orders.¹²

Another research strand focuses on the global governance of food and agriculture with an emphasis on the emergence of and the role of international regimes. These studies began their inquiry directly from international policy-making processes, and pre-established rules, principles and norms, while sidestepping the national context and the construction of such regime elements. They investigate the impact of the increasing institutional density, and plurality of regimes including multiple rules, principles, and norms over the agri-food policies.¹³ Social constructivist norm studies, closely related to this second research group, have rarely addressed global agri-food governance directly, despite the fact that norms and normativity have been crucial for the legitimization of contemporary food and agriculture policies. A few studies, however, demonstrated how global norms related to agriculture and food are constructed, contested, and used to shape policies.¹⁴ While existing accounts focus on macro level

¹² See Chapter 2. Friedman and McMichael, “The Rise and Decline of National Agricultures,”; Araghi, “Global Depeasantization, 1945-1990,”; McMichael, *Food Regimes and Agrarian Questions*; Devlin Kuyek, “Sowing the Seeds of Corporate Agriculture: The Rise of Canada’s Third Seed Regime,” *Studies in Political Economy* 80, no.1 (2017): 31-54. Harriet Friedman and Philip McMichael, “The Rise and Decline of National Agricultures, 1870 to the present,” *Sociologia Ruralis* 29, no. 2 (1989): 93-117; Farshad A. Araghi, “Global Depeasantization, 1945-1990,” *The Sociological Quarterly* 36, no. 2 (1995): 337-68; Philip McMichael, *Food Regimes and Agrarian Questions* (Practical Action Publishing, 2014).

¹³ Kal Raustiala and David G. Victor, “The Regime Complex for Plant Genetic Resources,” *International Organization* 58, no. 2 (2004): 277-309; Matias E. Margulis, “The Regime Complex for Food Security: Implications for the Global Hunger Challenge,” *Global Governance* 19, no. 1 (2013): 53-67; Christiane Gerstetter et al., “The International Treaty on Plant Genetic Resources for Food and Agriculture within the Current Legal Regime Complex on Plant Genetic Resources,” *The Journal of World Intellectual Property* 10, no. 3-4 (2007): 259-83; Jean-Frédéric Morin and Amandine Orsini, “Policy Coherency and Regime Complexes: The Case of Genetic Resources,” *Review of International Studies* 40, no. 2 (2014): 303-24; Sebastian Oberthür and Justyna Pożarowska, “Managing institutional complexity and fragmentation: The Nagoya protocol and the global governance of genetic resources,” *Global Environmental Politics* 13, no. 3 (2013): 100-18; Florian Rabitz, *The Global Governance of Genetic Resources: Institutional Change and Structural Constraints* (Routledge, 2017); Regine Andersen, *Governing Agrobiodiversity: Plant Genetics and Developing Countries* (Ashgate: 2008).

¹⁴ Robin Dunford, “Peasant Activism and the Rise of Food Sovereignty: Decolonising and Democratising Norm Diffusion?,” *European Journal of International Relations* 23, no. 1 (2017): 145-67; Julia Tschersich, “Norm Conflicts as Governance Challenges for Seed Commons: Comparing Cases from Germany and the Philippines,” *Earth System Governance* 7 (2021): 1-15; Noha Shawki, “Norms and Normative Change in World Politics: An Analysis of Land Rights and the Sustainable Development Goals,” *Global Change, Peace & Security* 28, no. 3 (2016): 249-69; Helmut Breitmeier et al., “Politicized Sustainability and Agricultural Policy: Comparing Norm Understandings of International Organizations,” *Journal of Comparative Policy Analysis: Research and Practice* 23, no. 5-6 (November 2, 2021): 625-43.

political-economic processes, international rules and norms in the globalization of productivist paradigm, they end up externalizing science and technology to social analysis by treating them as technical, thus neutral, objects.¹⁵

This omission of science and technology is unjustified and requires further examination. First, technological innovations and technical improvements in the agricultural input industry, such as synthetic fertilizer, plant breeding methods, seed production, and farming equipment, were crucial for increasing agricultural productivity, and forming an integrated agrifood system based on standardized inputs and mainstreamed procedures. Agricultural modernization based on a productivist paradigm has been a process of standardization.¹⁶ This is the reason for calling the Green Revolution a technology package, rather than stand-alone technical improvements. The productivist farming methods included a reliance on monocultures and increased use of mechanization and inputs such as fertilizer and pesticides. The seeds and the improved plants were the key that bind all these elements of modern farming.¹⁷ Scientific advances in genetics throughout the 20th century enabled the development of new plant breeding techniques. Through this new breeding technology, breeders were able to develop genetically uniform varieties to be used within standardized production modes of modern agriculture.¹⁸ Modern seeds and breeding techniques were adopted enthusiastically due to the rapid yield increase they provide. Their adoption by developing countries through the Green Revolution also facilitated the spread of industrial agricultural practices. Thus, the productivist paradigm in agriculture had been not only possible with the modern breeding system but also globalized through it. Therefore, technology is more than a technical

¹⁵ Geoffrey L. Herrera “Technology and International Systems,” *Millennium* 32, no. 3 (2003): 559-93; Matthias Leese and Marijn Huijntink, “How (not) to Talk About Technology: International Relations and The Question of Agency,” in *Technology and Agency in International Relations*, ed. Matthias Leese and Marijn Huijntink (Routledge: 2019): 1-23.

¹⁶ Lawrence Busch, *Standards: Recipes for Reality* (MIT Press: 2013), 104-06.

¹⁷ Tamara Wattne and Seed Laws, “Certification and Standardization: Outlawing Informal Seed Systems in The Global South” *The Journal of Peasant Studies*, 43, no. 4 (2016): 850-67.

¹⁸ Nils Roll-Hansen, “Plant Breeding and the Origins of Genetics,” *Cold Spring Harbor Perspectives in Biology* (2024); Helen Anne Curry, *Evolution Made to Order: Plant Breeding and Technological Innovation in Twentieth-Century America* (University of Chicago Press, 2016); See Chapter 5 for a more detailed elaboration on this point.

component of the productivist paradigm, it is the crucial element in its formation. In line with this, secondly, by enabling rapid and unprecedented increases in agricultural production, the science-led technological practices ensured the early success of the productivist paradigm, thus contributed directly to its wide-spread adoption and legitimized its integration into the international efforts for ending hunger.

Third, while an institutionalist approach on the content of international rules and global norms that enable and justify productivist farming practices provides insights over the enabling political and social environment, it ignores the fact that practices themselves, and the technology inform them, are in a process of change through improvement. Since the technical designs and “the political meaning of new technologies depends upon the development paths taken and not taken,” a historically grounded institutional analysis offers a broader analytical power.¹⁹ The contemporary discourse in the global food governance left behind the miracle seeds of the Green Revolution for the magic seeds of gene or biotechnology revolution.²⁰ Similarly, focus on the farm machinery has been replaced with digital farming technologies, such as drones, satellites and mobile phone applications, that provide enhanced capabilities for large-scale farmers, while posing novel threats for the small-scale farmers. While an investigation of the institutional mechanisms and international conventions for tracing the changing meanings of ‘norms’, such as food security and sustainable agriculture, has its own merits, a technology-oriented examination reveals changing and enduring practices in industrial agriculture.

1.3. Research Objectives and Theoretical Framework

Considering these shortcomings in conceptualizing the role of science in emergence and institutionalization of the productivist paradigm as the master frame of global food governance, this thesis takes this task by providing a critical historical analysis of the changes in plant improvement practices during the 19th and 20th century. In order to move beyond existing explanations that externalize science, this thesis aims to reveal the interplay between science progress and political developments in the co-production

¹⁹ Herrera “Technology and International Systems,” 592.

²⁰ Kathleen McAfee, “Neoliberalism on the Molecular Scale: Economic and Genetic Reductionism in Biotechnology Battles,” *Geoforum* 34, no. 2 (2003): 203-19.

of technical designs in plant breeding and the international institutions advancing them. To this end, this thesis relies on a theoretical framework that combines insights from practice-oriented understanding of normativity and the Science and Technology Studies (STS). This theoretical orientation is motivated by the perceived explanatory potential of examining technical/micro level processes and scientific debates, which have been often overlooked by existing studies regarding the development of contemporary agri-food paradigm. This theoretical opening is necessary for the proposed examination on several grounds.

Unlike norms or macro-level processes that often delegate capability to act to structural factors or structure-like social norms,²¹ practices are directly linked to agents in the form of human, non-human, or a network of both.²² Additionally, practice theory allows the integration of technology into the analysis by emphasizing the materiality of practices.²³ This focus on social and material has recently made its way into the International Relation. For example, Philipp Olbrich, following a socio-material approach, demonstrates the entangled role of technology and human actors in rendering contested practices as desirable and legitimate.²⁴

The need for a conceptualization of technology as an integral component of social relations is the second reason for adopting an alternative framework. Following the broader trends in social sciences, International Relations scholars too often treat

²¹ See Chapter 3 for a critique of conceptualizations of agency in existing norm scholarship. Also, Bernd Bucher, "Acting Abstractions: Metaphors, Narrative Structures, and the Eclipse of Agency," *European Journal of International Relations* 20, no. 3 (September 1, 2014): 742–65.

²² For an introduction to practice theory see Davide Nicolini, *Practice Theory, Work and Organization: An Introduction* (Oxford University Press, 2012). For International Relations, see Christian Bueger and Frank Gadinger, *International Practice Theory* (Palgrave Macmillan, 2018); David M. McCourt, "Practice Theory and Relationalism as the New Constructivism," *International Studies Quarterly* 60, no. 3 (2016): 475–85; David M. McCourt, *The New Constructivism in International Relations Theory* (Policy Press, 2022); Alena Drieschova, Christian Bueger and Ted Hopf, eds., *Conceptualizing International Practices: Directions for the Practice Turn in International Relations* (Cambridge University Press, 2022).

²³ Nicolini, *Practice Theory*, 38; Bueger and Gadinger, *International Practice Theory*, 66; Theodore R. Schatzki, *Social Change in a Material World* (Taylor & Francis, 2019), 36.

²⁴ Philipp Olbrich defines socio-material approaches as "... a networked understanding of human-material relations that is better suited for studying the contingent and assembled nature of (in)security on the ground." Philipp Olbrich, "Security and Technology: Unraveling the Politics in Satellite Imagery of North Korea," *Technology and Agency in International Relations* (Routledge, 2019): 66–87.

science and technology as external factors in analyzing social relations. This tendency mainly takes the form of technological determinism, a conceptualization that assumes technological development as an autonomous process and considers technologies as purely technical, thus neutral, force upon social relations.²⁵ However, STS literature convincingly demonstrate how political, economic and social processes influence the validity of scientific arguments and the design of technologies.²⁶ In one of the earliest interventions, Langdon Winner asked the question of “Do artifacts have politics?” and strongly argued that “technologies are ways of building order in our world.”²⁷ In order to emphasize the political nature of technology, Herrera plainly defines technologies as socio-technical systems and calls for “endogenize[ing] technology’s development and effects within the international politics systems.” Following this call for endogenizing technology to international politics, Leese and Hoijsink offered unpacking it, a clear focus on the construction, implementation and use of technology, in order to account for “the politics that go into technology, as well as for the politics that emanate from technology.”²⁸

Sheila Jasanoff offers the concept of *co-production* to move beyond ‘co-constitutionalist’ binaries that ontologically separate social and material. Co-production, as a shorthand, indicates that “the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we chose to live in it.”²⁹ The process of knowledge production, rather than being a neutral social

²⁵ See Chapter 3 for a critique of technological determinism in social analysis. Also see Marijn Hoijsink and Matthias Leese, eds., *Technology and Agency in International Relations*, Emerging Technologies, Ethics and International Affairs (Routledge Taylor & Francis Group, 2019); Ronald R. Kline, “Technological Determinism,” in *International Encyclopedia of the Social and Behavioral Sciences*, ed. James D. Wright (Elsevier, 2015), 109-12; Corneliu Bjola and Markus Kornprobst, *Digital International Relations: Technology, Agency and Order* (London: Routledge, 2023).

²⁶ See Chapter 3 for an extended introduction this. See also John Law, “STS as Method,” in *The Handbook of Science and Technology Studies*, eds. Ulrike Felt, Rayvon Fouché, Clark A. Miller and Laurel Smith-Doerr (MIT Press, 2016), 34; Sheila Jasanoff, “The Idiom of Co-production,” in *States of Knowledge: the Co-production of Science and Social Order*, ed. Sheila Jasanoff (Routledge, 2004), 1-12; Karin Knorr Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Harvard University Press, 1999).

²⁷ Langdon Winner, “Do Artifacts Have Politics?,” *Daedalus* 109, no. 1, (1980): 121-36.

²⁸ Leese and Hoijsink, “How (not) to Talk About Technology,” 3.

²⁹ Jasanoff, “The Idiom of Co-production,” 2.

activity, is being conditioned by “institutionalized ways of knowing things” which reinforces existing patterns of doing science and producing epistemologies. The pattern that safeguards the established ways of doing science is what Knorr-Cetina calls an “epistemic culture”, that is an “amalgam of arrangements and mechanisms, bonded through affinity, necessity, and historical coincidence, which, in a given field, makes up how we know what we know.”³⁰

Above mentioned insights on socio-materiality and a politically-informed science and technology understanding have been introduced to norm scholarship by practice-oriented approaches³¹ Alternative concepts were offered to zoom in on diverse sites and processes of norm dynamics and to reflect on multiple sources of social change, including “normativity”,³² “normative configuration”,³³ and “normative substances.”³⁴ Practice-oriented scholars urged that considering practices as mere reflections of norms is misleading as practices are also norm changing. Therefore, a focus on

³⁰ Knorr Cetina, “*Epistemic Cultures*,”

³¹ Sebastian Schmidt, “Foreign Military Presence and The Changing Practice of Sovereignty: A Pragmatist Explanation of Norm Change,” *American Political Science Review* 108, no. 4 (2014): 817-29; Matthias Hofferberth and Christian Weber, “Lost in Translation: A Critique of Constructivist Norm Research,” *Journal of International Relations and Development* 18 (2015): 75-103; Jason Ralph, *On Global Learning: Pragmatic Constructivism, International Practice and the Challenge of Global Governance* (Cambridge University Press, 2023); Ingvid Bode and Hendrik Huelss, *Autonomous Weapons Systems and International Norms* (McGill-Queen’s University Press, 2022); Ingvid Bode and Hendrik Huelss, “Artificial Intelligence Technologies and Practical Normativity/Normality: Investigating Practices beyond the Public Space,” [version 2; peer review: 4 approved, 1 approved with reservations], *Open Research Europe* (2024); Ingvid Bode, “Practice-Based and Public-Deliberative Normativity: Retaining Human Control over the Use of Force,” *European Journal of International Relations* 29, no. 4 (2023): 990-1016; Maïka Sondarjee, “Practice Contestation in and between Communities of Practice: From Top-Down to Inclusive Policymaking at the World Bank,” *Global Studies Quarterly* 4, no. 1 (2024): 1-13; Emanuel Adler, *World Ordering: A Social Theory of Cognitive Evolution* (Cambridge: Cambridge University Press, 2019), 131.

³² Frank Gadinger, “The Normativity of International Practices,” in *Conceptualizing International Practices: Directions for the Practice Turn in International Relations*, ed. Alena Drieschova, Christian Bueger and Ted Hopf (Cambridge University Press, 2022), 100-22; Dennis R. Schmidt and John Williams, “The Normativity of Global Ordering Practices,” *International Studies Quarterly* 67, no. 2 (2023): 1-13.

³³ Simon F. Pratt, “Norm Transformation and the Institutionalization of Targeted Killing in the US,” *European Journal of International Relations* 25, no. 3 (2019): 723-47; Simon F. Pratt, “From Norms to Normative Configurations: A Pragmatist and Relational Approach to Theorizing Normativity in IR,” *International Theory* 12, no. 1 (2020): 59-82; Simon F. Pratt, *Normative Transformation and the War on Terrorism: The Evolution of Targeted Killing, Torture and Private Military Contracting* (Cambridge University Press, 2022), 20.

³⁴ Guangyu Qiao-Franco and Ingvid Bode, “Weaponised Artificial Intelligence and Chinese Practices of Human–Machine Interaction,” *The Chinese Journal of International Politics* 16, no. 1 (2023): 108.

normativity, rather than norms is preferred as “emergence of norms is based on the practice.”³⁵

In a similar attempt, Bode and Huelss, drawing from Practice Theory, and Science & Technology Studies, identified additional sources of “normative substance” by highlighting the norm-generative role of “operational practices of design and use” that are “typically performed outside of the public eye.”³⁶ This perspective connects operational/non-discursive practices to norm dynamics by analyzing agents’ practices in technical-professional tasks. Furthermore, by addressing the agency attributed to technology and material artifacts (such as Artificial Intelligence) in shaping norms, this approach integrates the material into the social sphere. It builds on the idea that technology (materiality) is a “reservoir of social practices” rather than merely “part of objective-neutral processes of experimentation and problem-solving” in normative transformation processes.³⁷

These technical decisions serve as refinement practices that effectively determine what actors should precisely do to be recognized as norm implementer. Through this specification, broadly accepted fundamental norms translated into implementation mechanisms. These seemingly technical principles serve as a benchmark for judging actors’ performances, labelling them as competent or incompetent.³⁸

1.4. Argument and Contributions

Building on these insights, this thesis integrates science and technology into social analysis by examining the political processes in their development to show how scientific claims, technical designs, and technological devices become sites of contestation and tools for control. This thesis undertakes the above defined research

³⁵ Bueger and Gadinger, *International Practice Theory*, 111.

³⁶ Bode and Huelss, “Artificial Intelligence Technologies,” 1.

³⁷ Bode and Huelss, “Artificial Intelligence Technologies,” 6.

³⁸ Emanuel Adler and Vincent Pouliot, “International Practices,” *International Theory* 3, no. 1 (2011): 1-36.

aims through an analysis of transformations in seed systems and plant breeding practices, which had a crucial role in the globalization of the agri-food system.

This thesis argues that while the spread and institutionalization of productivist paradigm has been mainly driven by economic interests, political considerations and institutionalized normative visions, its operationalization required effective scientific backing and novel technologies. These factors, often framed as technical and neutral, have instead played a constitutive role in shaping the policies, institutions and power dynamics of global food governance. In other words, it required a process of co-production among scientific practices, technical tools, rules and norms.³⁹ Therefore, the research contends that existing agricultural paradigms and institutional arrangements are better understood by tracing how epistemic cultures and technological practices have been historically produced, and in turn provided the legitimacy and authority to actors for controlling plants and the genetic resources required for their improvement.

This thesis contributes to the existing literature in several ways. First, by adopting insights from practice-oriented understanding of normativity and the Science and Technology Studies (STS), this thesis confirms the necessity of this theoretical space in examining the role of science in the formation of international institutional context without relying on either technological or social determinism. Therefore, it contributes to recent calls for integrating technology into analysis of international politics. Secondly, it provides critical norm studies with a novel entry point by introducing multiple normativity claims and demonstrating the contested and power-laden dynamics of global agrifood politics. Third, it confirms the insights of the critical agrifood studies by revealing the legitimizing role of scientific discourse in maintaining the productivist paradigm in agriculture and extends them beyond discursive practices and calls for technically informed and detail-oriented approaches. Considering the swift institutionalization of biotechnology and digital technologies as contemporary science-led solutions of the neo-productivist paradigm, a critically

³⁹ The terms and process of co-production elaborated in Chapter 3. See Jasanoff, “The Idiom of Co-production,”.

informed, historically grounded and detail-oriented understanding of science and technology is not only necessary for resisting it, but also for producing alternatives.

1.5. Analytical Framework

The theoretical framework adopted in this thesis and the main research objective necessitates an analytical framework that could provide both flexibility and content stability. The co-production between scientific knowledge and social order, for instance, is a process itself, rather than an outcome. Therefore, it requires a sharp focus on the process of interaction between technology and policy. This also requires identifying changes in epistemic cultures, technical designs, and economic, political and normative structures throughout the analysis as they appear in line with the theoretical framework. Moreover, as the analysis offered in this thesis covers a relatively extended time period, it would face scientific, institutional and political transformations which required further flexibility in conceptualizing novel institutions.

For this task, this thesis makes use of a recent framework for explaining normative transformations with a focus on the institutionalization of practices. Samuel Pratt offered the concept of normative configurations as “an arrangement of ongoing, interacting practices establishing action-specific regulations, value-orientations, and avenues of contestation.”⁴⁰ Instead of a direct link between the norm and normativity of practice, normative configurations provide a broader setting within which normativity unfolds with novel institutionalized practices. The institutionalization of new practices refers to becoming “ongoing components of formal and informal social arrangements.”⁴¹ The process of institutionalization unfolds through three causal mechanisms, which are convention reorientation, technological revision, and network synthesis. Conventions are “institutionalized standards of right conduct,” and their reorientation refers to a successful act of changing its scope to make a previously sanctioned action normatively secured. Technological revision refers to innovative techniques and novel technological tools providing agent creative possibilities as they

⁴⁰ Pratt, *Normative Transformation*, 15.

⁴¹ Pratt, *Normative Transformation*, 3.

make it possible to perform a normatively controversial action with less sanctions. The third mechanism is network synthesis, which is essentially an alliance building practice. Through it, actors establish new institutions or agencies to enhance their material, institutional and moral capabilities.⁴² As a strategic move, it involves not only bringing capable actors or organizations together, but also excluding critical, reluctant or less capable ones.

The framework offered by Pratt has not been adopted in its entirety, therefore it diverges significantly in terms of key definitions and procedures to be followed. However, these three mechanisms prove useful for following the institutionalization of industrial agricultural practices. It provides necessary tools to follow technological changes, thus knowledge production process, within the broader epistemic and political context. This is in line with the theoretical framework which emphasizes the role of epistemic cultures, institutionalized ways of knowing things, or actor-networks in the construction of scientific facts.⁴³ Convention reorientation, on the other hand, has been understood in the broadest sense by referring to changes in the established meanings, standards and procedures that make new practices normatively acceptable.

1.6. Thesis Structure

Chapter 2 provides a comprehensive background to the global politics of food and agriculture. It aims to show how political and economic considerations led to the globalization of agricultural activities, and how these considerations further shaped the global governance of food and agriculture. Chapter 3 has two interlinked objectives. The first one is to create a theoretical space that enables the integration of science and technology into a social analysis which examines the institutionalization of the productivist paradigm in agriculture. The second one is to demonstrate the embeddedness of the productivist paradigm within the global governance of plant genetic resources. It connects these two objectives by critically analyzing the International Treaty on Plant Genetic Resources for Food and Agriculture

⁴² Ibid., 47.

⁴³ Knorr Cetina and Sheila Jasanoff, "The Idiom of Co-production," in *States of Knowledge: the Co-production of Science and Social Order*, ed. Sheila Jasanoff (Routledge, 2004); Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Harvard University Press, 1987).

(ITPGRFA). Chapter 4 examines scientific and institutional changes in plant improvement and agricultural modernization that took place throughout the 19th century in Europe. It demonstrates an early example of the interplay between science and politics in establishing a highly technical, and equally strategic plant improvement infrastructure. Chapter 5 introduces the debates over evolutionary theory in the second half of the 19th century and the famous experiment of Gregor Mendel. It shows how scientific ideas and political considerations led to the emergence and quick adoption of a gene-centric plant breeding paradigm in the United States and Europe. Chapter 6 traces two interlinked developments, globalization of modern plant breeding practices through Green Revolution and the international efforts on plant genetic resources conservation. It shows how these two developments together institutionalized the gene-centric plant breeding system at the international level.

CHAPTER 2

GLOBALIZATION OF AGRIFOOD SYSTEM AND GLOBAL FOOD GOVERNANCE

2.1. Introduction

This chapter provides a comprehensive background to the global politics of food and agriculture. It aims to show how political and economic considerations led to the globalization of agricultural activities, and how these considerations further shaped the global governance of food and agriculture. It begins by defining the global agri-food system as a highly integrated chain of activities, highlighting the interconnectedness of food and agriculture. It then provides a historical account of the globalization of the agri-food system through two well-established perspectives. Following this, the chapter introduces the dominant paradigm of the contemporary agrifood system, productivism, and its critics, most notably agroecology. In the following section, it delivers a chronological overview of the global governance of food and agriculture, with a particular emphasis on recent developments, including growing institutional fragmentation and the emergence of new governance models such as multistakeholder initiatives. Finally, it connects the broader agri-food politics with the main subject of this study: seeds, plant breeding and plant genetic resources.

2.2. From Food and Agriculture to Global Agri-Food Relations

Food and agriculture policy covers a wide range of social relations and involves related rules, regulations, and institutions governing them. Food policy addresses some established concepts such as food safety, food security, food waste, food distribution, food chains, and improved nutrition and health. Directly linked to food is the agricultural policy, which hosts arrangements for governing the processes and

relations of food production. Agricultural policy targets technical, economic, social, and environmental dimensions of food production practice and regulates both micro and macro processes ranging from daily farming practices to rural development and agricultural modernization schemas. It involves debates over the ownership of productive resources such as water, land, and seed; trends of urbanization, deruralization, and depeasantization; or broader discussions such as the impact of farming methods on climate change, environment, human well-being and so on. Although Food and Agriculture are seen as two separate policy areas, they are now being addressed in an integrated fashion in both national and international governance mechanisms.

Food and Agriculture as a chain of integrated activities involve and affect multiple practices, actors, and objects. A discussion on land ownership involves more than rural development or agricultural modernization topics, as changing land tenure regulations affect not only who produces what but also the type, quality, and price of the food that are accessed. In other cases, for example, changes in agricultural input prices directly affect how much food becomes accessible to those whom. A path-breaking reform in seed legislation or a minor revision of subsidy principles heavily determines the type of crops farmers produce and the methods and inputs they use. It also shapes the color, taste, and nutritional quality of plants that humans consume. The changes in agriculture change the way people feed themselves and vice versa. Food and agriculture are shaped by and shaped economic, political, social, and cultural dynamics.

How the world produce, distribute, and consume food is the domain of Food and Agriculture policies. For their interrelations, it is necessary to employ a holistic take on food and agriculture. The food system or Agrifood system is a conceptualization for addressing these interrelations as it offers a way of capturing the economic, social, and environmental dimensions of their co-existence.⁴⁴

⁴⁴ Fikret Adaman, *Sürdürülebilir ve Dirençli Bir Gıda Sistemi: Türkiye Analizi* (İstanbul: İstanbul Politikalar Merkezi, Mart 2022); Jessica Duncan, “Food Security Governance,” in *Elgar Encyclopedia of Environmental Sociology*, ed. Christine Overdevest (Edward Elgar Publishing Limited, 2024), 311–16.

Food System includes all the elements (environment, people, inputs, processes, infrastructure, institutions, etc.) and activities that relate to production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes.⁴⁵

Since 1950, some political, institutional, and financial dynamics have integrated food and agriculture. Sectoral divisions that had previously dominated economic or political discourse, such as those between agriculture and industry or agriculture and food, seem to have lost their referents. Instead, the term 'agrifood' reflects the current phenomenon of an extended chain of heterogeneous activities. As a result of changes in the global food supply and value chains, the direct link between farmers and consumers or the one between the farmers and farming activity has been broken, and instead, a new one has emerged, that is, between farmers and agri-food industry. While farmers need a variety of industrial inputs and financial tools for food production, they also need to rely on extended and overstretched distribution networks that cross borders to deliver products to the final consumers. Thus, farming today is more of a complex set of relations within an integrated food sector, which links previously divorced agents, practices, and materials.

As a field for highly privatized and commercialized relations, agrifood systems involve multiple activities and actors. The production phase itself requires observers to address not only the traditional elements of production, such as resources, farmers, their associations, and public authorities, but also private actors that invest in, develop, produce, distribute, and sell agricultural inputs, financial investors, researchers, and scientific processes. Moreover, it is crucial to consider technical and institutional mechanisms for storing, processing, and marketing the food just as public/private institutions, norms, and rules that are responsible for governing food safety, food standards, and food quality.

2.3. Globalization of Agri-Food Politics

Above-described extended chains of relations integrated food and agriculture not only in terms of sectors, but also transnationally. Food had already been subjected to

⁴⁵ High Level Panel of Experts on Food Security and Nutrition, *Food Losses and Waste in the Context of Sustainable Food Systems* (Food and Agriculture Organization of the United Nations, 2014), 12, <https://www.fao.org/3/i3901e/i3901e.pdf>.

international trade for several decades. However, a highly specialized global food supply chain has been established in the last decades. This has been done through a globally applied industrial agriculture, rule-based international trade, increasing financialization of the agrifood sector and several other connectivity-making transformations. This connectivity, however, eroded diversity of food production systems and increased vulnerability. Standardization was one reason behind this enhanced connectivity. Despite calls for diverse food systems, trajectories forced small-scale farmers to adopt industrial agriculture in the past, and now being towards digital and smart agriculture in a way to leave no one out of the global agrifood system.⁴⁶ A historical perspective is required to understand the ongoing globalization of Food and Agriculture politics.

Clapp and Moseley offer a periodization based on three distinct “food policy eras” which have emerged as responses to distinct crisis of the food system.⁴⁷ Food self-sufficiency and the first green revolution (1950-1970), Neoliberal food security (1980-2006), Neo-productionism and the New Green Revolution (2007-2020). The first era is known for the increased government expenditure for agricultural modernization in both developed and developing countries. While industrial countries increased their exports, developing countries were encouraged to supply their stocks through international markets. This era ended with the food price crisis of 1972-1974, which increased not only food and other inputs, but directly the hunger. The neoliberal food security era begins with structural adjustment programs that reduced government support for agriculture and opened the national markets of the developing world. The WTO Agreement on Agriculture (AoA) (1995) and Trade-Related Aspects of Intellectual Property Rights (TRIPs) was the high point of this period which forced nation states to integrate deeper into global agrifood system through unrestricted trade and intellectual property rights. While food prices decreased, so do the welfare of farmers both small-scale and larger ones. Agrifood corporations emerged as powerful actors who increasingly shape sectoral dynamics. The third period, Neo-Productionism and the New Green Revolution (2007-2020), begins with the 2007 food

⁴⁶ IPES-Food, *From Uniformity to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems*. International Panel of Experts on Sustainable Food Systems, 2016.

⁴⁷ Clapp and Moseley, “This Food Crisis Is Different,” 1393–17.

crisis. The crisis led to an increase in food prices, and a decline in the belief that the market would stabilize it. Hunger has increased once again. Unlike the first green revolution, this time productionist paradigm was conducted by the private sector. As a solution to multiple-crisis, once again modernization has been prescribed in the form of science-backed, technology-led smart agriculture models. The agri-food system became totally integrated, and financialized, thus vulnerable to speculation and sudden shocks. States and agrifood corporations increased their search for land, thus land grabbing intensified. Despite several voluntary guidelines regarding the responsible investment and land tenure rights, the trends remain as they are.

International Political Economy offers a broader lens for understanding why agri-food practices are globalized and take this form. Food regime conceptualization explains the post world war globalization process over two consecutive food regimes, one of which forms the basis of the other. The first phase, called second food regime, was shaped by state regulations over food and agriculture through market boards, price control mechanisms, and state-funded agricultural development programs in the era of national developmentalism.⁴⁸ Three main mechanisms that shaped this regime were the US policy of Food Aid for dumping its surplus food and containing the Soviet Union; spread of intensive agricultural practices through Green Revolution; and increased public spending for supplying this model of industrial agriculture. These three mechanisms in combination devastated developing world, shaped state-society relations, fueled urbanization and deruralization, thus set the stage for the next food regime. By the 1970s, US overproduction and grain stocks were the main mechanisms that kept grain prices stable in the world market and prevented food supply crises.⁴⁹ Although the US was still the world leader in grain production and export, its policy of decreasing production and stocks was slowly giving results. At the early days of Green Revolution, there was a belief that developing world could meet its demand by

⁴⁸ McMichael, *Food Regimes and Agrarian Questions*; Farshad Araghi, "The Invisible Hand and the Visible Foot: Peasants, Dispossession and Globalization," in *Peasants and Globalization: Political Economy, Agrarian Transformation and Development*, ed. A. Haroon Akram-Lodhi and Cristóbal Kay (Routledge, 2012), 129. Note that, unlike McMichael, Araghi calls this period long national developmentalism (1917-1973), following the colonial-liberal globalism, and preceding the postcolonial neoliberalism.

⁴⁹ Bryan L. McDonald, *Food Power: The Rise and Fall of the Postwar American Food System* (Oxford University Press, 2017), 163.

producing more and, if necessary, buying from the international market. Green Revolution and agricultural modernization led to hope, among developing world, of achieving self-sufficient in food supply and, even more enthusiastically, being food exporters. At the same time, food surpluses and affordable food prices were still feeding large urban populations, thus suppressing domestic unrest, and fueling the industrialization-urbanization dynamic.

The Green Revolution was a modern industrial design that “needs the lubricant of finance or credit” to work.⁵⁰ In other words, significant budgetary efforts were made or should have been made by national governments to produce more. A combination of the cost of the technology package, lack of resources to adapt industrial farming methods, and the selective transfer of subsidies to farmers who already had access to financial instruments or necessary resources to harness such technology paved the way for rural depopulation and rapid urbanization, particularly for small-scale farmers. This trend reduced the number of traditional farming communities and pushed industrial farmers into closer relations with agribusiness. The integration of agriculture and industry through complexes in transnational value chains made transnational agribusiness actors crucial for national economies by enabling them to invest, particularly in the agricultural input and food processing sectors.⁵¹ However, the agricultural sector was still heavily regulated by national authorities both in the US and the developing world. As long as the existing global economic arrangement and the Bretton Woods system persisted, it was unlikely that transnational corporations would expand their operations. A crack in the food supply chain and a macroeconomic shock were about to change this.

The period between 1972 and 1974 was the first time the term “Global Food Crisis” was used. The crisis was so threatening that, for the first time, an intergovernmental meeting regarding food was arranged to debate the causes and consider solutions: The United Nations World Food Conference in November 1974. Between 1971 and 1975, prices of cereals, soy, and corn tripled and remained higher than those of former trends

⁵⁰ Rockefeller Foundation, “The Rockefeller Foundation Annual Report of 1971,” 19.

⁵¹ Harriet Friedmann, “The International Political Economy of Food: A Global Crisis,” *International Journal of Health Services* 25, no. 3 (1995): 511-38.

for several years. This crisis was triggered by a series of human and non-human-made developments that created unexpected instability in supply and demand.⁵² One of the causes of the crisis was the doing of nature, which negatively affected yields. Poor weather created unfavorable conditions, leading to a decline in production and a search for imports from the world market where surplus should have roamed free.⁵³ However, the surplus grain was not available in world markets. The reason for this was the US policy of reducing production and decreasing stocks. Between 1970 and 1972, the US share in global grain production fell from 15% to 10%.⁵⁴ In order to ease the financial burden of surplus food, the US signed a grain deal with the Soviet Union in 1973.⁵⁵ The US-Soviet Grain Treaty included the export of wheat, corn, and soybeans, amounting to \$1.1 billion. The sale of \$700 million worth of wheat, one-third of US production, was a source of a major hole in the global wheat supply.⁵⁶ The food crisis further deepened with the surge in agricultural production costs due to the 1973-1974 Oil Crisis.⁵⁷ Along with the food crisis, a macroeconomic transformation has eroded the existing agrifood system. The Bretton Woods system was no longer, with Nixon's suspension of the dollar's convertibility into gold in 1971 and the end of the fixed exchange rate regime in 1973. 'Nixon Shock' was not unexpected. Public expenditure for the war in Vietnam, and large-scale social policies led to economic disruptions and attempts to compensate for this made the dollar overvalued. Things got worse during the oil crisis of 1972-1973.

The next phase of globalization, the third food regime, emerged after 1970 with the neoliberal wave of replacing the state with the market forces through trade liberalization, financial deregulation, and privatization, which collectively disempowered small-scale farmers not just against large-scale industrial farmers, but

⁵² Jennifer Clapp, "Concentration and Crises: Exploring the Deep Roots of Vulnerability in the Global Industrial Food System," *The Journal of Peasant Studies* 50, no. 1 (2023): 5.

⁵³ McDonald, *Food Power*, 163.

⁵⁴ Ibid.

⁵⁵ Clapp, "Concentration and Crisis," 5.

⁵⁶ McDonald, *Food Power*, 166.

⁵⁷ Clapp, "Concentration and Crisis," 5.

also other actors in the integrated agrifood system. The period following the collapse of the Bretton Woods system is called the "Corporate Food Regime"⁵⁸ that is "governed increasingly by financialization and neoliberal advocacy of market rule".⁵⁹ McMichael takes the lead from the inability of United States to sustain the Bretton Wood system in his analysis of the origins of the corporate agribusiness regime.⁶⁰ The 'post-developmental project' is characterized as the eroded capacity of states against "a systemic counteroffensive" that sought to dismantle state regulations over market dynamics.⁶¹ The new regime was built on the unregulated market rule, enabling the consolidation of corporate hegemony and the deployment of debt as a disciplinary mechanism by international financial institutions. For the latter part, international institutions played a key role, among which the IMF and WB served as disciplinary authorities that promoted deregulation for the overall structuring of national economies, and the WTO for extending deregulation into international trade through Agreement on Agriculture (1995). The increased capacity and lobbying abilities of TNCs enabled them to shape national and international law-making processes either through private-public links or with their activities in the WTO Dispute Settlement Board.⁶² Structural adjustment programs prescribed by the international financial institutions forced liberalization of trade and finance, and dismantling of marketing boards along with other public expenditures including agricultural research and extension programs.⁶³ The new World Bank was opposite in policy orientation to the World Bank of McNamara, which directed financial resources precisely for "building

⁵⁸ For an overview of critical agrarian studies and inter-discipline debates on the third food regime, see Atakan B  ke, "Capitalist Food Regime and the Agrifood Problem: A Critique of Political Economic and Post-Developmentalist Understandings of the Agrarian/Peasant Question / Kapitalist Gıda Rejimi ve Tarım-Gıda Sorunu: Tarım/K  yl   Sorununda Ekonomi Politik ve Post-Kalkınmacı Yaklaşımların Bir Eleştirisi" (PhD diss., Orta Doğu Teknik   niversitesi, 2018).

⁵⁹ McMichael, *Food Regimes*, 41.

⁶⁰ Ibid., 45.

⁶¹ Araghi, "Invisible Hand," 131.

⁶² McMichael, *Food Regimes*, 41.

⁶³ Araghi, "Invisible Hand," 133; Holt-Gim  nez and Shattuck, "Food Crises, Food Regimes and Food Movements," 111.

public institutions that could support farmers, through extension, credit and marketing".⁶⁴

As a result, "production, distribution and consumption networks are extended across localities, regions and nations to include new actors, products and technologies."⁶⁵ Therefore, agriculture and food became globally integrated. This extended network of relations has been justified for efficiency through science-led technological solutions, what is called now techno-fix. These solutions have been re-designed several times since 1945; began as a quest for ending hunger, then promoted for modernization of the Global South and its rural, then offered as a solution for saving the environment through sustainable agriculture, and recently in the form of new green revolution, that relies on digital and bio-technologies, as a solution for multiple crisis including climate change, increasing population, depletion of resources.

Today, global problems, including hunger, poverty, environmental degradation, climate crisis, and biodiversity loss loom large. Besides their global reach in terms of affected people, they are rooted in the very process of the transnationalization of agrifood practices. A global agribusiness sector has emerged, especially with the extension of transnational companies into local markets. Agribusiness increased its control over economic and political institutions through market concentration by using the paths cleared for them in the past decade. Intellectual property rights combined with enabling antitrust regulations led to mega-mergers and oligopolies in the agrifood industry.⁶⁶ Small number of corporate actors control markets of agrochemicals, seeds, genetic resources and related technologies, food processing and retail⁶⁷. They began implementing their own global standards.⁶⁸

⁶⁴ Raj Patel, *The World Bank and Agriculture*, A Critical Review of the World Bank's World Development Report 2008, Discussion Paper (ActionAid, 2008), 4.

⁶⁵ Busch and Juska, "Beyond Political Economy," 689.

⁶⁶ Clapp, "Concentration and Crises," 1-25.

⁶⁷ IPES-Food, *Too Big to Feed: Exploring the Impacts of Mega-Mergers and the Concentration of Power in the Agri-Food Sector* (International Panel of Experts on Sustainable Food Systems, 2017).

⁶⁸ Lawrence Busch and Christopher Bain, "New! Improved? The Transformation of the Global Agrifood System," *Rural Sociology* 69, no. 3 (2004): 321–46.

As the integrated set of activities crosses borders, the ability of states to regulate and control these activities is diminishing as new private governance mechanisms through multistakeholder governance replace intergovernmental governance.⁶⁹ In a way, an ever-expanding global agrifood system went ahead and left its governors behind. Since it encompasses cross-sector and cross-border activities, global governance of food and agriculture has high institutional density and regime complexity, making transformation burdensome.⁷⁰ In this context, the transformation of the agrifood system occupies the central stage within the global efforts to achieve sustainable development.⁷¹ Despite the consensus on adopting a systemic approach to address multiple and related problems in the agrifood sector, there are deep disagreements over the ways of regulating and transforming the system.⁷²

2.4. Contested Paradigms for the Future of Food and Agriculture

The global agri-food system has been contested both within national and international policy making processes as the dominant methods of farming proved ineffective to deal with multiple crises of 21st century, most predominantly persistent hunger. Recurring food crises, diet-related health problems, and the pressure of the food production process on the environment raise questions about the extent to which the basic principles and practices of the agri-food system are appropriate in solving extant and future problems. Although each crisis is followed by a reform process that introduced newly empowered actors, revised methods and novel principles, the structural conditions that make crisis recurring and hunger persistent remain as such. Therefore, a “food war” remain to be concluded over the agricultural practices that

⁶⁹ Doris Fuchs, Agni Kalfagianni, Jennifer Clapp, and Lawrence Busch, “Introduction to Symposium on Private Agrifood Governance: Values, Shortcomings and Strategies,” *Agriculture and Human Values* 28 (2011): 335-44; Matthew Canfield, Molly D. Anderson, and Philip McMichael, “UN Food Systems Summit 2021: Dismantling Democracy and Resetting Corporate Control of Food Systems,” *Frontiers in Sustainable Food Systems* 5 (2021): 1-15.

⁷⁰ Raustiala and Victor, “Regime Complex for Plant Genetic Resources,” 277-309; Margulis, “Regime Complex for Food Security,” 53-67.

⁷¹ United Nations General Assembly, *Transforming Our World: The 2030 Agenda for Sustainable Development*, Resolution 70/1, A/RES/70/1, October 21, 2015, <https://www.refworld.org/legal/resolution/unga/2015/en/111816>.

⁷² McKeon, “Global Food Governance,” 48–55.

condition how the food is produced and the market dynamics that determine how the food is accessed.⁷³

In the developed world, a series of technological and institutional transformations that took place in the early decades of 20th century resulted in a rapid increase in agricultural production and quantity of available food. Monoculture farming based on an intensive input application particularly in cereal and grain production come to be known as industrial agriculture. Following the Second World War, hunger was recognized as a global problem that requires concerted effort. Around 1970s, “food security” emerged as the dominant discourse within the global vision of fighting the hunger and began shaping policies and practices in food and agriculture sector. It was argued and eagerly accepted that the predominant cause of hunger is related to supply problems, that is the low level of productivity and efficiency in developing countries. Therefore, it was decided that increasing food production through agricultural modernization in the developing world would solve the problem of hunger just as it did decades ago in developed ones.⁷⁴ Therefore, following the 1960s, a coordinated policy of technology transfer and adaptation has been carried out towards the developing world to increase food production. This agricultural modernization process is called the Green Revolution and since then it has been known to be an example of the productivist paradigm of agriculture.⁷⁵ The increase in agricultural productivity made possible with the increased use of inputs, advances in plant and animal breeding, increased mechanization and fossil fuel use, a shift to monoculture farming, the replacement of small-scale farmers with large-size entrepreneur farms and accompanying economic and institutional public reforms.⁷⁶ This productivist paradigm devised as a response to changing population dynamics, most predominantly to feed the increasing number of working classes that resulted from the twin process of industrialization/urbanization, and deruralization. Therefore, the increase in

⁷³ Lang and Heasman, *Food Wars*, 1.

⁷⁴ McKeon, *Food Security Governance*, 74.

⁷⁵ Lang and Heasman, *Food Wars*, 19-20; McKeon, *Food Security Governance*, 71.

⁷⁶ Lang and Heasman, *Food Wars*, 19.

agricultural productivity compensated for the diminishing number of rural populations.

With the 1980s, the environmental damage caused by rapid development has become a matter of global politics. The Green Revolution was criticized for its resource-intensive and ecologically harmful methods. Moreover, objections have intensified on the ground that so-called revolution failed to end hunger, prevent food crises, eliminate rural poverty. The search for solutions resulted in the emergence of sustainable development, an understanding that policies should ensure the balance between social, economic and environmental dimensions of development. Following this, the practice of filling the world with food at the expense of depleting resources has become taboo, and the concept of sustainable agriculture, a committed to feeding the world sustainably, has become an alternative to the productivist paradigm.

Sustainable agriculture, as an abstract principle that seeks a balance between production-consumption dynamics and resource efficiency, is highly contested in implementation. Even the concept of sustainable development itself lacks a precise definition, thus carries a variety of meanings “from almost meaningless to of extreme importance to humanity” depending on the interpretation.⁷⁷ As with sustainable development, sustainable agriculture has been re-interpreted variously by several approaches which formulate the relationship between society, economy and natural resources in different ways, sometimes setting conflicting priorities. In other words, the meaning of sustainable agriculture as an abstract normative ideal has been re-enacted through implementation in different ways. As a result, competing agri-food approaches have been promoted by diverse actors within the agri-food system.⁷⁸

⁷⁷ Bill Hopwood, Mary Mellor and Geoff O'Brien, “Sustainable Development: Mapping Different Approaches,” *Sustainable Development* 13, no. 1 (2005): 40. See also Lucas Seghezza, “The Five Dimensions of Sustainability,” *Environmental Politics* 18, no. 4 (2009): 539–56; William M. Lafferty and Oluf Langhelle, “Sustainable Development as Concept and Norm,” in *Towards Sustainable Development: On the Goals of Development and the Conditions of Sustainability* (London: Palgrave Macmillan UK, 1999), 1–29; Steve Connelly, “Mapping Sustainable Development as a Contested Concept,” *Local Environment* 12, no. 3 (2007): 259–78.

⁷⁸ Jennifer Clapp and Caitlin Scott, “The Global Environmental Politics of Food,” *Global Environmental Politics* 18, no. 2 (May 2018): 3; Judith Janker, Stefan Mann, and Stephan Rist, “What Is Sustainable Agriculture? Critical Analysis of the International Political Discourse,” *Sustainability* 10, no. 12 (2018):1-19.

Paradigms of agri-food system offer distinct paths and regarding the questions of “how food is produced, who produces it, how it is sold ... where the food is produced (global versus local sourcing) and the place of food in human health.”⁷⁹ Alternative paradigms for the post-productivist agri-food system have been named and categorized in several ways. Among these competing visions, sustainable intensification and agroecology are among the most referred ones. These two broad visions have been alternatively called sustainable agricultural intensification vs. agro-ecological intensification,⁸⁰ Life Sciences integrated paradigm vs. ecologically integrated paradigm,⁸¹ and food security vs. food sovereignty.⁸²

The most fundamental distinction between these alternative paradigms, discourses, normative agendas or methods is the degree of emphasis on the social and political aspect of sustainability. In other words, alternative ideas about the future of the agri-food system differ in terms of the level at which they identify the problem and the nature of the solution they propose. They engage in a struggle over whether to maintain existing economic and social structures. For example, Holt-Giménez and Shattuck conceptualizes the debate over the future of agri-food system as a social and political struggle rather than a technical disagreement, therefore categorizes alternative visions into four, neoliberal, reformist, progressive and radical, in line with their positions between reform and transformation.⁸³

Lang and Heasman calls the food war over the post-productivist era as a struggle between two basic paradigms or worldviews. The productionist paradigm, which had been dominant so far, is being challenged by the near-mainstream Life Sciences

⁷⁹ Lang and Heasman, *Food Wars*, 18.

⁸⁰ Jonathan Mockshell and Josey Kamanda, “Beyond the Agroecological and Sustainable Agricultural Intensification Debate: Is Blended Sustainability the Way Forward?,” *International Journal of Agricultural Sustainability* 16, no. 2 (2018): 127–49; Barbara Bernard and Alexandra Lux, “How to Feed the World Sustainably: An Overview of the Discourse on Agroecology and Sustainable Intensification,” *Regional Environmental Change* 17, no. 5 (2017): 1279–90. See also Gliessman, *Agroecology*, 19–31; Breitmeier et al., “Politicized Sustainability,” 652–43.

⁸¹ Most notably in Lang and Heasman, *Food Wars*.

⁸² Jennifer Clapp, “Food Security and Food Sovereignty: Getting Past the Binary,” *Dialogues in Human Geography* 4, no. 2 (2014): 206–11; Jarosz, “Comparing Food Security,” 168–81.

⁸³ Holt-Giménez and Annie Shattuck, “Food Crises, Food Regimes and Food Movements,” 109–44.

Integrated paradigm and the relatively marginalized Ecologically Integrated paradigm. Proponents of the Life Sciences integrated paradigm argue that it is possible to solve problems related to human and environmental health by using the methods and tools of biotechnology in food production, in particular plant and animal breeding methods based on genetic engineering. It promotes a vision of food production in which the harmful practices of the current productivist paradigm are eliminated with the tools of science and technology. Consistent with productivist paradigm, it promotes a revised yet equally totalizing project in which locally, geographically and culturally established practices in terms of food production and consumption are replaced with better, technology-led solutions. For example, with the Golden Rice projects, scientists developed a rice variety by inserting several genes into the rice genome which in turn increased the amount of beta-carotene, a precursor of Vitamin A. In other words, they managed to increase the amount of Vitamin A taken by consumers of this genetically modified rice variety. This project has been praised as a breakthrough biotechnological solution for solving Vitamin A deficiency among kids in underdeveloped countries. Therefore, Golden Rice project constituted a direct intervention mechanism through technology, food and health, and presented as the prime example of “genetically engineered, technical-fix solution”.⁸⁴ In fact, this paradigm has been called the neo-productivist vision by its critics and equated with the sustainable intensification since the 2000s.⁸⁵ Once again monoculture farming, universal diets and globalized agribusiness are prioritized instead of diversified food systems, local markets and small-scale farming communities.⁸⁶

Sustainable intensification aims to strike a balance between increasing population and depleted resources by making production more efficient. It is a technical design based on resource use efficiency for increasing output while reducing input. Lately, this vision began occupying a privileged position within global agri-food politics. The adaptation of technical advances, especially biotechnology and digital farming, is

⁸⁴ Colin Sage, “Food Security, Food Sovereignty and the Special Rapporteur: Shaping Food Policy Discourse through Realising the Right to Food,” *Dialogues in Human Geography* 4, no. 2 (2014): 197.

⁸⁵ Wilson and Burton, “‘Neo-Productivist’ Agriculture”; Montenegro de Wit and Canfield, “‘Feeding the World, Byte by Byte’,” 384.

⁸⁶ Lang and Heasman, *Food Wars*, 21-22.

promoted as the appropriate way for increasing resource use efficiency. Therefore, sustainable intensification has been promoted by its proponents as a revision of the Green Revolution for making it “greener, double-green, evergreen, real green, greening of the green revolution.”⁸⁷ This vision is accompanied by non-farming rules and institutions, particularly with a greater emphasis on the liberalization of agri-food markets and enhancement of existing intellectual property rights. Accordingly, it offers technical revisions to the existing production, consumption and access dynamics in the agri-food system. With this emphasis, sustainable intensification reduces the problem to a technical level, and the solution to technological development.⁸⁸ Therefore, it ignores calls for a structural transformation of the economic, social and political institutions within the agri-food system.

Against this problem-solving approach and its ongoing failures in feeding the world equitably, a transformative agenda has been developed by critical food movements. Lang and Heasman calls the alternative the Ecologically Integrated paradigm, which recognizes the co-existence of human, food, and nature, and aims to maintain diversity in production and consumption practices.⁸⁹ Agroecology, for example, made its way through the halls of global agri-food platforms as a candidate for implementing sustainable agriculture. Rather than reforming the globalized agri-food system incrementally, proponents of agroecology call for a total replacement of neo-productivist approaches with a decentralized agri-food system, one that protects and promotes indigenous cultures, local practices, fair trade relations, social justice, food and seed sovereignty. Under pressures from civil society and grassroots movements, Food and Agriculture Organization (FAO) has developed 10 elements of agroecology reflecting its understanding of this approach.⁹⁰

⁸⁷ Paul C. Struik and Thomas W. Kuyper, “Sustainable Intensification in Agriculture: The Richer Shade of Green. A Review,” *Agronomy for Sustainable Development* 37 (2017): 3

⁸⁸ *Ibid.*, 1.

⁸⁹ Lang and Heasman, *Food Wars*, 26.

⁹⁰ Food and Agriculture Organization of the United Nations, “The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems,” FAO’s 10 elements of agroecology are “diversity, synergies, efficiency, resilience, recycling, co-creation and sharing of knowledge, human and social values, culture and food traditions, responsible governance, circular and solidarity economy.”

However, increasing visibility of critical approaches such as agroecology within global policy-making platforms do not guarantee the long desired transformation. On the contrary, it might lead to the co-optation of the transformative movement. For the proponents of neo-productivist paradigm, it gets costly to maintain appropriateness of existing practices under the existing problems and rising objections. One way to legitimize ‘business as usual’ model that powerful actors often employ is to tame critical discourses and movements by stripping them from their politically or ideologically guided elements in a way to decontextualize transformational spirit.

Critical agri-food system experts cautioned against the increasing number and prominence of seemingly reformist framings and narratives at the global policy spaces which nonetheless remain committed to neo-productivist paradigm of agriculture. Several promising narratives, including regenerative agriculture, climate-smart agriculture, conservation agriculture, organic agriculture and nature-based solutions, might sterilize structural reform demands from their political and social underpinnings.⁹¹ Even the term agroecology itself remains as a battleground on which a struggle over its meaning unfolds. Pimbert noted that the agroecology within the food sovereignty movement differs vastly from an interpretation of agroecology embedded in climate-smart agriculture narrative. Each offers distinct “normative visions of the future that either seeks to conform to the dominant industrial food and farming system, or to radically transform it.”⁹² As a result of ongoing struggle, the meaning of agroecology had been further destabilized to the point that it is possible to mention two forms of agroecology, a reformist, green revolution compatible one and a radical, food sovereignty based one.⁹³ For this reason, critical scholars pointed out that agroecology refers more than a set of well-defined principles that guides a particular form of agricultural practice. Instead, it is also a scientific discipline that contains distinct knowledge production practices, and an increasingly consolidated

⁹¹ IDS and IPES-Food, *Agroecology, Regenerative Agriculture, and Nature-based Solutions: Competing Framings of Food System Sustainability in Global Policy and Funding Spaces* (2022), 7.

⁹² Michel Pimbert, “Agroecology as an Alternative Vision to Conventional Development and Climate-Smart Agriculture,” *Development* 58, no. 2 (2015): 287.

⁹³ Holt-Giménez and Altieri, “Agroecology, Food Sovereignty and the New Green Revolution,” 90-102.

political and social movement.⁹⁴ Steve Gliessman revisited the origins of agroecology as a resistance movement against the Green Revolution in Mexico, and argued that agroecology as a social movement, that is committed to foster social justice, should remain at the core of the term along with agroecology as science (science & technology) and agroecology as a practice (farming) in order not to “let the artificial separation of these three areas be an excuse some may use to justify doing only the research or technology parts.”⁹⁵

2.5. Global Governance of Agri-Food System

In parallel with the extension of the food and agriculture into the agrifood system, its global governance has also expanded to include interrelated topics. In this process, there has been a proliferation of issues, actors and governance formats. The governance format was initially designed as an intergovernmental forum; small number of international organizations and mega summits convened in the aftermath of food crises. It has subsequently become more flexible with the spread of inclusivity and multistakeholderism. On the other hand, while initially aiming to solve related but separate single problems such as ending hunger, ensuring food security and achieving agricultural modernization, in the following period, it started to address multiple agendas, sometimes conflicting, such as ensuring environmental sustainability while ending hunger; liberalization of international trade while ensuring food security; maintaining financial discipline or expanding intellectual property rights while ensuring agricultural modernization; and protecting the rights of farmers, rural and indigenous peoples while increasing production.

A reason for the emergence of these multi-issue agendas is the increasing institutional density of the global governance architecture to accommodate new agendas. With the emergence of different actors, international organizations, treaties and eventually regimes, the number of processes, rules and norms affecting the field of food and

⁹⁴ Alexander Wezel et al., “Agroecology as a Science, a Movement and a Practice: A Review,” *Agronomy for Sustainable Development* 29, (2009): 503-515.

⁹⁵ Steve Gliessman, “Agroecology: Growing the Roots of Resistance,” *Agroecology and Sustainable Food Systems* 37, no. 1 (2013): 19–31; Steve Gliessman, “A Voice for Sustainability from Latin America: Editorial,” *Journal of Sustainable Agriculture* 36, no. 1 (2012): 1.

agriculture proliferated. This has placed the global governance of the food and agriculture system within a regime complex consisting of actors working with multiple and interrelated mandates with sometimes conflicting norms and rules.⁹⁶ For example, Margulis defined the global governance of food security as “a complex and fluid set of inter-organizational clusters that work on one or multiple dimensions of world food security” that consists of seven policy areas which are nutrition, agricultural production, agricultural trade, food safety, human right to food, agriculture and development, agriculture and climate change.⁹⁷

The first step for international cooperation in the agri-food system was taken during the Second World War to combat hunger and malnutrition. US President Roosevelt, following the advice of his advisors that food would be an appropriate topic for international cooperation in the post-war period, convened the United Nations Conference on Food and Agriculture, the first of many, in Hot Springs, Virginia on 18 May-3 June 1943. Attended by forty-four country representatives, the conference defined the problem as originating from poverty and pointed out the need for a concerted effort to achieve the goal of “freedom from hunger”.⁹⁸

2.5.1 FAO

Following the decision of the 1943 Conference, FAO was established on 16 January 1945, 8 days before the United Nations Charter.⁹⁹ The FAO, with Boyd Orr as its first Director-General (DG), was equipped with a broad mandate to raise nutrition levels, improve food production and distribution, and end hunger.¹⁰⁰ Orr thought that the post-war situation necessitates more fundamental and structural solutions to combat food

⁹⁶ Margulis, “Regime Complex for Food Security,” 53-67.

⁹⁷ Matias E. Margulis, “The Global Governance of Food Security,” in *Handbook of Inter-Organizational Relations*, ed. Joachim A. Koops and Rafael Biermann (London: Palgrave MacMillan, 2016), 505.

⁹⁸ Ralph W. Phillips, *FAO: Its Origins, Formation and Evolution 1945–1981*, no. 284 (Rome: Food and Agriculture Organization of the United Nations, 1981); United Nations Conference on Food and Agriculture, *Final Act and Section Reports: Hot Springs, Virginia, May 18–June 3, 1943* (Washington, DC: U.S. Government Printing Office, 1943).

⁹⁹ Margaret Rose Biswas, “FAO: Its History and Achievements During the First Four Decades, 1945–1985” (PhD thesis, University of Oxford, 2007).

¹⁰⁰ Shaw, *World Food Security*, 4.

crisis beyond the emergency food supply. Under these circumstances, Orr proposed to “reorganise international agricultural trade on a non-free-market basis” through a World Food Board with executive authority, focusing not just food production and trade but also on the broader relationship between nutrition, health, agriculture, industry and trade.¹⁰¹ The proposal included the establishment of a system to coordinate grain production and trade and to distribute surplus food. This system included a proposal for the establishment of a fund to stabilize grain prices in the world market; the creation of a world food reserve against supply problems; the collection of resources to ensure the distribution of excess agricultural production under favorable conditions; and finally, cooperation with international credit, trade and other financial institutions for industrial and agricultural development.¹⁰² However, this proposal was rejected by the USA and the UK. For them, it was unacceptable to delegate regulatory power in grain trade and finance to an intergovernmental organization which operated on the basis of one-country-one vote system. The US began supplying its surplus food unilaterally, first through the Marshall Plan and later with the Food for Peace programme.¹⁰³ Orr found this rejection understandable “Britain and America were not prepared to give either funds or authority to an organization over which they had not got full control”.¹⁰⁴ Nevertheless, his disappointment was clear and he resigned from his post in the summer of 1948. In 1949, he was awarded the Nobel Peace Prize for his organizational and academic work that contributed to ending hunger.¹⁰⁵ According to Addeke Boerma, another FAO DG, it was a political and ideological refusal, beyond technical and logistical reasons.¹⁰⁶

¹⁰¹ Nora McKeon, *The United Nations and Civil Society: Legitimizing Global Governance—Whose Voice?* (Bloomsbury Publishing, 2009), 18.

¹⁰² Shaw, *World Food Security*, 24.

¹⁰³ Margulis, “Regime Complex for Food Security,” 55.

¹⁰⁴ Shaw, *World Food Security*, 27.

¹⁰⁵ McKeon, *Food Security Governance*, 14.

¹⁰⁶ Shaw, *World Food Security*, 29.

2.5.2 World Food Programme 1961

United States had been ‘dumbing’ its surplus since the WW2. Moreover, the Food Aid, through long-term loans and concessional sales below market prices created an international market in which others failed to compete. Several rounds of GATT witnessed intense debates regarding this issue.¹⁰⁷ In response to these objections, the FAO Council adopted the “FAO Principles of Surplus Disposal” in 1954 and to ensure “... constructive use of surplus agricultural commodities and at the same time safeguards the interest of commercial exporters and local producers”.¹⁰⁸ In addition to criticism from other exporters, the review of the Food for Peace Programme during Kennedy presidency led policy-makers for its multi-lateralization. George McGovern, as the head of the Food for Peace Programme, advised Kennedy that FAO's role should be expanded and tasked with operating the multilateral food distribution program.¹⁰⁹ Thus, in 1962, the World Food Programme (WFP) was established as a joint UN/FAO initiative. It was decided that the executive director of the program would be appointed by the FAO Director-General and the UN Secretary General, and the FAO DG was designated as the trustee of the WFP fund. The WFP both relieved the US from unilateral food aid and allowed other exporting countries to participate. However, the WFP has traditionally been a program where US dominated the agenda. There have been struggles between WFP executive directors and FAO DGs. WFP finally obtained a relatively more independent status after a series of decision taken in 1992. Since then, all the executive directors, despite being appointed by FAO DG, have been US citizens.¹¹⁰

¹⁰⁷ Matias E. Margulis, “The Forgotten History of Food Security in Multilateral Trade Negotiations,” *World Trade Review* 16, no. 1 (2017): 25–57.

¹⁰⁸ Food and Agriculture Organization of the United Nations, *Reporting Procedures and Consultative Obligations Under the FAO Principles of Surplus Disposal: A Guide for Members of the FAO Consultative Subcommittee on Surplus Disposal* (Rome: FAO, 2001), iii.

¹⁰⁹ Shaw, *World Food Security*, 96.

¹¹⁰ D. John Shaw, *The UN World Food Programme and the Development of Food Aid* (Palgrave, 2001), 222; Sebastian Schindler, “Man versus State: Contested Agency in the United Nations,” *Millennium Journal of International Studies* 43, no. 1 (2014): 3–23.

2.5.3 FAOs Freedom From Hunger Campaign (1959-1980)

In 1956, newly elected FAO Director-General Binay Ranjan Sen realized that poverty, hunger and malnutrition could not be solved with short-term programs due to their structural causes, thus offered a long-term campaign, called Freedom From Hunger Campaign (FFHC) in order to draw attention to the problem, ensure the participation and cooperation of all those affected, and initiate global mobilization, thus to trigger national and international action.¹¹¹ The FFHC, endorsed by ECOSOC and approved by the FAO Conference, was extended for 5-year periods and continued until the 1980s. Through the campaign, UN bodies, governments, civil society, private sector and others were brought together through various mechanisms to work on a common agenda. The FFHC enabled grassroots movements from the South into the UN system. These early instances of local participation through FFHC increased the visibility of grassroots movements within the global governance of food and agriculture. Despite its success, the campaign declined under the new Director-General, Edouard Saouma (1975-1993), whose negative attitude towards the civil society has argued to had a remarkable legacy within FAO's institutional strategy in cooperating with the non-state actors.¹¹²

2.5.4 The First Mega Summit: World Food Conference (1974)

The food crisis of the 1970s increased criticism towards FAO for failing to ensure the continuity of food supply.¹¹³ Ironically, the mechanisms proposed by the FAO to solve these problems, such as regulating international trade and creating food reserves, had been rejected by its very critics.¹¹⁴ The leaders of the non-aligned movement met in 1973 and proposed to organize an international conference to solve food shortages and stabilize market prices. US Secretary of State, Henry Kissinger, in his first ever statement to the UN General Assembly on 24 September 1973, proposed a World Food

¹¹¹ Shaw, *World Food Security*, 77.

¹¹² McKeon, *United Nations and Civil Society*, 20-22.

¹¹³ Biswas, *FAO: Its History*, 54.

¹¹⁴ Shaw, *World Food Security*, 27; McKeon, *United Nations and Civil Society*, 18.

Conference under the auspices of the UN.¹¹⁵ In fact, the US, and Kissinger in particular, were against allowing intergovernmental mechanisms into food trade and aid issues for using them as diplomatic tools. However, several reasons led to his call for a Conference under the umbrella of the UN. Kissinger was under heavy criticism from the Third World for his policies, thus this proposal was a move against such criticism.¹¹⁶ On the other hand, the financial burden of the Food Aid program was getting out of hand, thus the need to share the burden not just with other net exporter countries, but also OPEC seemed reasonable.¹¹⁷

The proposal to move the conference out of FAO's sphere and place it under the United Nations had two dimensions: Firstly, Kissinger wanted to maintain the Food Aid policy in line with his foreign policy purposes. However, the US Department of Agriculture, influential within FAO circle, were favoring free trade in agriculture. Therefore, Kissinger wanted to limit USDA's influence by moving the issue into the UN. Secondly, he wanted USSR, which was not a FAO member, to participate in the conference.¹¹⁸ On the grounds that such an UN-led process would narrow its mandate and field of activity, FAO demanded that the conference, its secretariat and preparations be organized under their responsibility.¹¹⁹ However, these demands were rejected, and the preparations for the conference were funded by the Ford Foundation and the Rockefeller Foundation.¹²⁰ These developments were part of the US attempts to weaken FAO's mandate through the CGIAR.¹²¹

The Conference resulted in a UNGA declaration, 21 conference resolutions, three new institutions, International Fund for Agricultural Development (IFAD), World Food Council (WFC), FAO Committee on World Food Security (CFS), and a consensus on

¹¹⁵ Shaw, *UN World Food Programme*, 80.

¹¹⁶ Biswas, *FAO: Its History*, 55.

¹¹⁷ Shaw, *World Food Security*, 122.

¹¹⁸ Shaw, *World Food Security*, 122.

¹¹⁹ Biswas, *FAO: Its History*, 55.

¹²⁰ McDonald, *Food Power*, 183.

¹²¹ See Chapter 6.

the origins of the food problem (quantity and distribution) and solutions (production, aid, development) for addressing it, that is through international cooperation for food security. The “Universal Declaration on the Eradication of Hunger and Malnutrition” adopted by the UNGA one month after the conference remains to be one of the leading normative sources in global food policy. The Declaration recognizes the ‘right to be free from hunger and malnutrition’ of all people, sets ‘eradication of hunger’ as a common goal of all countries and defines the fundamental responsibility of governments “to work together for higher food production and a more equitable and efficient distribution of food between countries and within countries”.¹²² The Conference also adopted several resolutions for each of the agendas including fertilizers, pesticides, seed industry, research and education, water management, women and food, trade and other topics.

The 1974 Conference associated the Food Crisis with production (quantity) and distribution problems, thus ignoring root causes, and political issues. Therefore, “adequate production and distribution of food as well as the establishment of a world food security system...” emerged as the consensus solution.¹²³ In order to increase food production, it was decided to increase the efficiency provided by science and technology (i.e. Green Revolution). Moreover, it was also decided to support agricultural research centers and other scientific initiatives, and to fund agricultural modernization. The Conference agreed to strengthen bilateral and multilateral, such as WFP, processes to overcome distribution problems. The International Fund for Agricultural Development (IFAD) was established as a funding agency for the developing countries. With IFAD, it was aimed to force OPEC countries, which were reluctant to fund through the World Bank system, to share the burden.¹²⁴

The idea of establishing a political forum for coordination and negotiation of the global food security system emerged as an idea. FAO was concerned, once again, a restriction

¹²² United Nations General Assembly, *Universal Declaration on the Eradication of Hunger and Malnutrition*, Resolution 3348 (XXIX), December 16, 1974, <https://digitallibrary.un.org/record/57723>.

¹²³ Ibid.

¹²⁴ Biswas, *FAO: Its History*, 56.

on its mandate.¹²⁵ The proposal to establish a World Food Authority with a strong and broad mandate was not accepted. Instead, it was suggested that the World Food Council (WFC) be established, and its members be selected from the members of the UN Security Council. The aim was to make politics of food as a core issue within international relations. Ultimately, the decision was taken to establish the World Food Council (WFC) to conduct high-level political processes at the UN level. The WFC, which would be hosted by FAO and submit its reports to the UN General Assembly, was created with a direct ‘politics of food’ agenda, apart from technical and financial issues.¹²⁶ However, it was a rather weak and “a pale reflection of the originally proposed World Food Authority”, thus short-lived and terminated in 1994.¹²⁷ Another institution established by the Conference was the Committee of World Food Security (CFS), which was tasked with monitoring food stocks, demand and supply, and to exchange ideas and best practices among countries. The CFS, considered insignificant at that time for not being a policy-making arena, lived longer than the WFC, and has become the most important negotiation forum of international food policies with the structural reform it underwent in 2009.

2.5.5 International Trade-WTO

Agriculture and Food were not included in the GATT, which regulated international trade between 1947 and 1994. Free movement of food has been debated during various rounds, yet no common position was found between net exporters and net importers. As previously mentioned, the US pushed agri-food topic off the free trade agenda since its Food Aid policy had been selectively applied as a carrot and stick strategy during the Cold War. This regime changed in 1995 with the WTO, Agreement on Agriculture and Trade-Related Aspects of Intellectual Property Rights. The AoA attempted to remove trade-distorting interventions by placing agriculture within the international trade regime in line with the WTO. During the negotiations leading up to the AoA, there were considerable debates whether liberalization of agri-food trade would

¹²⁵ Shaw, *World Food Security*, 138.

¹²⁶ Biswas, *FAO: Its History*, 56; McKeon, *United Nations and Civil Society*, 193.

¹²⁷ Shaw, *World Food Security*, 147.

negatively affect food security. Grassroot movements strongly protested liberalization of agri-food system. US and other supporters of full liberalization argued that food security would be achieved through free trade. As a result of this debate, WTO established “Working Group for Trade and Food Security” to monitor the impact of treaty on food security.¹²⁸

AoA attributed a special status to agriculture in broader liberal trade regime. In line with developing countries position, it frames food security as a “non-trade concern” that justifies domestic supports under specific conditions, particularly for agricultural and rural development, low-income and resource poor farmers through direct food subsidies and food assistance programs in developing countries. It allows public food stockholding as an integral part of food security measures, along with domestic food aid programs that would enable citizens to buy food below market prices.¹²⁹

TRIPs enabled agrifood corporations and biotechnology firms to operate within national markets, especially in input sectors such as seeds. It is argued that TRIPs further institutionalized the legal regime that favors “mainstreaming biotechnology in agricultural production on a global scale and for the potential closure of a public commons for seed saving and distribution.”¹³⁰

2.5.6 World Food Summit 1996

In 1993, Jacques Diouf, who was appointed as FAO Director-General, proposed to organize a conference despite the lack of any sign of a food crisis and the ‘conference fatigue’ of the 1990s. The conference was attended by 6600 delegates from 190 countries and 1200 NGOs from 80 countries. The “Rome Declaration on World Food Security” and the ‘World Food Summit Plan of Action” prepared through an intense

¹²⁸ Ibid., 354.

¹²⁹ World Trade Organization, *Agreement on Agriculture*, annex to the *Marrakesh Agreement Establishing the World Trade Organization*, April 15, 1994, https://www.wto.org/english/docs_e/legal_e/ag_e.htm#art6.

¹³⁰ Margulis, *Hunger in a Globalizing World*, 21.

dialogue process during the preparation of the conference, were unanimously adopted at the beginning of the conference despite some reservations.¹³¹

The adopted declaration unusually brought food into the framework of human rights by referring to Art. 11 of the International Covenant on Economic, Social and Cultural Rights (ICESCR), which declared the common objectives of states as “promotion and protection of... progressive realization of the right to adequate food”.¹³² Governments declared their willingness to take the necessary steps to realize ICESCR Art. 11. The UN High Commissioner for Human Rights and FAO were invited to co-operate in providing recommendations for the clarification and realization of the rights under Article 11.¹³³ It was a decisive moment in the global governance of food security. FAO began working closely with Geneva-based Human Rights bodies with the Memorandum of Understanding signed with OHCHR. Following this early move, the Committee on Economic, Social and Cultural Rights (CESCR) adopted General Comment 12 on the right to adequate food in 1999, clarifying the meaning, spelled out the foundational concept and set out state obligations to respect, to protect and to fulfill. Following these developments, in 2000 the Human Rights Commission established the Special Rapporteur on Right to Food (SrRT) to mainstream Right to Food withing global governance of agrifood and to cooperate with FAO. Five years after the World Food Summit, the declaration adopted at the World Food Summit +5 mandated the FAO Council to establish an Intergovernmental Working Group to prepare Voluntary Guidelines on Right to Food (VgRT) which was adopted in 2005 after a close collaboration among SrRT and grassroots farmers’ movement.

The 1996 Summit enabled new actors in the global governance of food and agriculture as FAO deliberately included southern and grassroots movements in the preparatory process. The 1996 Summit was decisive for the institutionalization of La Via

¹³¹ Shaw, *World Food Security*, 350.

¹³² United Nations General Assembly, *International Covenant on Economic, Social and Cultural Rights*, opened for signature December 16, 1966, 993 U.N.T.S. 3 (entered into force January 3, 1976), <https://www.refworld.org/legal/agreements/unga/1966/en/33423>.

¹³³ Food and Agriculture Organization of the United Nations, *Rome Declaration on World Food Security and World Food Summit Plan of Action: World Food Summit, 13–17 November 1996, Rome, Italy* (Rome: Food and Agriculture Organization of the United Nations, 1996), <https://digitallibrary.un.org/record/195568>.

Campesina and the establishment of its transnational networks. Parallel to the 2002 summit, the NGO/CSO ‘Forum for Food Sovereignty: A Right for All’ led to the creation of the International Planning Committee on Food Sovereignty (IPC).¹³⁴ The IPC was designed as ‘a space of co-ordination’ bringing together a large number of actors with different visions on the future of the food system. This period was the formative years of grassroots movements in the global governance of food and agriculture. There were significant debates on which frame to be used against the dominant paradigm of Food Security. Food Sovereignty and Right to Food emerged as the main discourses and visions challenging the productionist understanding of Food Security.¹³⁵ IPC was recognized by FAO in 2003 through the Exchange of Letters.¹³⁶ Thus, it ensured the participation of small-scale farmers and peasants in the FAO-led processes.

The Food Crisis of 2007-2008 led to the questioning of the success of global governance in solving food problems. FAO was, once again, the usual suspect. The crisis has strengthened the view that the focus should be directed to structural problems and that political rather than technical solutions are needed. Moreover, it is recognized, at least by some actors, that the fragmented structure of global governance, especially with the introduction of the WTO, has increased its vulnerability.¹³⁷ There were competing proposals and initiatives to reform the system. One of them was the Geneva Consensus, offered by WTO director Pascal Lamy, which aimed to institutionalize the organized fragmentation.¹³⁸ Another was the High-Level Task Force on the Global Food Security Crisis, established by the UN Secretary-General, as a technical and administrative solution for strengthening cooperation between existing institutions. G8

¹³⁴ “About Us,” International Planning Committee for Food Sovereignty, accessed January 10, 2025, <https://www.foodsovereignty.org/about/>.

¹³⁵ Claey's, *Human Rights and the Food Sovereignty Movement*.

¹³⁶ McKeon, *United Nations and Civil Society*, 77-78.

¹³⁷ Olivier De Schutter, “The Reform of the Committee on World Food Security: The Quest for Coherence in Global Governance,” in *Rethinking Food Systems: Structural Challenges, New Strategies and the Law*, ed. Nadia C.S. Lambek, Priscilla Claey's, Adrienna Wong, and Lea Brilmayer (Springer, 2014), 220.

¹³⁸ *Ibid.*, 227.

countries established the Global Partnership for Agriculture and Food Security, as an attempt to maintain business as usual.¹³⁹

The alternative plan was to reform the Committee on World Food Security (CFS). The negotiations for reform were fierce but open to civil society's participation. While developed countries wanted to design the CFS as a "platform for sharing good practices", grassroots movements and developing countries pushed for making it a political forum. Ultimately, the CFS was reformed "as the foremost inclusive international and intergovernmental platform in the field of food security and nutrition".¹⁴⁰ The Civil Society Mechanism (CSM) was established within CFS and institutionalized civil society participation in political negotiations. As a result of this reform, the voices of those most affected were officially heard in the decision-making processes for the first time.¹⁴¹

2.5.7 A New Form of Governance

However, the role of the CFS as the foremost mechanism has quickly eroded as developed countries and the private sector began forming new alliances to ignore existing mechanisms.¹⁴² The fragmentation of global governance is further worsened by another process that claims to address the problems emerging from the fragmentation itself. A new governance model has emerged in recent years and is rapidly becoming the dominant problem-solving mechanism of global governance architecture. This governance system, observed in areas such as climate change, environment, health, education, food and agriculture, human rights, internet governance, is an ongoing formation that replaces intergovernmental mechanisms with "a loose ecosystem of multi-actor-coalitions partnering around common goals, but

¹³⁹ McKeon, *Food Security Governance*, 9.

¹⁴⁰ McKeon, *Food Security Governance*, 108.

¹⁴¹ Josh Brem-Wilson, "Towards Food Sovereignty: Interrogating Peasant Voice in the United Nations Committee on World Food Security," *Journal of Peasant Studies* 42, no. 1 (2015): 73–95; Ingeborg Gaarde and Olivier De Schutter, *Peasants Negotiating a Global Policy Space: La Via Campesina in the Committee on World Food Security* (Routledge, 2017).

¹⁴² Shalmali Guttal, "Re-imagining the UN Committee on World Food Security," *Development* 64, no. 3 (2021): 227–235.

without mechanisms of accountability”.¹⁴³ This new mode of governance, conceptualized as ‘Multistakeholder Governance’, includes dynamic and issue-based networks among different actors such as philanthropy, IOs, the UN system, development organizations, international financial institutions, states, private sector, universities, research institutions, and civil society.¹⁴⁴

The World Economic Forum established the framework of this model with the Great Redesign Initiative launched in 2010. In its report, the WEF proposed a rebuilding of the existing framework of global cooperation in order to reduce the risks and seize opportunities in a world where interdependence is all dominating. It argued that risks and opportunities affect each and every actor as a result of social and technological connections. Moreover, states are no longer the dominant regulators of these beyond state connections. WEF’s Great Redesign offers a broad and multidimensional system of global cooperation in which intergovernmental, both legal and institutional, mechanisms still play a fundamental, but a limited role. It urges that experience and resources of non-state actors should be made available to realign the inefficient rules and rather weak capacities of states.¹⁴⁵

UN Secretary-General supported this new mode of governance by arguing that problems of 21st century requires initiatives beyond the existing multilateralism based on intergovernmental processes; thus a new form of multilateralism “that is more networked, more inclusive and more effective.”¹⁴⁶ In this new form of multilateralism, UN play a key role as a “trusted platform for collaboration between a growing number

¹⁴³ Askha Naik et al., “Corporate Capture of FAO: Industry’s Deepening Influence on Global Food Governance,” (Corporate Accountability & FIAN International, 2022), 15, <https://www.fian.org/files/files/CorporateCaptureoftheFAO-EN.pdf>.

¹⁴⁴ Harris Gleckman, *Multistakeholder Governance and Democracy: A Global Challenge* (Routledge, 2018).

¹⁴⁵ World Economic Forum, “Everybody’s Business: Strengthening International Cooperation in a More Interdependent World,” (Report of the Global Redesign Initiative, 2010), 7, https://www3.weforum.org/docs/WEF_GRI_EverybodysBusiness_Report_2010.pdf.

¹⁴⁶ United Nations, *Our Common Agenda – Report of the Secretary-General* (New York: United Nations, 2021), 66, https://www.un.org/en/content/common-agenda-report/assets/pdf/Common_Agenda_Report_English.pdf.

and diversity of actors.”¹⁴⁷ The concept of “corporate-led multistakeholderism” is widely used to define this new mechanism since multistakeholder initiatives are heavily dominated by the private sector representatives either through their management or planning. Therefore, critics called this transformation as the “corporate capture” of UN systems since they replace existing, accountable, mechanisms.¹⁴⁸

Manahan and Kumar identified 103 Multistakeholder Initiatives in their mapping study in five areas of environment, education, health, food & agriculture and the internet. In the field of Food and Agriculture, they analyzed and mapped 27 MSIs.¹⁴⁹ They observed that while the private sector is strong in the management of MSIs, Northern countries and Philanthropy are at the biggest funders. MSIs do not reflect the diversity of ‘stakeholders’ with different interests, capabilities, rights and responsibilities, and this creates a lack of accountability compared to intergovernmental multilateralism. On the other hand, they questioned whether the supposedly inclusive nature of these initiatives genuinely ensured that the non-state actors participating in MSIs represented a broad spectrum of non-state agents. For example, the Alliance for Green Revolution in Africa (AGRA),¹⁵⁰ despite being a public-private-philanthropy MSI itself, is recognized as a Civil Society in several MSIs in which it participates. Moreover, AGRA's claim to represent Africa is highly questionable given the ‘real’ and inclusive farmers' organizations that had been forged for decades. The proliferation of MSIs has also sidestepped human rights-based norms in the agri-food sector. Most MSIs offer market-oriented solutions such as efficiency, competition, productivity. The prescriptions offer conceptualize food-related

¹⁴⁷ Ibid., 16.

¹⁴⁸ Kirtana Chandrasekaran, Shalmali Guttal, Madhuresh Kumar, Laura Langner, and Mary Ann Manahan, *Exposing Corporate Capture of the UNFSS through Multistakeholderism* (Food Systems 4 People, 2021), <https://www.foodsystems4people.org/wp-content/uploads/2021/09/UNFSSreport2021.pdf>; Philip McMichael, “Shock and Awe in the UNFSS,” *Development* 64, no. 3-4 (2021): 162.

¹⁴⁹ Mary Ann Manahan and Madhuresh Kumar, *The Great Takeover: Mapping of Multistakeholderism in Global Governance* (People’s Working Group on Multistakeholderism, 2022), <https://www.tni.org/en/publication/the-great-takeover>.

¹⁵⁰ AGRA was originally the acronym of the initiative. However, due to widespread distrust of the term “Green Revolution,” it renamed itself simply as AGRA. See Timothy A. Wise, “AGRA Retreats from its Own ‘Green Revolution,’” *Food Tank*, October 26, 2022, <https://foodtank.com/news/2022/10/agra-retreats-from-its-own-green-revolution/>.

problems on the century-old production-distribution equation and offer a solution based on science and innovation. Even the most ambitious MSI, the SUN Movement, has failed to mainstream a human rights-based approach to food, thus ignored the root causes of global hunger and crucial links between food and agricultural. For example, the WEF-led New Vision for Agriculture Initiative aims to “demonstrate that the market-based, multistakeholder approach can deliver food security, environmental sustainability and economic opportunity.”¹⁵¹

In a recent study, Slater et al. mapped the boards of Ultra-Processed Food (UPF) industry MSIs in the Global Food Governance through network analysis to reveal who makes the calls in MSIs. They identified 601 board seat position in 45 MSIs. 431 of these positions are filled by executives of transnational corporations. What makes it more troublesome is that 263 of these positions are filled by representatives of the UPF industry or related interest groups. A small number of mega corporations such as Unilever, Nestle, PepsiCo, The Coca-Cola Company, and similar actors are over-represented in these positions. In terms of country-based classification, they found out that 495 board seat positions were filled by countries from the global north, 350 of which were filled by only four countries.¹⁵²

Another study applied a network analysis on AGRA, and similar to earlier studies, found out that AGRA’s network is “dominated by foundations, intergovernmental organizations, corporations and development agencies, with decision-making located within Global North institutions.”¹⁵³ Rather than help transformation of African agricultural systems through an inclusive process with a strong all-affected principles, AGRA follows, or rather leading the way for “an ideological advocacy network which centers on pro-business and technology-oriented values.”¹⁵⁴ Authors concluded that

¹⁵¹ World Economic Forum, “New Vision for Agriculture? A Global Initiative of the World Economic Forum,” https://www3.weforum.org/docs/WEF_CO_NVA_Overview.pdf.

¹⁵² Scott Slater et al., “The Rise of Multi-stakeholderism, the Power of Ultra-processed Food Corporations, and the Implications for Global Food Governance: A Network Analysis,” *Agriculture and Human Values* 42 (2025): 1-16.

¹⁵³ Stefan Vicedom and Rachel Wynberg, “Power and Networks in the Shaping of the Alliance for a Green Revolution in Africa (AGRA),” *Third World Quarterly* 45, no. 3 (2024): 584.

¹⁵⁴ Ibid.

AGRA is a prime example and a clear representation of dominant neoliberal food regime.¹⁵⁵

Another threat that is perceived by grassroot movements is the “corporate capture” of FAO. The networks that FAO has established with grassroots movements in the past decades have begun crumbling. In recent years, it is observed that FAO began adopting discourses and methods of agrifood corporations. In 2021, FAO renewed its Memorandum of Understanding with the International Fertilizer Association (IFA), which is a prime target of grassroot movements. The IFA prioritizes solving problems of food and agricultural through sustainable agricultural intensification (SAI), a method known as rebranded form of green revolution by its critics. Similarly, FAO signed MoU with the International Chamber of Commerce (ICC) in 2022, which raised concerns once again since ICC is known for defending the interests of private sector within UN system.¹⁵⁶

In 2023, IPES-Food¹⁵⁷ published its report, ‘Who's Tipping the Scales?’ in order to analyze the increasing influence of the agribusiness sector on global food governance, in parallel with the increasing market concentration in the food supply chain. The market consolidation of agribusiness has also increased their influence on policy-making processes. The report argues that market consolidation emerged as a result of both legal and technical factors. For example, neoliberal-era characteristics of weakly implemented anti-trust regulations, combined with rapid technological advances of which only those already capable can capitalize on, resulted in elimination of new actors. Moreover, IPRs over patents pushed them to collect patents, a trend since 1980s with the early biotechnology era, from smaller firms, then charging “high licensing fees” for its users. The report found that these corporate giants not only directly shape food system, but also its governance. It is a common practice for private actors to

¹⁵⁵ Ibid., 567.

¹⁵⁶ Naik et al., “Corporate Capture of FAO,” 17.

¹⁵⁷ The International Panel of Experts on Sustainable Food Systems (IPES-Food) is a highly influential epistemic community within agrifood politics. Its board consists of 25 independent researchers. IPES-Food criticizes the productivist paradigm for its failure to solve global food problems and calls for inclusion of alternative paradigms.

spend considerable sum for lobbying activities. The total amount spent for lobbying increased from 79 million in 2000 to 150 million in 2021 in United States.

Agribusiness also influence policy-making process by using “revolving door” strategies in which senior figures previously employed in public agencies were transferred into private sector or MSIs.¹⁵⁸ For example, Dr Kalibat, who was appointed as Special Envoy by the UN Secretary-General to lead the UN Food Security Summit (UNFSS) preparations, had served as the chair of AGRA since 2014. Prior to his leadership in AGRA, she was Rwanda Minister of Agriculture and Animal Resource of Rwanda. She also sat at the high-level boards of several MSIs.

In fact, it is necessary to mention UNFSS since it was a watershed moment for critical scholars and grassroot movements in which they realized the changing structure of the agri-food governance. The UNFSS was prepared on the basis of strategic cooperation between the UN SG and WEF, without a call neither from FAO, as it had been in the World Food Summit 1996, nor from UNGA, as it had been in World Food Congress 1974; thus, bypassing extant mechanisms and the CPF. The discussions during the preparatory phase led to grassroots organizations protests, as it became clear for them that UNFSS was in line with the corporate agenda, prioritizing solutions to maintain the business as usual, and not targeting transformative actions and structural problems.¹⁵⁹ Movements called for protest to “expose its [UNFSS] double-facedness of aiming to end hunger and malnutrition and heal the planet and at the same time being dominated by corporations precisely causing the problems.”¹⁶⁰

The corporate sector not only lobbies for policies but also shapes knowledge production processes through private-funded science. Ultra processed food and agro-chemical companies, for example, increased their sponsorships on scientific research

¹⁵⁸ IPES-Food, *Who's Tipping the Scales? The Growing Influence of Corporations on the Governance of Food Systems, and How to Counter It* (International Panel of Experts on Sustainable Food Systems, 2023), 12.

¹⁵⁹ McMichael, “Shock and Awe,”; IPES-Food, *Who's Tipping the Scales*, 7.

¹⁶⁰ FIAN International, “UNFSS: Not Our Summit,” (July 15, 2021) <https://www.fian.org/en/press-release/article/unfss-not-our-summit-2813>.

to “shape broader environment in which regulatory decisions are made.”¹⁶¹ Through this method, they produce and disseminate scientific ‘facts’ that legitimize their ways of solving global food problems. In this way, they become able to utilize scientific authority to shape popular discourse. Critics call industry sponsored reports and articles as “industry-authored articles.”¹⁶² What is more dangerous for an inclusive knowledge production process is that it might be costly for scholars to challenge industry positions. In order to silence researchers who defend opposing arguments, industry attempts to remove them from their positions by funding studies that question dissent’s scientific validity or by organizing smear campaigns.¹⁶³

2.6. Seed System and Plant Genetic Resources

The Green Revolution showed that agriculture and seeds are directly related. As a technology package, the Green Revolution could not have spread without miracle seeds. Miracle seeds enabled its quick adaptation, and thus the globalization of industrial agriculture. A similar relationship, more organic, exists between seeds and plant genetic resources. Seeds, as carriers of the plant variety, serve as the means by which plant reproduces. Plants, on the other hand, need crop diversity to be improved.

In the 20th century, technological, institutional, and legal changes transformed how farmers access their seeds. It is argued that such changes restricted farmers' traditional seed practices and resulted in the commodification and privatization of seeds. In other words, seeds became private properties owned for profit rather than as common resources for food and biodiversity. Kloppenburg uses seeds and plant genetic resources interchangeably, and this is understandable. Similar discourse is also employed by La Via Campesina. One reason for this is that for small-scale farmers, seed and plant genetic resources have no difference. This is because farmers improve their plants by using, selecting and exchanging seeds. On the other hand, the modern seed system is built on a strict division of labor: farmers, breeders, seed producers and

¹⁶¹ IPES-Food, *Who's Tipping the Scales*, 12.

¹⁶² Ibid.

¹⁶³ “Spinning Science and Silencing Scientists: A Case Study in How the Chemical Industry Attempts to Influence Science,” Minority Staff Report Prepared for Members of the Committee on Science, Space & Technology (U.S. House of Representatives: February 06, 2018).

distribution. The clear difference between these two groups is that for the formal breeders, plants are genetic resources to be utilized. For farmers it is crop diversity, not genetic diversity, that maintains agricultural practices. Therefore, Kloppenburg made a discursive choice by calling reproductive parts of plants seeds.¹⁶⁴

At first, modernizing seed systems seems quite neutral and beneficial for all. A large number of plant breeders, looking for profit and efficiency, use advanced technology and scientific methods to commercialize new varieties which would trigger a process of competition, research and development that, in turn, could solve problems regarding global food security, farmers' poverty, and genetic erosion. This indeed constitutes the basic logic behind prescribed solutions to food and ecological problems, that is, the modernization of agriculture based on technology and entrepreneurship. Agricultural systems relying on high-yield varieties combined with modern fertilizers and pesticides-herbicides have spread with this seemingly rational formula. Yet, the failure is clear. Hunger remains a global problem; farmers remain in poverty. The genetic diversity of agricultural crops has declined. This is why grassroot movements of small-scale farming communities resist against this market-based breeding system:

[...] under the pretext of “improving” seed productivity, agribusiness has created a neo-liberal seed system that has homogenized, impoverished and monopolized seeds, causing the loss of three-quarters of seed diversity and annihilating a diversity that it took people – thanks to the work of peasants – 10000 years to generate.¹⁶⁵

In line with the agricultural modernization process, seeds have been re-routed from informal seed systems into formal seed systems. Today, it is possible to talk about two types of seeds and seed systems. These are the Proprietary Seeds (improved varieties), bred and distributed through formal seeds systems, and the local seeds (farmers' varieties), produced through traditional breeding methods and circulated through the informal seed system. In developed countries, agricultural production is dominated by proprietary seeds and the formal seed system. In developing countries, the prevalence

¹⁶⁴ Kloppenburg, *First the Seed*.

¹⁶⁵ Nyéléni, *Peasant Seeds, the Heart of the Struggle for Food Sovereignty*, Nyéléni Newsletter, no. 38 (December 2019)
https://nyeleni.org/DOWNLOADS/newsletters/Nyeleni_Newsletter_Num_38_EN.pdf.

of farmer varieties is higher, and the informal seed system is still the main way farmers access seeds. While the former relies on local and traditional social relations and maintains seed diffusion through gifting and exchanging, the latter is built on basic market principles of supply and demand, regulated through public and private institutions.¹⁶⁶ The breeding techniques applied in the production of certified seeds enable the derivation of homogeneous, distinct, uniform, and stable varieties, which are easier to protect under various forms of property regimes (IPRs, PBRs, Patents). Farmers' varieties do not have this homogeneity because they are improved through traditional methods. Farmers see this non-homogeneity as a guarantee for adaptation to various climatic and environmental conditions and avoidance of gene erosion resulting from the modern seed system. Plant breeders, on the other hand, suggest that their elite varieties guarantee production efficiency, preventing food crises and enabling them to increase farmers' incomes.

Over the past century, there has been a global effort to replace farmers' seed systems with the formal seed system, farm-saved seeds with modern seeds, and landraces/traditional plant varieties with modern varieties. In the first World Food Conference of 1974 it is agreed that:

Recognizing the urgent need to increase agricultural production in many countries to meet world-wide food demand... Recognizing the importance which a secured supply of viable seeds of high genetical and physical purity' of high-yielding and adapted varieties has to increasing crop production and productivity [...] Affirming therefore that the development of seed industries should be given high priority in national agricultural development strategies [...]¹⁶⁷

Today, however, seeds are much more important. It is understood that resource-intensive Green Revolution practices adversely affected the sustainability of agriculture by damaging livelihoods, environment, and soil quality. Moreover, monoculture farming reduced biological diversity, which is essential for food security since it enables farmers to adopt their plants into changing conditions and preferences. At the same time, climate change emerged as another source of challenge in

¹⁶⁶ Fakhri, *Seeds, Right to Life and Farmers' Rights*.

¹⁶⁷ World Food Conference, "Resolution XII: Seed Industry Development," Report of the World Food Conference, Rome: 5-16 November 1974.

maintaining agricultural productivity and harvest predictability. Moreover, the agrifood system is responsible for 31 percent of global greenhouse gas emissions.¹⁶⁸ In addition to these challenges, it is estimated that the world population will reach 9 billion in 2050. As a response to these pressing conditions, it is argued that “we must produce more - more quantity and more food diversity with higher quality - with less - less inputs of resources and less impacts on the environment.”¹⁶⁹ This overarching narrative constitutes the globally agreed solution that governs what should actors do with the seeds. Today, once again ‘good seeds’ being promoted as the solution for multiple crises.

Good harvest depends on good seeds. The world is facing a global population rise – that is expected to reach about 10 billion by 2050! We need to produce 50 percent more food to adequately feed everyone. The only way to achieve this target is by increasing crop productivity, through science and innovation... With innovative technologies and new business models we can do so in a sustainable manner, to protect our planet, our limited natural resources and biodiversity.¹⁷⁰

Under these circumstances, a new consensus emerged to replace the old green revolution with an alternative that respects biodiversity conservation, sustainable development, climate change mitigation. These alternatives have been named in various ways including sustainable intensification, sustainable productivity, climate-smart, carbon-neutral, regenerative agriculture, nature-based solutions, agroecological intensification.¹⁷¹ The paradigm shift for an ecologically sound agriculture downgraded the importance of ‘miracle’ fertilizers. However, the other green era materials, miracle seeds maintained their status as the first step in ending hunger. The

¹⁶⁸ Food and Agriculture Organization of the United Nations, *Greenhouse Gas Emissions from Agrifood Systems: Global, Regional and Country Trends, 2000-2020* (FAOSTAT Analytical Brief 50, 2022), 1-12, <https://openknowledge.fao.org/server/api/core/bitstreams/121cc613-3d0f-431c-b083-cc2031dd8826/content>

¹⁶⁹ Food and Agriculture Organization of the United Nations, *Opening Remarks by the Director-General of FAO at the Global Conference on Green Development of Seed Industries* (November 4, 2021). <https://www.fao.org/director-general/speeches/details/Global-Conference-on-Green-Development-of-Seed-Industries-Opening-Remarks/en>.

¹⁷⁰ Ibid.

¹⁷¹ IPES-Food, *Smoke and Mirrors: Examining Competing Framings of Food System Sustainability: Agroecology, Regenerative Agriculture, and Naturebased Solutions* (International Panel of Experts on Sustainable Food Systems, 2022).

world needs improved seeds more than ever, it is argued since climate change increases frequency and intensity of extreme events including droughts, floods, and storms. It also increases the risks of sudden changes in rainfall patterns, reduced water availability and extreme heat waves. New plant varieties need to be adapted to climate-induced stress. The problem is that the pace of climate change is far beyond the pace of plant breeding innovations. It is difficult for plant breeders to produce plants that can adapt to new conditions with the traditional breeding methods. Yet, the solution is once again achievable through technology and science. This time, instead of Borlaug's miracle seeds, Bill Gates' magic seeds are the solution that would save humanity from multiple crises:

Fourteen years ago, our foundation began supporting a group of African crop researchers. Their goal was to develop a new type of maize—what I started calling “magic seeds.” Of course, the seeds weren't actually magic, but by breeding select varieties of the crop, the researchers believed they could produce a hybrid maize that would be more resistant to hotter, drier climates. They succeeded wildly.¹⁷²

Innovations in biotechnology have equipped breeders with new plant breeding techniques and advanced tools. The Gene Revolution replaced the Green Revolution. Technological innovations such as Biotechnology that make genetic modification faster and more precise allows plant breeders to develop new plants quickly and effectively.¹⁷³ Genetic modification enables breeders to develop plants with herbicide tolerance by inserting herbicide resistant gene/genes from other plant varieties; or plants with insect tolerance by inserting insect resistant genes from other species.¹⁷⁴ These new technologies enable scientists to design plants that “lower both pesticide use and soil damage (cultivating disease-resistant, herbicide-resistant, and stress-

¹⁷² Bill and Melinda Gates Foundation, *Goalkeepers: The Future of Progress Report* (2022), 20 https://www.gatesfoundation.org/goalkeepers/downloads/2022-report/2022-goalkeepers-report_en.pdf.

¹⁷³ John H. Dodds et al., “Biotechnology, the Gene Revolution, and Proprietary Technology in Agriculture: A Strategic Note for the World Bank,” *IP Strategy Today* 2, (2001): 1-43.

¹⁷⁴ Stuart J. Smyth, “Regulatory Barriers to Improving Global Food Security,” *Global Food Security*, 26 (2020): 1-5.

tolerant plants and increasing the nutritional quality of plants) and reduce greenhouse gas (GHG) emissions.”¹⁷⁵

Moreover, with new genomic techniques invented after 2010, the genetic information of plants can be sequenced more quickly and less costly. Thus, by utilizing the Digital Sequence Information (DSI) stored in databanks, new plants can be produced without the need for physical material preserved in gene banks.¹⁷⁶ The number and capacities of international initiatives in this direction have increased. The DivSeek network, a joint initiative of many partners, “aims to mine the genetic treasure in seed bank vaults.”¹⁷⁷

However, the industry demands legal backing for these technological advances. Majority of states, through restrictive regulations, exclude GMO products from their markets or human diets. The “overregulation and public misperceptions” hinder the expected benefits of new breeding methods, especially in regions that could benefit the most, such as Africa and Asia.¹⁷⁸ In particular, the restrictive regulations of European creates a risk of spillover to other regions, especially Africa.¹⁷⁹ Recently, the European Commission submitted its proposal to soften regulations on GMO crops under the Green Deal, Farm to Fork and Biodiversity strategies.¹⁸⁰ Italy has temporarily authorized the first outdoor trial of a rice plant, that has been edited with the CRISPS-CAR9 technology “to reduce the need for fungicides, thus promoting

¹⁷⁵ Agata Tyczewska, Tomasz Twardowski, Ewa Woźniak-Gientka, “Agricultural Biotechnology for Sustainable Food Security,” *Trends in Biotechnology*, 41, no. 3 (2023): 331-41.

¹⁷⁶ Recent technological developments that enable de-materialization of plant genetic resources disturb existing international regime governing PGRFA. Both fundamental international treaties, CBD and ITPGRFA, have been under reform processes for the past decade. See Sara Nawaz, Terre Satterfield and Shannon Hagerman, “From Seed to Sequence: Dematerialization and the Battle to (re)define Genetic Resources,” *Global Environmental Change* 68, (2021): 1-9.

¹⁷⁷ Jan Piotrowski, “DivSeek Project Aims to Uncover Crops’ Hidden Genetic Data,” *SciDevNet* (January 12, 2015). <https://www.scidev.net/global/news/divseek-project-crops-genetic-data/>

¹⁷⁸ Martin Qaim, “Role of New Plant Breeding Technologies for Food Security and Sustainable Agricultural Development,” *Applied Economic Perspectives and Policy* 42, no. 2 (2020): 129.

¹⁷⁹ Smyth, “Regulatory Barriers,” 2.

¹⁸⁰ European Commission, *Proposal for a Regulation of the European Parliament and of the Council on Plants Obtained by Certain New Genomic Techniques*, (July 5, 2023).

more sustainable farming practices”. However, it was destroyed by unknown agents, who are dubbed as “anti-science vandals” by the European Seed Association.¹⁸¹

On the other hand, the Breeding Industry demands that IPR regimes should be more restrictive in order to ensure a return on investment in technologically advanced and costly new methods. In particular, demands for the globalization of the patent system, rather than Plant Breeders’ Rights, are gaining momentum. There is an ongoing debate on access to Digital Sequence Information (DSI) obtained by new methods. While DSI currently enables interested parties to access information without sharing benefits, discussions are ongoing in several international fora, including the CBD and ITPGRFA.¹⁸²

A new rush towards wild plants is rising. It is understood that Crop Wild Relatives (CWR) will play a key role in overcoming multiple crises with the traits they store in their genes. Moreover, now that breeders have modern technologies to obtain DSI, CRW can be analyzed for their useful genes quickly. A team of forty experts from the public and private sectors wrote, in their article “Feeding the Future”, that “time is ripe for an effort to harness the full power of biodiversity to feed the world” and asked: “How should we begin to mine biodiversity for food security?”¹⁸³

2.6.1 The Problem with the Modern Breeding System

In his study of the political economy of plant breeding, Kloppenburg argued that the three mechanisms extended capitalist relations of production into the plant breeding and seed sector. These are the commodification of seeds, the division of labor between public science and private science, and germplasm transfer from the gene-rich South to the gene-poor North. The commodification of seeds has occurred in two

¹⁸¹ “Anti-Science Vandals Destroy Italy’s First Open Field Trial with Gene Edited Rice to Test Resistance Against Fungal Disease,” Euroseed, June 25, 2024, <https://euroseeds.eu/app/uploads/2024/06/24.0504-Anti-science-vandalists-destroy-Italys-first-open-field-trial-with-gene-edited-rice-to-test-resistance-against-fungal-disease.pdf>.

¹⁸² B.E. (Bob) Kreiken and B.J.M. (Bas) Arts, “Disruptive Data: How Access and Benefit-Sharing Discourses Structured Ideas and Decisions During the Convention on Biological Diversity Negotiations Over Digital Sequence Information from 2016 to 2022,” *Global Environmental Change*, 87 (2024): 1-11.

¹⁸³ Susan McCouch et al., “Feeding the Future,” *Nature* 499, (2013): 23-24.

ways: technical and social. The hybrid method, which rendered seeds biologically unreproducible, transformed seeds into a commodity that should be purchased, thus ensuring the profitability of private breeders. After 1990, the introduction of agricultural biotechnology and GM varieties has also paved the way for commodification.

When the hybrid method did not work out, profits guaranteed through legislative acts. U.S Plant Patent Act (PPA) of 1930 had granted patent protection to breeders of novel varieties of asexually reproducing plants, while the Plant Variety Protection Act of 1970 (PVPA), which was enacted after intense lobbying, protected the rights of breeders of sexually reproducing plant varieties. Institutional change, on the other hand, occurred when the private sector replaced state-sponsored research and development processes in plant breeding and research. Publicly funded universities and research centers not only accumulated basic knowledge in plant breeding but also provided farmers with low-cost, improved varieties that they could reproduce, thus preventing market dominance by the private sector. The competition was addressed by creating a duality of function and purpose between publicly funded research and privately funded research. Then, somehow,¹⁸⁴ public research was limited to “basic science” as a complementary side mission to the private sector’s “applied science” that has one aim: collect plant genetic resources to produce new plants.

Finally, the asymmetrical germplasm transfer between North and South made “continuous appropriation” and “systematic acquisition” of the plant genetic resources possible. Kloppenburg argues that “access to, utilization of, and control over plant genetic resources” are facilitated by novel institutions. These institutions have multiplied over the course, beginning with the U.S Patent Office’s “global collection of plant germplasm” in 1839. The Green Revolution era research centers served a dual function of “... introduc[ing] capitalism into the countryside” and “... collect[ing] systematically the exotic germplasm required by the breeding programs of the developed nations.” However, the transfer of germplasm between gene-poor and gene-rich countries has been asymmetrical in the sense that while gene-rich countries accessed more genetic resources as a free good based on the idea that such resources

¹⁸⁴ More on this in the following chapters.

are the common heritage of mankind, gene-poor countries had to pay for restricted PGRs which are protected by patents or other tools, thus not as free goods but as private properties.¹⁸⁵

The commodification of seeds is conceptualized as a process of enclosure.¹⁸⁶ It is usually argued that multiple mechanisms worked in tandem to establish and maintain enclosure. These mechanisms included legal, institutional, and technological strategies that enabled plant breeders to tap into rich genetic resources, while at the same time preventing farmers from maintaining their traditional ways of using seeds and improving plants.

The legal basis of the seed enclosures includes, among others, intellectual property rights. The extension of the intellectual property regime into crop improvement activities have been the main device in the privatization of plant breeding, globalization of formal seed systems, and restricting farmers' access to PGRs. The intellectual property regime had provided two forms of protection which are patents and plant breeders' rights/plant variety protection. While the patents, in the form of plant patents and utility patents, enforce a highly restrictive type of protection by enabling the patentability of seeds, their traits, processes, and techniques, the plant variety protection (PVP) enables other breeders to use protected material for developing new varieties.

The UPOV Convention (International Convention for the Protection of New Varieties of Plants) was signed in 1961 by six Western European states to protect new plant varieties and secure Plant Breeders' Rights. It underwent revisions in 1972, 1978, and 1991. In the beginning, it was intended to provide more flexible protection than the patent system, thus enabling breeders to access protected plant genetic resources with the concept of "breeder exception" and allowing farmers to re-use protected seeds under the provision of "farmers' privilege". However, it started to function similarly to the patent system after the 1991 revision and redefined previously enabled practices

¹⁸⁵ Kloppenburg, *First the Seed*, 10-15.

¹⁸⁶ Raquel Ajates, "From Land Enclosures to Lab Enclosures: Digital Sequence Information, Cultivated Biodiversity and the Movement for Open Source Seed Systems," *The Journal of Peasant Studies* 50, no. 3 (2023): 1056-84.

for farmers and breeders.¹⁸⁷ The 1978 version of the UPOV Convention remained open for accession until 1998, after which only the 1991 version was open for new accessions. UPOV, whose number of members increased marginally until the 1990s, has reached 78 member states with intense participation in recent years. As one of the conditions of membership, member states should make regulations covering Plant Breeders' Rights in their national legislation. UPOV has enabled “legal enclosure” processes in the international seed system with the PVP concept it created and spread.

Moreover, UPOV defined Distinct, Uniform, and Stable (DUS) criteria for protection, which became a standard for registering and certifying seeds. Several countries formed their Seed Laws to regulate seed markets by adopting DUS criteria for registering a variety for marketing. There is also opposition to national seed laws that would allow proprietary seeds to dominate seed markets and the agricultural sector in developing countries. Promotion of the Formal Seed System and the use of certified seeds are presented by various international organizations, developed countries, and philanthropists as a solution to the global food crisis. Seed Laws in many countries set quality standards for seeds to be sold in the seed market and require registration. If the analysis and test results meet the quality standards (new, distinct, uniform, stable), the new variety can be registered and sold. Farmer varieties, on the other hand, cannot be registered in the formal seed system since they do not meet these standards, thus remaining within the informal seed sector. These legal tools outlaw informal seed practices in the developing world.¹⁸⁸ In developing countries, objections to national laws that encourage the formal seed system while outlawing the informal seed system - that encourages the circulation of certified seeds while restricting the sale of farmers' varieties - are becoming more pronounced.

With the introduction of the WTO TRIPS agreement, it became mandatory for signatory countries to establish effective protection regimes. Article 27.3 (b) states that member states may exempt the patentability of plants but are obliged to establish an effective protection or sui generis system to protect plant varieties. While this

¹⁸⁷ Andersen, *Governing Agrobiodiversity*, 159.

¹⁸⁸ Tamara Wattnem, “Seed Laws, Certification and Standardization: Outlawing Informal Seed Systems in the Global South,” *The Journal of Peasant Studies* 43, no. 4 (2016): 850–67.

provision, combined with bilateral pressures, increased interest in UPOV, it also paved the way for UPOV to move towards a more restrictive system of protection. Another institutional mechanism is built on conditionality. With the introduction of TRIPs that oblige member states to provide an effective protection regime for plant varieties, several countries have been forced to adopt the UPOV 1991 version, which is a patent-like restrictive system despite having provisions for establishing a balanced regime. It has been observed that developed countries offered bilateral/regional trade agreements or development assistance packages on the grounds that the receiver country should join UPOV.¹⁸⁹

Technology has been a significant source of seed enclosures as waves of technological developments left farmers with much more restricted seed rights. Since the Green Revolution, science-led models and technological innovation have occupied the central discourse within global agricultural debates. As a result, the technology-centered progressive discourse served as a meta-narrative for the appropriateness of transforming traditional ways of agriculture and seed practices.

Apart from its function as a discourse, the innovative techniques have severely restricted farmers' relations with the seeds by functioning as biological patents, in the words of Ajates, "enclosure through (bio)-technological means".¹⁹⁰ The hybrid technique has eliminated the biological barrier to the commodification of seeds by blocking the way for the reproduction of seeds and forcing farmers' access to seeds through the market. Later, genetic use restriction technology (GURT), based on the genetic modification technique, offered a similar restrictive system, which was called Terminator Technology by its critics. Having developed through a partnership between the United States Department of Agriculture and Delta&Pine Land Company as a means for protecting IP rights, GURT has been unable to be commercialized in the face of intense public pressure. Yet again, recent technical advances have created new means of control and sources of debate. Genome

¹⁸⁹ Nirmalya Syam, Shirin Syed, and Viviana Munoz-Tellez, *The UPOV Accession Process: Preventing Appropriate PVP Laws for New Members* (Geneva: South Centre and APBREBES, February 2023), https://www.southcentre.int/wp-content/uploads/2023/02/SC_Apbrebes_UPOV-accession-process_EN_2-23_fin.pdf.

¹⁹⁰ Ajates, "From Land Enclosures to Lab Enclosures," 1056-84.

engineering techniques within Synthetic Biotechnology such as “zinc-finger nucleases (ZFNs)”, “transcription activator-like effector nucleases (TALENs)”, and “CRISPR-Cas9” have further advanced the abilities of gene manipulation. For example, currently under attack from activists, “gene drive” is “a technology of genetic engineering through which certain desired traits can be introduced to almost all individuals in a population.”

The conditions favoring private entrepreneurship, coupled with a development approach based on technological progress and consolidated market structure have widened the gap in technical capabilities among firms, as well as between seed companies and farmers. Since the early 20th century, advances in seed breeding techniques have transformed seed breeding from a routine farm activity to a lab activity. Hybrid seed developments in the 1930s, the genetic breakthrough in the 1980s, new methods in synthetic biotechnology techniques, and digitalization after the 2000s took seed breeding out of the fields and into laboratories.

From a grassroot perspective Biopiracy is the leading danger.¹⁹¹ Biopiracy is the seizure of plant genetic resources, which have been conserved and diversified for centuries through farmers' seed practices, by private companies without consent and without compensation. Biopiracy, combined with the IPR regulations, forces farmers to buy their seeds from the market. Open access to Plant Genetic Resources can benefit farmers and professional breeders. However, farmers are disadvantaged by the concentration of technical and financial resources needed for breeding in consolidated multinational firms. On the other hand, existing intellectual property rights and patent regimes restrict open access to Plant Genetic Resources of varieties produced by breeders. In fact, in the face of growing unrest against developed countries early regulatory bodies were established during the 1980s.

The commodification of seeds cannot be the sole cause of seed enclosures, of course, but the process has been accelerated by their transformation into a patentable private good (proprietary seeds). Patents had an unintended effect. The patent system is thought to serve as a catalyst for innovation, research, and development to attract

¹⁹¹ Vandana Shiva, *Biopiracy: The Plunder of Nature and Knowledge* (North Atlantic Books, 1997).

private-sector investment in seed breeding. However, the struggle for patents resulted in market consolidation and control and, relatedly, less research incentive. Agro-chemical companies, seeking new markets in the face of stable profits and tightening environmental regulations, have resorted to acquisitions to gain access to the patented genetic resources of seed companies as part of a strategy to produce seeds (Monsanto-Roundup Ready) that are resistant to their own chemicals (Monsanto-Roundup) using new genetic modification techniques. The consolidation of the seed market is threatening. Over the last 40 years vertical (chemical-seed) and horizontal (seed-seed) integration movements have led to the disappearance of small-scale seed companies. Seed companies, thus the patents and genetic resources they own, are acquired by agro-chemical producer companies. Today, four big companies control 60% of the global seed market.¹⁹²

The globalization of these regulations restricting access to protected seeds and plant genetic resources has enabled large seed companies to expand into new markets and increase their profits while at the same time creating a legal basis for making it illegal for farmers to store, exchange, and sell seeds. While the transfiguration of seeds ontologically redefined them as products for sale on the market, the market itself progressively occupied “all spaces where seeds are exchanged”.¹⁹³ All of these developments have led to farmers' freedom of seed and agricultural methods being imposed by market-based factors.

“Public retreat” is another source for restricted rights. Public-funded breeding activities have been replaced by the private sector over the years, which leads to easier control for the private sector. Although the public sector's withdrawal from the breeding sector was justified on grounds such as efficiency and technology, structural adjustment programs and neoliberal transformation agendas at the end of 20th century had a major impact on this sectoral shift particularly in Global South.

¹⁹² Philip Howard, *Concentration and Power in the Food System* (Bloomsbury Academic, 2021); IPES-Food, *Too Big to Feed*.

¹⁹³ Fabien Girard, Christine Frison, and Christine Noiville, “Seed: Commodification, Decommodification and Commoning” in *Routledge Handbook of Commodification*, ed. Elodie Bertrand and Vida Panitch (Routledge, 2023), 402-16.

Lately, public-private partnerships have been hailed as the solution to global problems. Despite intense opposition from Civil Society and Grassroots Movements, the private sector is getting a higher seat in the global governance system. As discussed above, these new forms of partnerships reify existing hierarchies among stakeholders.

This trend has become visible in recent years and led to the emergence of new agencies not limited to global forums but also in the policy-making process at the national level. Governments, international development agencies, international organizations, agricultural research centers, and, decisively, philanthropic foundations have come together to form a new kind of “an international assemblage of biotechnology proponents.”¹⁹⁴ Several foundations, including Rockefeller and The Bill and Melinda Gates Foundation, support agricultural transformation programs in the developing world and “...advocate for a particular vision of technology-driven innovation led by the private sector.”¹⁹⁵ This new form of agency has been called Philanthrocapitalism.¹⁹⁶

There is growing concern that such novel agencies might serve as trojan horses in evading current rules on access to plant genetic resources. For example, DivSeek, a not-for-profit initiative co-founded by seed giants such as Bayer and DuPont and public-private research centers aims to generate digital sequence information of the genetic resources conserved in national and international gene banks. The announcement that it will collaborate with ITPGRFA has raised concerns out of the fear that existing access and benefit-sharing mechanisms will be bypassed and PGRs under ITPGRFA custody will be made available to companies.

¹⁹⁴ Jacqueline Alyce Ignatova, “Seeds of Contestation: Genetically Modified Crops and the Politics of Agricultural Modernization in Ghana” (PhD Diss., University of Maryland, 2017).

¹⁹⁵ Matthew Canfield, “The Ideology of Innovation: Philanthropy and Racial Capitalism in Global Food Governance,” *The Journal of Peasant Studies* 50, no. 6 (2023), 2381.

¹⁹⁶ See Carol Thompson, “Philanthrocapitalism: Rendering the Public Domain Obsolete?,” *Third World Quarterly* 39, no. 1 (2016): 51-67; Behrooz Morvaridi, “Capitalist Philanthropy and Hegemonic Partnerships,” *Third World Quarterly* 33, no. 7 (2022): 1191-10.

Under pressure from growing grassroots movements, this collaboration was withdrawn,¹⁹⁷ only to be resumed in 2022.¹⁹⁸

2.6.2 A Brief History of PGRFA Governance

The consensus on conserving biodiversity was institutionalized with the signing of the Convention on Biological Diversity (CBD) at the 1992 Rio Earth Summit. Global leaders agreed to work together to slow down, if not stop, mainly human-induced threats on the diversity of life on earth. Although it was praised as a transformational step in humanity's ages old struggle with nature, in fact, earlier international initiatives to conserve diversity started 30 years prior to the CBD. It was directly related to food and agriculture.

Plants have evolved and diversified over the centuries as a result of their interaction with human and non-human forces. This mechanism of diversification led to cultivation of new plant varieties with different, and much desired, traits. It is understood that some plants were more resistant to diseases, able to tolerate environmental stress, and some others were simply more productive. Therefore, “harnessing the crop diversity” has been recognized as a path for breeding better plants and increasing agricultural efficiency.

With the beginning of the 20th century, a radical transformation arrived at the farmers' fields. Industrial agriculture became the dominant mode of agricultural production, first in USA, and then spread into other developed countries. The Green Revolution, as a productivist technology package, was the solution for the leaders of the developing world in their search for self-sufficiency in food production or income from international markets. This newly acquired ability encouraged policymakers to open natural habitats, that had been previously excluded from agricultural production to human influence. It also fueled the transition from a diversified agricultural model to

¹⁹⁷ La Via Campesina “The International Treaty of Seed: FAO Refuses to Collaborate in Biopiracy: INRA and CIRAD Must Do the Same!” La Via Campesina (February 10, 2017) <https://viacampesina.org/en/2017/02/the-international-treaty-of-seed-fao-refuses-to-collaborate-in-biopiracy-inra-and-cirad-must-do-the-same/>.

¹⁹⁸ “DivSeek Signs MOU with International Treaty,” DivSeek International Network (June 6, 2022), <https://divseekintl.org/news-mou-itpgrfa/>.

monoculture, one that is based on uniform plant varieties. As a result, however, crop diversity came under threat.

In the 1960s, a series of technical meetings initiated by FAO declared the problem and named it as the “genetic erosion”. This early epistemic community agreed on the technical consensus that these “genetic resources” should be conserved as they are too valuable for the modernization of agricultural practices and ending hunger.¹⁹⁹ This new agenda was quickly embraced by the CGIAR (Consultative Group on International Agricultural Research) which was established in 1971 to coordinate and support international agricultural research processes.²⁰⁰ Under CGIAR’s control, the International Board for Plant Genetic Resources (IBPGR) was established as a mechanism for the international coordination of gene banks that are located at various regions. This initiative had two main objectives: Crop diversity should be collected and conserved before it is lost. These valuable resources should be made available to plant breeders who desperately need them for breeding better plants.

This institutional arrangement destabilized in the following period as a result of two moves, one triggering the other, that led to the fragmentation of the PGRFA governance. UPOV convention, signed as an intergovernmental treaty in 1961 at the initiative of European plant breeders, enabled IPRs for those who develop plant varieties. This protection scheme, known as Plant Breeders Rights (PBRs), was adopted in the USA with the U.S Plant Variety Protection Act of 1970. With these new rules, plant varieties that are “new, distinct, uniform and stable” are secured and its breeders obtained exclusive rights. Although researchers, other breeders and farmers allowed to use these varieties for some purposes, other than selling, it created a distinction between plant genetic resources as raw materials and elite-modern varieties as private properties. In other words, two different regimes began applying for two different materials. Therefore, it became a matter of debate who can access all genetic

¹⁹⁹ Robin Pistorius, *Scientists, Plants and Politics: A History of the Plant Genetic Resources Movement* (International Plant Genetic Resources Institute, 1997), 16-33.

²⁰⁰ Helen Anne Curry, *Endangered Maize: Industrial Agriculture and the Crisis of Extinction* (University of California Press, 2022), 116-23; Marianna Fenzi, “Crop Genetic Diversity under the CGIAR Lens,” in *Agricultural Science as International Development: Historical Perspectives on the CGIAR Era*, ed. Helen Anne Curry and Timothy W. Lorek (Cambridge University Press, 2024), 259-85.

resources in genebanks. Moreover, breakthroughs in biotechnology were about to shape the future of plant breeding. In 1980, U.S Supreme Court Decision *Diamond v. Chakrabarty* recognized that genetically modified life forms are patentable innovations.²⁰¹ In other words, anything man-made under the sun is eligible for patents. Similarly, United States Patent and Trademark Office (USPTO) *Ex parte Hibberd* decision (1985) extended the scope of patentable objects to cover sexually reproduced plants, plant materials including seeds and tissue cultures.²⁰² Thus, crop improvement and plant breeding emerged as a highly lucrative sector.

In the 1980s, this early institutional setting came under intense criticism from civil society and developing world for its activities and governance. One reason for this unrest was that, while breeders were using genetic resources freely to produce modern varieties, they began restricting access to the genetic resources contained within these “elite” seeds through mechanisms of intellectual property rights (IPR). Moreover, the market was getting increasingly consolidated by the small number of large agro-industrial firms, thus the breeding sector was getting less competitive. Global South demanded a fair system for governing plant genetic resources. As a result of these criticism, the “International Undertaking on Plant Genetic Resources” (IUPGR) was adopted as a non-binding agreement by majority vote at the 1983 FAO Conference. It was a significant breakthrough as it defined all plant genetic resources, raw and improved (protected and non-protected), as “the common heritage of mankind” and recognized the contribution of farmers to the conservation of plant genetic resources and the maintenance of diversity. However, it did not function as planned due to the sharp debates between the global north and the south. For the developed world, IU was unacceptable since it recognized all genetic resources as the common heritage of humanity, without making any distinction between the elite and the raw and therefore ignored the existing property rules.

Under pressure, the developing world had to water down the content of IUPGR. Through a series of agreed interpretations (89-89-91), concessions made by developing countries for enabling assistance in their agricultural modernization, the

²⁰¹ *Diamond v. Chakrabarty*, 447 U.S. 303 (1980).

²⁰² *Ex Parte Hibberd* [1984] 227 U.S.P.Q. (BNA) 443.

initiative institutionalized access to plant genetic resources in exchange for benefits arising from their utilization; and redefined plant genetic resources under the logic of “sovereign rights”. These debates lasted until the CBD which excluded genetic resources with significant importance for food and agriculture (plant genetic resources for food and agriculture, PGRFA). Parties decided to initiate another negotiation process for the PGRFA, with the aim of establishing a parallel mechanism in line with the basic principles of the CBD (conservation, utilization, benefit sharing).

The reason for this division was that, while CBD has formed a bilateral benefit-sharing mechanism based on the principle of sovereign rights over genetic resources, the same considered impractical for PGRFA since centuries of breeding and improvement practices made plants truly ‘global’. Moreover, since these resources serve for the common good, their conservation can only be achieved through joint action. More importantly, countries were interdependent in terms of germplasm exchange, thus a multilateral mechanism, rather than bilateral, was necessary. In other words, they should be available to interested parties to be utilized for the benefit of humanity. A bilateral system seemed potentially restrictive to achieve this end.

The negotiation process resulted with the “International Treaty on Plant Genetic Resources for Food and Agriculture” (ITPGRFA), signed in 2001 and entered into force in 2004.²⁰³

2.7. Conclusion

This chapter examined the transformation of food and agriculture, from locally significant social relations to globally integrated chain of activities with a focus on scientific and political developments. It shows how this transformation was facilitated by a productivist paradigm rooted in scientific progress and technological innovation, sponsored by public and private sectors, and institutionally secured through international institutions within global food governance. This chapter underlined the dual function of science and technology in mainstreaming productivist agriculture, as

²⁰³ *International Treaty on Plant Genetic Resources for Food and Agriculture*, adopted November 3, 2001, entered into force June 29, 2004, Food and Agriculture Organization of the United Nations, <https://www.fao.org/plant-treaty/en/>.

a technical tool for boosting production and as a discursive tool for securing the appropriateness of resource-hungry farming practices. Those who support the paradigm quickly co-opted the early international efforts for food security by claiming their technical ability to feed the world. Towards the 2000s, they embraced yet another agenda, sustainable agriculture, by claiming a renewed ability to improve resource-use efficiency in order to feed the world, despite of their direct role in persistent hunger, increased rural poverty and environmental catastrophe. In each of these promises of feeding the world by innovating solutions through science-backed technological progress, the techno-scientific discourse served as a legitimizing move. Even today, new alliances of techno-scientific vision push for an unregulated space for their biotechnological solutions by promising to increase production while mitigating climate change. The productivist paradigm is under heavy criticism from social movements, such as Food Sovereignty and Agroecology, who demand structural reforms in political and economic spheres instead of technical solutions. Despite the growing backlash, the productivist paradigm managed to mainstream its vision for the 21st century into the contemporary global food governance mechanism. They produced novel technical programmes, such as Nature-Based Solutions and Climate-Smart Agriculture, claiming to include non-productivist practices and promoted them successfully as the main framework of the global efforts. These novel concepts, despite claiming to include non-productivist farming practices, have been dubbed as false solutions by critics for their dismissal of the structural reform demands. In recent decades, academics began pointing out the role of science, both as a discourse and a technical tool, in maintaining the productivist paradigm. However, as this thesis argues, the science had already played a crucial role in making and maintaining productivism throughout the 20th century. The next chapter provides a theoretical space for adding science as a causal mechanism for the analysis of institutionalization of productivism in national and international contexts.

CHAPTER 3

THEORETICAL BACKGROUND: INTERNATIONAL REGIMES, GLOBAL NORMS, SCIENCE AND TECHNOLOGY

3.1. Introduction

This chapter has two interlinked objectives. The first one is to create a theoretical space that enables the integration of science and technology into a social analysis which examines the institutionalization of the productivist paradigm in agriculture. The second one is to demonstrate the embeddedness of the productivist paradigm within the global governance of plant genetic resources. It connects these two objectives by critically analyzing the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The analysis shows the shortcomings of existing theoretical frameworks, international regime studies and mainstream norm scholarship, argues for an alternative approach that provides a holistic understanding of the interplay between technical practices and normativity without falling into the trap of either social or technological determinism.

3.2. International Regime Complexes

Plurality of institutions, rules and norms is the new normal of the fragmented global governance architecture. This institutional density, interplay between rules and norms, synergies and contradictions between them have been the subject of global governance studies.²⁰⁴ The term regime complex first introduced by Raustiala and Victor in 2004 as a conceptual tool for taking into account the developing trend of institutional density

²⁰⁴ Raustiala and Victor, “Regime Complex for Plant Genetic Resources,” 77-309; Gerstetter et al., “International Treaty,” 259–83; Andersen, *Governing Agrobiodiversity*; Morin and Orsini, “Policy Coherency and Regime Complexes,” 303-24; Oberthür and Pożarowska, “Managing Institutional Complexity and Fragmentation,” 100-18; Rabitz, *Global Governance of Genetic Resources*.

and overlapping norms. They argued that ongoing legalization process in the global politics produce the conditions for regime complexes, defined as “collective of partially overlapping and nonhierarchical institutions governing a particular issue-area.”²⁰⁵ It is argued that regime complexes emerge when negotiators end up with large number of broadly defined rules and norms that are open to divergent interpretations and implementation.

Raustiala and Victor selected the governance of plant genetic resources as the case for introducing their conceptual innovation. Evidently, this decision was based on their observation of the increasing number of norms and rules in this sector of governance even in the early 2000s. They identified five elemental regimes that make up and govern the plant genetic resources (PGR) regime complex with different, partly overlapping rules and norms.²⁰⁶ As a result of this process, plant genetic resources, that had initially been governed by common heritage of mankind principle and open access norms, had been supplied with novel interpretations; with the CBD sovereign rights over plant genetic resources; and with the UPOV and TRIPS intellectual property rights. Raustiala and Victor suggested that “... this transition was driven by the perception-and the reality-of the rising value of PGR, in particular as new techniques of genetic manipulation permitted innovators to add substantial value to plants.”²⁰⁷

Regarding the “normative shift” in the governance of PGR from common heritage to private property, Raustiala and Victor argues that in the formation of regime complexity of PGR there was “no clean slate” (i.e there were pre-existing institutions and rules). Plant Breeders’ Rights had already been institutionalized among some developed countries. Moreover, developing countries too understood the value of

²⁰⁵ Raustiala and Victor, “Regime Complex for Plant Genetic Resources,” 279.

²⁰⁶ Regarding property rights, the International Convention for the Protection of New Varieties of Plants (UPOV), signed in 1961 to protect the rights of plant breeders among European countries; patents originated from US legislation; and the WTO’s TRIPs set the minimum standards for property regimes, and enforced their diffusion. The FAO initiated International Undertaking and then ITPGRFA, CGIAR and coordination of gene banks, thus open access. CBD sovereign rights over natural resources and benefit-sharing.

²⁰⁷ Raustiala and Victor, “Regime Complex for Plant Genetic Resources,” 305.

PGR, thus “sought to assert sovereign rights and to reverse the long-standing principle of common heritage.”²⁰⁸

Rabitz argued that institutional changes within regime complexes occur through two mechanisms: club cooperation and institutional layering. Club cooperation is visible when states “band together to form smaller cooperative arrangements” in the cases where they are “unable to achieve their respective policy objectives within wider, multilateral settings,” while the institutional layering “refers to incremental changes whereby actors build upon existing institutions in order to develop them into their preferred direction.”²⁰⁹

According to Rabitz, institutional changes in PGR regime complex follow a process of institutional layering rather than regime shifting and interplay management. One reason for this is the “asymmetrical distribution of genetic raw materials as well as the scientific and technological capacities for their utilization.”²¹⁰ Those technologically develop actors require cooperative frameworks to access genetic resources while others, gene-rich countries, requires cooperation for benefit-sharing. The problem is that while the plant breeders within rich countries can access genetic material from non-Treaty Ex Situ sources, gene-rich countries desperately need cooperation for obtaining the benefits the treaty would provide them. Moreover, it is technically difficult and demanding to monitor whether industry pays its share and act in line with the treaty:

[...] thus, those countries where utilization takes place have no reason to share the benefits they generate and have little to gain from international cooperation. Those countries that do not utilize genetic resources have reasons to ensure benefit-sharing by creating strong international institutions yet have little leverage for prodding the former into cooperation.²¹¹

²⁰⁸ Ibid., 297.

²⁰⁹ Rabitz, *The Global Governance of Genetic Resources*, 3.

²¹⁰ Ibid., 4.

²¹¹ Ibid., 5.

3.3. Norms Studies

Norms have been added to the toolkit of International Relations theory at the end of 20th century. The second-generation Constructivists (i.e. conventional norm scholars) begin their quest for showing and explaining “the effect of norms on state behavior.”²¹² They empirically demonstrated that norms could influence state behavior as an “independent variable”.²¹³ To do this, they clarified the definition by separating norms from broader institutions, specifying their components and offered another logic of action, appropriateness, through which norms can shape the action. Before all this, they narrowed original constructivist focus from “the way social reality changes” (the social world with its agents, rules and structures) to “changes in agents’ practices” (state behavior). To make clear their workings separate from broader institutions, norms isolated to refer “single standards of behavior” within broader institutions that are “relatively stable collection[s] of practices and rules defining appropriate behavior for specific groups of actors in specific situation.”²¹⁴ While institutions stands for “the way in which behavioral rules are structured together and interrelate,”²¹⁵ norms are conceptualized as only one of the components. Norms have been defined as “standards of appropriate behavior for actors with a given identity”.²¹⁶ As social facts they have been praised for making cooperation possible among international actors and maintaining the order, by directing them towards collectively desired ends that could be achieved through intersubjectively agreed upon means. In order to separate norms

²¹² Martha Finnemore and Kathryn Sikkink, “International Norm Dynamics and Political Change,” *International Organization* 52, no. 4 (1998): 892.

²¹³ Martha Finnemore, “International Organizations as Teachers of Norms: The United Nations Educational, Scientific, and Cultural Organization and Science Policy,” *International Organization* 47, no. 4 (1993): 565-97; Audie Klotz, “Norms Reconstituting Interests: Global Racial Equality and U.S. Sanctions Against South Africa,” *International Organization* 49, no. 3 (Summer 1995): 451–78; Martha Finnemore, “Norms, Culture, and World Politics: Insights from Sociology’s Institutionalism,” *International organization* 50, no. 2 (1996): 325-47. Richard M. Price, *The Chemical Weapons Taboo* (Cornell University Press, 1997).

²¹⁴ James G. March and Johan P. Olsen, “The Institutional Dynamics of International Political Orders,” *International Organization* 52, no. 4 (1998): 948.

²¹⁵ Finnemore and Sikkink, “International Norm Dynamics,” 891.

²¹⁶ Ibid.

from other “social stuff”,²¹⁷ a norm needs to contain a moral sense of *oughtness*; defined actor of a given identity; a specific behavior or action.²¹⁸ It is argued that a norm exists and shape behavior when all three components are “collectively shared within a particular society,”²¹⁹ and built upon an intersubjective agreement.²²⁰

The easiest way to find norms, for norm scholars, is to look for intersubjectively “arrested meanings” which usually reveal themselves through well-known concepts. Considering the text of the Treaty Text, plant genetic resources should be conserved, used sustainably and the benefits arising from their use should be shared fairly and equitably. All this arrangement is for the realization of food security and sustainable agriculture.

However, there is a clear difficulty in naming and effectively describing, if we must, the norm of treaty that guides behavior, not to mention even bigger struggle of showing its effect on the practices. In one of the earliest studies covering governance of the plant genetic resources, Andersen called out three key norms of ITPGRFA, that are conservation, sustainable use and access; and three secondary norms, benefit-sharing, farmers’ rights, limited intellectual property rights.²²¹ It seems there is a plurality of norms within this social arrangement, and it is no surprise since plurality of norms, rules and institutions is one of the well-known symptoms of the fragmentation of global governance.²²² Considering the apparent plurality, not it is possible to begin

²¹⁷ Martha Finnemore and Michelle Jurkovich, “The Politics of Aspiration,” *International Studies Quarterly* 64, no. 4 (2020), 759.

²¹⁸ Michelle Jurkovich, “What Isn’t a Norm? Redefining the Conceptual Boundaries of ‘Norms’ in the Human Rights Literature,” *International Studies Review* 22, no. 3 (2020): 694.

²¹⁹ Ibid.

²²⁰ Betsy Jose, *Norm Contestation: Insights into Non-Conformity with Armed Conflict Norms* (Springer, 2017).

²²¹ Andersen, *Governing Agrobiodiversity*, 127.

²²² Christian Kreuder-Sonnen and Michael Zürn, “After Fragmentation: Norm Collisions, Interface Conflicts, and Conflict Management,” *Global Constitutionalism* 9, no. 2 (2020): 241-67; Sassan Gholiagha, Anna Holzscheiter and Andrea Liese, “Activating Norm Collisions: Interface Conflicts in International Drug Control,” *Global Constitutionalism*, 9, no. 2 (2020): 290-17; Eglantine Staunton and Jason Ralph, “The Responsibility to Protect Norm Cluster and the Challenge of Atrocity Prevention: An Analysis of the European Union’s Strategy in Myanmar,” *European Journal of International Relations* 26, no. 3 (2020): 660-86; Carla Winston, “International Norms as Emergent Properties of Complex Adaptive Systems,” *International Studies Quarterly* 67, no. 3 (2023): 1-8; Caroline Fehl,

speculating over which one is the fundamental norm, and others are organizing principles,²²³ whether it is a core norm or a secondary norm,²²⁴ whether they are in conflict and how do they interplay.²²⁵

This weakness has led scholars to alternative conceptualizations to move deeper into norms' content. Recent conceptual advances have led to a shift towards a more dynamic understanding of norms from the rather static and structural take of earlier norm scholars. In one of these advances, Winston offered the concept of norm clusters based on a tripartite structure of norm's internal components in a move to take plurality of interpretation seriously. Her conceptual innovation, norm cluster, is a "collection of interrelated specific problems, values, and behaviors that are understood to be similar enough."²²⁶ Accordingly, a norm contains a problem to be solved, a behavior that will solve it, and value that morally supplies this behavior. Although norms are still being considered as a package that contains answers to what, why and how of an actor's behavior, it enables researchers to still talk about norms even when they contain multiple distinct elements. It is possible to observe more than one option for each component, and agents may combine them in line with their preferences. In any case, norm clusters refer to "phenomenon of multiple realizability" in which variation in norm implementation is possible."²²⁷ However, as will be debated in the following pages, distinct elements within the ITPGRFA 'norm cluster' are difficult to be combined.

Lantis and Wunderlich offered another conceptualization of norm clusters. This one is outward looking and takes into account multiple single norms, rather than their internal

"Protect and Punish: Norm Linkage and International Responses to Mass Atrocities," *European Journal of International Relations* 29, no. 3 (2023): 751-79.

²²³ Antje Wiener, *Contestation and Constitution of Norms in Global International Relations* (Cambridge: Cambridge University Press, 2018), 62.

²²⁴ Andersen, *Governing Agrobiodiversity*, 36-37.

²²⁵ Tschersich, "Norm Conflicts," 1-15.

²²⁶ Carla Winston, "Norm Structure, Diffusion, and Evolution: A Conceptual Approach," *European Journal of International Relations* 24, no. 3 (2018): 638-61.

²²⁷ Jennifer Clapp and Linda Swanston, "Doing Away with Plastic Shopping Bags: International Patterns of Norm Emergence and Policy Implementation," *Environmental Politics* 18, no. 3 (2009): 315.

content. A norm cluster is defined as “collections of aligned, but distinct norms or principles at the center of a regime.”²²⁸ Based on this definition, PGR norm cluster consists of multiple (conservation, use, sharing benefits), aligned (through food security and sustainable agriculture) but distinct norms. It is even possible to add intellectual property rights as a standalone norm since they should be allowed for encouraging innovation which would help feed the world.

These conceptual tools help us to talk about norms. However, by deducing normativity from norms, it effectively de-historicizes and, reifies them by taking their existence and normativity for granted. What about the agency and its non-discursive practices? Who made this norm in the first place or who re-arranged them within this treaty. This highly sterilized analysis creates an “illusion of agency”²²⁹ by “substituting acting abstractions for actual agents” in producing and maintaining normativity of practices. Even if we accept this ontologization²³⁰ of dynamic goals as reified social facts that act,²³¹ then we should ignore decades old academic and political debates over their meanings and appropriate means to achieve food security and sustainable agriculture.²³²

The academic tendency of ignoring the historical processes in which norms embedded into social arrangements is a by-product of the supplying norms with explanatory power. However, another problem remains with this understanding of norms, that is, the normativity of norms. Early norm studies recognized norms as the sole sources of normativity. Therefore, they assumed a direct causal relationship between norms and

²²⁸ Jeffrey S. Lantis and Carmen Wunderlich, “Resiliency Dynamics of Norm Clusters: Norm Contestation and International Cooperation,” *Review of International Studies* 44, no. 3 (2018): 570-93.

²²⁹ Patrick Thaddeus Jackson and Daniel H. Nexon, “Relations Before States: Substance, Process and the Study of World Politics,” *European Journal of International Relations* 5, no. 3 (1999): 294; Bucher, “Acting Abstractions,” 742–65.

²³⁰ Wiener, *Contestation and Constitution of Norms*.

²³¹ Pratt, *Normative Transformation*.

²³² Tim Lang and David Barling, “Food Security and Food Sustainability: Reformulating the Debate,” *Geographical Journal* 178, no. 4 (2012): 313-26; Eric Holt-Giménez et al., “We already Grow Enough Food for 10 Billion People... and Still can't End Hunger,” *Journal of Sustainable Agriculture* 36, no. 6 (2012): 595-98; Jessica Duncan, *Global Food Security Governance: Civil Society Engagement in the Reformed Committee on World Food Security* (Routledge, 2015).

behaviors. The diffusion of norms takes place when others learn and internalize the appropriateness of the prescribed behavior embedded in the norm. This conceptualization turned the normativity from a patterned social relation into norms that are social facts whose content is quite clear and stable. The conceptual degeneration of norms for the sake of explanatory power, attributed a highly structural understanding of agency in the process of constituting normativity. Normativity then automatically embedded into the appropriate behaviors through norms which themselves somehow emerged through treaties, institutions and agreed upon principles. As a result, normativity stripped away from its dynamic, malleable and emergent properties, and turned into an instrumental product as is the case with regime studies. However, even when norms were considered as stable containers of pre-given normativity, their diffusion process, with all strategic and coercive actions, still requires a closer look since it is the process that made one particular normativity among others the global one.

3.4. Practice-oriented Norm Studies

Recently, relational, practice-oriented, and pragmatist approaches have drawn norm scholars' attention to processes and relations in order to overcome the determinism of structure-like norms and to better trace the creativity of agents in the change and stability of social arrangements.²³³ There has been an increase in efforts to redirect social constructivism towards a research focus on such topics. Thus, a search has begun toward understanding "relations" and "processes" beyond norms, structures, actors, and the isolated qualities attributed to these concepts.²³⁴ A similar trend can be observed in norm studies. These studies have significantly contributed to re-evaluating dominant understandings regarding the conceptualization of norms, explanations

²³³ Patrick Thaddeus Jackson and Daniel H. Nexon, "Reclaiming the Social: Relationalism in Anglophone International Studies," *Cambridge Review of International Affairs* 32, no. 5 (2019): 582-600; Jackson and Nexon, "Relations Before States," 291-332; Bueger and Gadinger, *International Practice Theory*; McCourt, "Practice Theory and Relationalism," 475-85; McCourt, *The New Constructivism*; Drieschova, Bueger and Hopf, eds., *Conceptualizing International Practices*.

²³⁴ Mustafa Emirbayer, "Manifesto for a Relational Sociology," *American Journal of Sociology* 103, no. 2 (1997): 281-17.

offered for norm change, and the sources of normativity in international relations.²³⁵ These newly added grounds challenged the dominant conceptualization of norms as “ideal-typical bounded” stable social facts.²³⁶ Alternative concepts were offered to zoom in on diverse sites and processes of norm dynamics and to reflect on multiple sources of social change, including “normativity”,²³⁷ “normative configuration”,²³⁸ and “normative, substances.”²³⁹ Practice-oriented scholars urged that considering practices as mere reflections of norms is misleading as practices are also norm changing. Therefore, a focus on normativity, rather than norms is preferred as “emergence of norms is based on the practice.”²⁴⁰

Less static conceptualizations allowed scholars to discuss diverse sources of evolving/emergent normativity by focusing on the transactional character of social action that unfolds through the processes of emergence, maintenance, and transformation of normativity. Practices and their institutionalization in different sites became legitimate subjects of inquiry as they sustain and transform normativity. Through such interventions, normativity came to be understood as a “relational constitution in practices”²⁴¹ that “can emerge in practices in unstructured but sedimented or increasingly standardized procedures.”²⁴²

²³⁵ Schmidt, “A Pragmatist Explanation of Norm Change,” 817-29; Hofferberth and Weber, “Lost in Translation,” 75-103; Ralph, *On Global Learning*; Bode and Huelss, *Autonomous Weapons Systems and International Norms*; Bode and Huelss, “Artificial Intelligence Technologies,”; Bode, “Practice-Based and Public-Deliberative Normativity,” 990-1016; Sondarjee, “Practice Contestation in and between Communities of Practice” 1-13; Adler, *A Social Theory of Cognitive Evolution*, 131.

²³⁶ Ingvild Bode, “Emergent Normativity: Communities of Practice, Technology, and Lethal Autonomous Weapon Systems,” *Global Studies Quarterly* 4, no. 1 (2024): 2.

²³⁷ Gadinger, “The Normativity of International Practices,” 100-22; Schmidt and Williams, “The Normativity of Global Ordering Practices,” 13.

²³⁸ Pratt, “Norm Transformation,” 723-47; Pratt, “From Norms to Normative Configurations,” 59-82; Pratt, *Normative Transformation*, 20.

²³⁹ Qiao-Franco and Bode, “Weaponised Artificial Intelligence,” 108.

²⁴⁰ Bueger and Gadinger, *International Practice Theory*, 111.

²⁴¹ Qiao-Franco and Bode, “Weaponised Artificial Intelligence,” 108.

²⁴² Bode and Huelss, “Artificial Intelligence Technologies,” 5.

Similarly, Pratt openly suggested the “de-reification of norms,” and offered the concept of “normative configuration” to explain their function in social relations and to highlight the recursive dynamics of normativity and practices.²⁴³ Rather than attributing inherent and pre-formed qualities to actors, these approaches offered ways to think beyond dualistic agency/structure and environment/action dynamics by embedding agency in situations emerging from transactions.²⁴⁴ Actors make use of norms, legitimize their actions, and find creative solutions to expand their meanings in “problem situations” where and when their practices are interrupted.²⁴⁵ Qiao-Franco and Bode suggested that competing practices of domestic actors in diverse governance sectors may result in gradually emergent normativity.²⁴⁶ Critical norm scholars were aware of the fact that norms that diffuse in fact emerged out of local contestations.

The notion that norms are fixed and agreed upon once institutionalized ignores the fact that normative content continues to develop through implementation practices. Huelss pointed out that “statistical, indicator-based operationalization” practices as a part of the process of norm implementation are indeed norm-changing. Accordingly, the technical process of “developing procedures (such as assessments, evaluations, and monitoring processes) to generate comparable and calculable data and indicators” is another source of normativity. Usually neglected due to the overreliance on discourse-based practices of norm generation in formal spaces, “the act of translating norms into operational concepts transforms (or even defines) their substance.” Based on a Foucauldian understanding of governmentality, norms are operationalized “in constitutional documents and evaluation guidelines, through standardized procedures

²⁴³ Pratt uses de-reification as an analytical move to historicize the process of institutionalization of practices; Pratt, *Normative Transformation*, 50. For Pratt’s application of de-reification see Pratt, *Normative Transformation*, 62-70, 89-95, 123-127. For a critique de-reification of norms see Miles E. Evers, “Just the Facts: Why Norms Remain Relevant in an age of Practice,” *International Theory* 12, no. 2 (2020): 220-30. For Pratt’s reply: Simon F. Pratt, “Reification, Practice, and The Ontological Status of Social Facts,” *International Theory* 12, no. 2 (2020): 231-37.

²⁴⁴ Emirbayer, “Manifesto for a Relational Sociology,” 281-17; Jackson and Nexon, “Relations Before States,” 291-332.

²⁴⁵ Hofferberth and Weber, “Lost in Translation,” 8; Ted Hopf, “Change in International Practices,” *European Journal of International Relations* 24, no. 3 (2018): 695.

²⁴⁶ Qiao-Franco and Bode, “Weaponised Artificial Intelligence,” 113.

or informal ways of doing things, and are enacted locally in micro-practices.”²⁴⁷ Therefore, implementation is a “site where normative content emerges through practices rather than considering it as technical or apolitical.”²⁴⁸ Bode and Huelss, drawing from Practice Theory, and Science & Technology Studies, identifying additional sources of “normative substance” by highlighting the norm-generative role of “operational practices of design and use” that are “typically performed outside of the public eye.”²⁴⁹ This perspective connects operational/non-discursive practices to norm dynamics by analyzing agents’ practices in technical-professional tasks. Furthermore, by addressing the agency attributed to technology and material artifacts (such as Artificial Intelligence) in shaping norms, this approach integrates the material into the social sphere. It builds on the idea that technology (materiality) is a “reservoir of social practices” rather than merely “part of objective-neutral processes of experimentation and problem-solving” in normative transformation processes.²⁵⁰

Bode further attempted to integrate diverse sources of normativity by analyzing the interaction of public-deliberative processes of normativity (deliberation and behavioral practices in formal sites of governance) and operational practices that produce normativity/normality in the process of developing and deploying technological/material devices.

Technologies do not ‘naturally’ become important reference points by themselves, but because of processes of social meaning-making. They are carriers of practices, often not necessarily in intended ways. Thinking about agency also raises the question of who benefits from the type of normativity/normality that emerges in practice-based processes being performed at sites unseen by the public.²⁵¹

²⁴⁷ Hendrik Huelss, “After Decision-Making: The Operationalization of Norms in International Relations,” *International Theory* 9, no. 3 (2017): 383.

²⁴⁸ Ingvild Bode and John Karlsrud, “Implementation in Practice: The Use of Force to Protect Civilians in United Nations Peacekeeping,” *European Journal of International Relations* 25, no. 2 (2019): 461.

²⁴⁹ Bode and Huelss, “Artificial Intelligence Technologies,” 1.

²⁵⁰ Bode and Huelss, “Artificial Intelligence Technologies,” 6.

²⁵¹ Bode, “Practice-Based and Public-Deliberative Normativity,” 1007.

Sondarjee extended the scope of available practices in normative transformations by introducing the concept of practice contestation. The notion of practice contestation, in addition to Wiener's established discursive practices concerning values, norms, and rules, encompasses contestation through practices in practical and cognitive knowledge domains, including tools, concepts, guidelines, and causal understandings. Sondarjee also pointed out the impact of epistemic power relations over the outcomes of practices contestation.²⁵²

Contrary to stability notion of early studies, norms now understood to be as “emergent properties”²⁵³ of complex and dynamic social arrangements that are subject to contestation, on multiple grounds, through discourses and behaviors.²⁵⁴ Even when implementing a norm, social actors have creative agency to redefine its content. Therefore, rather than focusing on finished products and their power, taking these moments of creative agency seriously, either for stabilizing or destabilizing the content, is important for capturing their dynamic nature. However, as norms are institutionally embedded and powerful, a space of action in the form of an institutional crack in which agency can penetrate should be spotted in order to capture these creative practices. For this reason, and to zoom in to the process in which normativity is institutionalized through routinized ways of doing things, it is necessary to deconstruct seemingly stable arrangements, standards, prescriptions and conventions into its constituent parts. De-reification of norms, in this regard, refers to

[...] specifying a configuration of institutions, actors, and practices featuring both mechanisms of reproduction, defined by historical place as well as regulatory function, and describing how it generates stability, where it contains places or relations of tension, and where problems of implementation or disagreement may spark innovation and transformation.²⁵⁵

Technical details, procedures and implementation practices, that are often ignored for their non-ideational nature, are in fact steps in which the meaning of the norm enacted

²⁵² Sondarjee, “Practice Contestation,” 1-13.

²⁵³ Winston, “International Norms as Emergent Properties,” 1-8.

²⁵⁴ Anette Stimmer and Lea Wisken, “The Dynamics of Dissent: When Actions Are Louder than Words,” *International Affairs* 95, no. 3 (2019): 515-33.

²⁵⁵ Pratt, *Normative Transformation*, 50.

into practices. These technical decisions serve as refinement practices that effectively determine what actors should precisely do to be recognized as norm implementer. Through this specification, broadly accepted fundamental norms translated into implementation mechanisms. These seemingly technical principles serve as a benchmark for judging actors' performances, labelling them as competent or incompetent.²⁵⁶ Since all practices, as patterned performances, should be socially recognized as "competent" by its practitioners to be appropriate, then these non-political tools further solidify the deeply political worldview they embedded by enacting the dominant meaning of conserving plants into the ways of doing it.

It is argued that ITPGRFA is a balanced agreement achieved through compromise. Despite these seemingly well-balanced provisions, the treaty has been partly implemented so far. While access has been facilitated to some actors, benefits remained to be shared.²⁵⁷ For this reason, it is a matter of debate how balanced this compromise was. Based on the conceptual advances above, a closer look at the ITPGRFA shows that it prescribes a set of highly specified behaviors for actors, beyond broadly defined norms of food security, sustainable agriculture or cluster elements. It is therefore necessary to understand which particular meaning these norms loaded at the implementation level of ITPGRFA.

The Treaty does not, in its provision, establish a hierarchy among the stakeholders. The implementation, however, reinforces the existing hierarchy between farmers and breeders. Firstly, the treaty implements the principle of sustainable use and facilitated access in a limited sense. Although the Multilateral System of Access and Benefit-Sharing (MLS) provides facilitated access to "any legal and natural persons under the jurisdiction of any Contracting Party,"²⁵⁸ it does this "solely for the purpose of

²⁵⁶ Emanuel Adler and Vincent Pouliot, "International Practices," *International Theory* 3, no. 1 (2011): 1-36.

²⁵⁷ Florian Rabitz, "Access without Benefit-Sharing: Design, Effectiveness and Reform of the FAO Seed Treaty," *International Journal of the Commons* 11, no. 2 (2017): 621-40; "Industry Benefits but Does Not Pay Its Dues," La Via Campesina (May 9, 2016), <https://viacampesina.org/en/2016/05/industry-benefits-but-does-not-pay-its-dues-patents-are-an-assault-on-genetic-resources/>.

²⁵⁸ Food and Agriculture Organization of the United Nations, International Treaty on Plant Genetic Resources for Food and Agriculture, *Article 12.2*.

utilization and conservation for research, breeding, and training for food and agriculture.”²⁵⁹ Unlike formal breeders who improve plants at the experiment fields or labs, farmers improve theirs by using them in the fields, selecting them after harvest, exchanging with the community, and selling them at the local market. Therefore, the way they improve plants, through direct use/cultivation. However, the MLS does not provide farmers with facilitated access to genetic material for direct use in farming activities,²⁶⁰ therefore farmers’ practices were not considered as proper breeding, researching or training method.²⁶¹

This separation of research/breeding and farming in the Treaty seems to be imported from existing intellectual property regulations. Farmers improve plants collectively, on-farm, however IPRs do not recognize products of informal collaborations as patentable subject matter. Moreover, under the current UPOV provisions and national seed laws, modern plant varieties should meet the criteria of novelty, distinctness, uniformity, and stability. Farmer varieties are sure to fail to meet the criteria for PVP under UPOV and standards for marketing under national laws. Therefore, it is not possible for farmers to protect their seeds with the tools designed within the IPR and seed laws. As they fail to produce protectable varieties, farmers’ practices are not considered as breeding activity. Unlike the treaty text, users are redefined through implementation practices. Only formal breeders’ methods recognized as ‘right’ way to improve plants, thus eligible for access and use. The problem is that while farmers are the main beneficiaries of the MLS benefit-sharing arrangements, and facilitated access is worded as one of the non-monetary benefits, they are prevented from this.

Secondly, the Treaty confirms and relies on the existing hierarchy among distinct crop diversity conservation system by aligning MLS with Ex Situ conservation infrastructure. Although several conservation methods, including In Situ, On-Farm and Ex Situ, were agreed upon as appropriate strategies,²⁶² the Treaty implicitly

²⁵⁹ Ibid., *Article 12.3.a*.

²⁶⁰ Frison, *Redesigning the Global Seed Commons*, 200.

²⁶¹ Food and Agriculture Organization of the United Nations, *International Treaty on Plant Genetic Resources for Food and Agriculture*, 13.2.d.ii.

²⁶² Ibid., *Article 5*.

excluded In Situ PGRFA out of the MLS by leaving terms of access to In Situ collections to be governed by national regulations.²⁶³ By not creating an implementation mechanism, ITPGRFA prioritized, and so far implemented, Ex Situ strategy as the prominent method of conserving plants, which “removes germplasm from their natural evolutionary environments.”²⁶⁴ With this ‘technical’ choice, it abandoned the alternative conservation strategy of In Situ, one that provides for the conservation of plants within the hub of dynamic relations surrounding them, i.e. in the fields with the farmers, rather than moving them into gene banks. This seemingly neutral decision has several consequences, one of which is deepening the existing hierarchy between formal and informal breeders. Access to MLS material requires considerable competence regarding the technical procedures. Individual farmers, particularly those from the developing world, rarely obtain such expertise. Plant breeding industry, either with the support of their associations or through creating their issue-specific departments with competent professionals, can overcome complex legal, bureaucratic, and technical obstacles. It would be beyond optimistic to assume that most small-scale farmers are aware of the Treaty and its MLS. Even when they are made aware of the MLS, they still need assistance in searching for, identifying, requesting genetic materials, signing SMTAs, and receiving the samples.

These observations reveal that ITPGRFA provides not only a legal framework, but also “a semantic framework defining what exactly to collect and why.”²⁶⁵ It has put forth a particular conservation regime, one that is exclusively designed for the utilization of existing genetic resources in plant breeding activities. In this, plants were conceptualized as ‘resources’ that are valuable for their future use within a particular production system, and that is why they should be conserved. In line with this understanding of plants as resources, it promoted and established a particular conservation strategy, one that relies on stored genes. Behind this technical choice, a

²⁶³ Ibid., Article 12.3.h.

²⁶⁴ Kafi Britwum and Matty Demont, “Food Security and the Cultural Heritage: Missing Link,” *Global Food Security* 35, (2022), 4.

²⁶⁵ Suzana Alpsancar, “Plants as Digital Things: The Global Circulation of Future Breeding Options and their Storage in Gene Banks,” *Tecnoscienza–Italian Journal of Science & Technology Studies* 7, no. 1, 50.

rather social one was buried deep inside, providing breeders with quick access to these ‘resources’ to enable them to breed new, better and problem-solving varieties. As a combination of these ideational and technical choices, crop diversity was designed to be a manufactured diversity, rather than a result of slow and gradual evolution. Formal breeders, rather than farmers, emerged as the ‘real’ beneficiaries of this regulation, and tasked with manufacturing genetic diversity.

As a result, the Treaty supplied the “resourcist cosmovision”²⁶⁶ with legitimacy by leaving plants that are either ecologically or culturally important, yet commercially insignificant, out of this conservation regime. The genetic erosion in locally significant plant varieties usually contribute to cultural erosion by taking with them related traditional knowledge, nutritional patterns and habitual practices.²⁶⁷ The international regime for the plant genetic resources, despite its contrary provisions, ends up with implementing a vision that seeks to conserve genes for their instrumental values “as means to achieve human ends, or satisfy human preferences.”²⁶⁸ This ‘socio-technical arrangement’ has been made operational through above mentioned technical choices and implementation principles which themselves are designed in line with utilitarian worldview. Therefore, it has been criticized for its value-monism (anthropocentrism), and for its failure to acknowledge diversity of values that include non-anthropocentric and non-European ones.²⁶⁹

²⁶⁶ Marianna Fenzi and Christophe Bonneuil, “From “Genetic Resources” to “Ecosystems Services”: A Century of Science and Global Policies for Crop Diversity Conservation,” *Culture, Agriculture, Food and Environment* 38, no. 2 (2016): 73; Sara Peres, “Seed Banking as Cryopower: A Cryopolitical Account of the Work of the International Board of Plant Genetic Resources, 1973–1984,” *Culture, Agriculture, Food and Environment* 41, no. 2 (2019): 77; Christophe Bonneuil, “Seeing Nature as a ‘Universal Store of Genes’: How Biological Diversity Became ‘Genetic Resources’, 1890–1940,” *Studies in History and Philosophy of Biological and Biomedical Sciences* 75, (2019): 1-14; Helen Anne Curry, “The History of Seed Banking and the Hazards of Backup,” *Social Studies of Science* 52, no. 5 (2022): 664-88.

²⁶⁷ IPES-Food, *From Uniformity to Diversity*, 27.

²⁶⁸ Unai Pascual et al., “Valuing Nature’s Contributions to People: The IPBES Approach,” *Current Opinion in Environmental Sustainability* 26-27, (2017): 9.

²⁶⁹ *Ibid.*, 7-16.

3.5. Social Analysis of Science and Technology

Taking a practice-oriented approach to normativity reveals that the combination of the appropriate behavior, value, and the problem goes beyond the words and agreed meanings. In the case of plant genetic resources for food and agriculture, it seems that a particular intersubjective understanding has been institutionalized within the implementation practices. Following implementation practices of the Treaty, rather than the presumed norms of it, enable us to answer the questions of what should be conserved (plants that are useful), why they should be conserved (utilization by breeders), how and where they should be conserved (Ex Situ-Gene Banks). Considering the limitations imposed by the concept of norm, it is better to call this arrangement a normative configuration, that is “an arrangement of ongoing, interacting practices establishing action-specific regulation, value orientation, and avenues of contestation”,²⁷⁰ to understand what is enables for whom.

ITPGRFA as a normative configuration tells us precisely what states agreed to do, that is conservation for use. The irony with this configuration is that while it offers genetic resources to breeders to produce modern seeds, it ignores the fact that genetic resources came under threat of erosion with the spread of modern seeds in the first place. Therefore, the treaty reproduces the very danger it aims to evade. In the early 1970s, scientists and politicians alike agreed that the miracle seeds of the Green Revolution were destroying genetic resources. Then, the question is how did the idea that considers making genetic resources available for breeders as the best conservation strategy make its way through the existing normative configuration? More clearly, how did global governors accept this specific way of conserving genetic resources, despite its quite visible contradiction.

Some accounts offer innovative conceptual tools for integrating political and economic factors with the process of knowledge production. Studies on the history of science, technology, genetics, and biology provide rich insights into how a particular

²⁷⁰ Pratt, *Normative Transformations*, 16.

conservation method came to dominate the global agenda.²⁷¹ Rather than taking science and technology as neutral activities and objects, these studies conceptualize them as inherently political and embedded into social and economic contexts. This understanding of interaction between science, technology and politics helps us understand the co-production of technologies and social norms. It explains how technologies are produced to function in specific ways for enabling new means of action, while simultaneously constraining those actions by limiting the available directions for it. Therefore, they show how technical choices determine what is conserved and why, and how political struggles shape the very designs of these technical solutions.

For example von Dooren shows that Ex Situ methods “do not aim to conserve agricultural biodiversity at all, but rather aim to protect and make readily available for use a unique kind of instrumentalized genetic life.”²⁷² Similarly, Peres suggests that when the genetic erosion made its debut as a problem to be solved, global governors decided to freeze them, rather than conserving in their dynamic form, in order to “make genetic resources... stable and mobile, not only across space but, importantly, over time.”²⁷³ Moreover, seed banks are not stand alone technical solutions designed by some powerful actors to achieve their goals. Rather, they are part of a larger socio-technical arrangement. Curry shows that seed bank had been “a crucial addition to the technologies of industrial agricultural production.”²⁷⁴ Fenzi adopts Karin Know Cetina’s conceptualization of epistemic cultures, “as the historically specific

²⁷¹ Sara Peres, “Saving the Gene Pool for the Future: Seed Banks as Archives,” *Studies in History and Philosophy Biological and Biomedical Sciences* 55 (2015): 96–104; Helen Anne Curry, “Data, Duplication, and Decentralisation: Gene Bank Management in the 1980s and 1990s,” in *Towards Responsible Plant Data Linkage: Data Challenges for Agricultural Research and Development*, ed. Hugh F. Williamson and Sabina Leonelli (Springer International Publishing, 2023), 163–82; Peres, “Seed Banking as Cryopower,” 1973–84; Bonneuil, “Universal Store of Genes,” 1890–40; Fenzi and Bonneuil, “Global Policies for Crop Diversity Conservation,” 72–83; Thom Van Dooren, “Banking Seed: Use and Value in the Conservation of Agricultural Diversity,” *Science as Culture* 18, no. 4 (2009): 373–95; Fenzi, “Crop Genetic Diversity,” 259–85; Helen Anne Curry, “Breeding Uniformity and Banking Diversity: The Genescapes of Industrial Agriculture, 1935–70,” *Global Environment* 10, no.1 (2017): 83–113; Curry, “History of Seed Banking,” 664–88.

²⁷² Van Dooren, “Banking Seed,” 375.

²⁷³ Peres, “Seed Banking as Cryopower,” 84.

²⁷⁴ Curry, “Breeding Uniformity,” 86.

arrangements of individuals, institutions, and ideas that form cultures that create and warrant knowledge”, and explains the victory of Ex Situ methods over alternatives in the early days of conservation agenda as a victory of breeders’ epistemic culture over others.²⁷⁵

Above mentioned insights took their root mostly from Science and Technology Studies (STS). STS suggest that a supposedly linear path from pure scientific knowledge to technical objects or systems in fact involves choices made by social actors based on political, cultural or economic considerations. This contradicts two commonly held assumptions, one that separates science and technology into distinct realms of basic science and applied science; and the other that distinguish scientific and technical from political and economic. In fact, this separationist understanding can be seen as an extension of broader demarcations such as society and nature, material and ideational, discursive and behavioral, and agents and structures which emerge from “an ontological register that treats separation as the fundamental condition of existence, while rendering interconnection secondary or largely derivative.”²⁷⁶

As an ontological register, separationist lens has consequences regarding what we see while observing social relations, how we see them, and the ways of knowing them. This is particularly the case with the conceptualizations of science and technology, and the role of non-human objects in social life. In general, social scientific approaches to science, technology and materiality can be categorized into three main groups. The first way of studying technology and society is through technological determinism, which claims that technological systems develop autonomously based on their internal/technical logic; and they determine social relations significantly.²⁷⁷ It is criticized for following “a teleological, linear and one-dimensional” understanding of technological development which externalizes technology to social relations, then supplies it with agency, one that more capable to act than social beings who design,

²⁷⁵ Fenzi, “Crop Genetic Diversity,” 261.

²⁷⁶ Tamara Trowsell, “Recrafting Ontology,” *Review of International Studies* 48, no. 5 (2022): 802.

²⁷⁷ Kline, “Technological Determinism,” 109-12.

develop and use it. This sort of conceptualization generally reifies technology and technical objects as neutral, apolitical means of action.²⁷⁸

The second approach emerged as a critique of technological determinism and a rejection of the idea of internal logic of technology development. Based on a social constructivist premise, it recognized that “technologies could have been otherwise.”²⁷⁹

[...] technologies are not purely technological [...] they are heterogeneous, that artifacts embody trade-offs and compromises. In particular, they embody social, political, psychological, economic, and professional commitments, skills, prejudices, possibilities, and constraints [...] if this is the case, then the technologies [...] could in another world have been different. And this means that the technologies that are currently in the process of being developed might, at least in principle, take a variety of different forms, shapes, and sizes.”²⁸⁰

The social construction of technology (SCOT) integrates human agents into the development process of technology. While in its mild form, it argues for the consideration of the social context in explaining the process in which technology develops (embedding into social relations), the radical version puts a stronger emphasis on the socially constructed content of science and technology, which is argued to be constructed through human practices. Social relations reproduce existing patterns or transform them through designing technologies.²⁸¹

A third group of studies seeks to overcome existing dichotomies, such as nature-society, actor-structure, material-social, objective-subjective, and conceptualize science, technology and society as an entangled web of relations that emerge and transform throughout the processes. Several distinct frameworks emerged as part of a broader epistemic turn against technological determinism including Actor & Network Theory, Assemblage thinking, and Science, Technology & Society and spread into various branches of social sciences. These studies criticized social constructivist

²⁷⁸ Wiebe E. Bijker, “Social Construction of Technology,” in *A Companion to the Philosophy of Technology*, eds. Jan Kyrre Berg Olsen, Stif Andur Pedersen and Vincent F. Hendricks (John Wiley & Sons, Ltd, 2009), 88–94.

²⁷⁹ Ibid., 91.

²⁸⁰ Wiebe E. Bijker and John Law, “General Introduction,” in *Shaping Technology/Building Society: Studies in Sociotechnical Change*, eds. Wiebe E. Bijker and John Law (MIT Press, 1992), 7–8.

²⁸¹ Law, “STS as Method,” 34.

accounts for their separation of human and non-human, and for assuming a one-way interaction process which predominantly attributed agency to human actors. Even when equipped with co-constructionist understanding of social relations, whether in its radical form or mild form, it necessarily and ontologically separates the realm of social from nature. In this way, however, “it makes incomprehensible the very linkages between Nature and Society” that Latour wish to account for.²⁸² In Latourian sense, the nature-social divide serves as a constitutional move for modernity which “invents a separation between the scientific power charged with representing things and the political power charged with representing subjects”,²⁸³ in turn “underwrites all other ways of grasping the world”.²⁸⁴

Within this latest strand of studies, one recurring concept is the coexistence of material and social in producing practices, which are understood as socio-material practices or material-discursive practices. The entangled nature of discursive and material, nature and culture, or the social and scientific have been captured by distinct conceptual tools, including Sheila Jasanoff's “co-production,”²⁸⁵ Karen Barad's “intra-acting agencies,”²⁸⁶ and Latour's actants. Andrew Pickering argued that human and material agencies are “connected with one another, reciprocally and emergently defining and sustaining each other” in other words they are “constitutively intertwined... interactively stabilized.” The process in which human and non-human agencies reciprocally tune each other in practice is called “dance of agency” and takes the form of a dialectic of resistance and accommodation. The “mangle of practice” refers to this

²⁸² Bruno Latour, “One More Turn after the Social Turn: Easing Science Studies into the non-modern World,” in *The Social Dimensions of Science*, ed. Ernan McMullin (Notre Dame University Press, 1992), 292.

²⁸³ Bruno Latour, *We Have Never Been Modern*, trans. Catherina Porter (Harvard University Press, 1993), 29.

²⁸⁴ Sheila Jasanoff, “Ordering Knowledge, Ordering Society,” in *States of Knowledge: The Co-production of Science and Social Order*, ed. Sheila Jasanoff (Routledge, 2004), 22.

²⁸⁵ Jasanoff, “The Idiom of Co-production,” 1-12.

²⁸⁶ Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Duke University Press, 2007).

dialectical process of transforming one another which involves active and passive phases for human and material performances.²⁸⁷

Jasanoff offers the concept of co-production to move beyond ‘co-constitutionalist’ binaries that ontologically separate social and material. The concept of co-production considers that the “knowledge and social orders are co-produced”²⁸⁸ in a way “that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we chose to live in it.”²⁸⁹ Co-production is a process of world-making that renders invisible all the connections between material objects, such as cloned sheep Dolly or GMO seeds and social facts, such as expertise, rules, institutions.²⁹⁰ The process of knowledge production is therefore a highly social activity. It is also a patterned one as knowledge of objects had to be re-ordered by institutions that “offer ready-made instruments for putting things in their places at times of uncertainty and disorder.”²⁹¹ The meaning of new objects stabilized through “institutionalized ways of knowing things” that shape “how people recognize them, name them, investigate them, and assign meaning to them; and how they mark them off from other existing entities, creating new languages in which to speak of them and new ways of visually representing them.”²⁹²

These patterned ways of knowing things endure challenges as they are socially and epistemologically enacted through practices of like-minded community of scientists who authorize validity of knowledge claims, “the right ways to observe nature, to represent those observations, and to make persuasive sense of what has been

²⁸⁷ Andrew Pickering, *The Mangle of Practice: Time, Agency, and Science* (University of Chicago Press, 2010), 17.

²⁸⁸ Ulrike Felt, “Making Knowledge, People and Societies,” in *The Handbook of Science and Technology Studies*, eds. Ulrike Felt, Rayvon Fouché, Clark A. Miller and Laurel Smith-Doerr (MIT Press, 2016): 253-57.

²⁸⁹ Jasanoff, “The Idiom of Co-production,” 2.

²⁹⁰ Jasanoff, “Ordering Knowledge, Ordering Society,” 22.

²⁹¹ *Ibid.*, 40.

²⁹² Jasanoff, “The Idiom of Co-production,” 5.

observed.”²⁹³ The pattern that safeguards the established ways of doing science is what Knorr-Cetina calls an “epistemic culture”, that is an “amalgam of arrangements and mechanisms, bonded through affinity, necessity, and historical coincidence, which, in a given field, makes up how we know what we know.”²⁹⁴ The science, then, “is understood as neither a simple reflection of the truth about nature nor an epiphenomenon of social and political interests.”²⁹⁵

3.6. Framework for Analysis

Insights from the critical studies of science and technology make it possible to trace multiple sources of social change, including scientific practices, technical developments, political and economic struggles, and institutional revisions. In line with this, Samuel Pratt offers a conceptual framework for tracing multiple causal mechanisms simultaneously.

As previously introduced, Pratt argues that the difficulty in explaining some institutional changes through norms or their clusters is related to pace and form of the change, and the conceptual limitations of the norms. Some changes unfold gradually through micro-level processes, thus do not represent a clear-cut shift from old norms to new norms. However, even these minor changes refer to shifts in how people act and the motive behind the action. Since these changes “are uneven or internally inconsistent, span a heterogenous set of practices,”²⁹⁶ norm studies with a clearly defined norm definition fails to trace or explain such changes. To explain such transformations, Pratt argues that norms should be “de-reified into configurations of processes and relations of interaction.”²⁹⁷ This is because normativity, rather than norms, is more useful in tracing such transformations. Normativity, as noted above, had been aligned with the existence of norms in earlier studies. However, practice-

²⁹³ Sheila Jasanoff, “Chapter 4: Science and Technology Studies,” in *Research Handbook on Climate Governance*, ed. Karin Bäckstrand and Eva Lövbrand (Edward Elgar Publishing, 2015), 37.

²⁹⁴ Knorr Cetina, *Epistemic Cultures*.

²⁹⁵ Jasanoff, “The Idiom of Co-production,” 4.

²⁹⁶ Simon F. Pratt, *Normative Transformation and the War on Terrorism: The Evolution of Targeted Killing, Torture and Private Military Contracting* (Cambridge University Press, 2022), 20.

²⁹⁷ Pratt, *Normative Transformation*, 21.

oriented and relational approaches take normative for its dynamic and relational quality. It still requires commonly held appropriateness since, as Rouse said, “[...] performances of a practice are intentionally directed toward and accountable to ‘something’”. For Rouse, that ‘something’ which provides appropriateness to practices and informs their normativity is mutual accountability, rather than a determinate norm.²⁹⁸

Pratt offers an alternative concept “normative configuration” as “an arrangement of ongoing, interacting practices establishing action-specific regulations, value-orientations, and avenues of contestation”.²⁹⁹ It replaces norms with “configurations of institutionalized relationships and practices”, by de-reification, that is a process of “redescription of norms as granular arrangements of conventions, values, and routines of action spanning multiple legal, bureaucratic, and legislative fields.”³⁰⁰ In general, normative configuration refers to the broader setting within which normativity unfolds with novel institutionalized practices, that become “ongoing components of formal and informal social arrangements...”³⁰¹

Pratt offered a framework to trace institutionalization of new practices into normative arrangements or their removal thereof through three linked processes which are called causal mechanisms of normative transformation.

The first mechanism is named convention reorientation, which refers to “the re-description of a situation to reposition it within a different set of definitional and regulatory terms.” Conventions are understood as “institutionalized standards of right conduct... or practical devices for adjudicating disputes over what should be done,”³⁰² and covers both legal and practical sources. Pratt argues that when actors fail to achieve their desired ends through existing arrangements, they attempt to frame the

²⁹⁸ Joseph Rouse, “Social Practices and Normativity,” *Philosophy of the social sciences* 37, no. 1 (2007), 51.

²⁹⁹ Pratt, *Normative Transformation*, 15.

³⁰⁰ *Ibid.*, 10.

³⁰¹ *Ibid.*, 3.

³⁰² *Ibid.* 42.

issue in a novel way or within another frame to move the issue into a different regulatory framework. Those who succeed in reorienting existing conventions produce “different obligations, actor identities, and local ends.”³⁰³ Convention reorientation becomes visible in several ways, usually over definitional disputes, attempts to redefine ends and means of action, and inclusions and exclusions of particular meanings attributed to dynamics of social relations. Legal interpretations of the existing conventions may result in shifts regarding the scope of actions. Pratt argues that there should be clear evidence of a definitional dispute over which convention should be applicable in particular cases, rather than overall validity or appropriateness of an action, and its resolve determines the normativity of practice.³⁰⁴

The second mechanism is called technological revision. It refers to problem solving attempts or materials that actors come up with when they fail to move on with existing tools. Through technological revision, actors channel their practices through “new media of intervention” which includes material tools to be designed, skills to be trained at, and technical knowledge to learn.³⁰⁵ Innovative techniques and novel technological tools provide agent creative possibilities as they make it possible to perform a normatively controversial action with less sanctions.

The third mechanism is network synthesis, which is essentially an alliance building practice. It refers to “the formation of new organizational structures able to authorize new actions”. Through this mechanism, actors establish new institutions or agencies to enhance their material, institutional and moral capabilities.³⁰⁶ As a strategic move, it involves not only bringing capable actors or organizations together, but also excluding critical, reluctant or less capable ones.

Offered as a way of describing what has changed and how those changes have occurred, three causal mechanisms “drove the normative (and institutional) transformations underlying the emergence and institutionalization” of previously

³⁰³ Ibid.

³⁰⁴ Ibid., 67.

³⁰⁵ Ibid., 57.

³⁰⁶ Ibid., 47.

unavailable practices for practitioners.³⁰⁷ It allows researchers to locate institutions, practices, and their value orientations within broader social arrangements without having referring norms.

3.6.1 Operationalization of the Framework

Chapter 4 examines how colonial empires managed to control plant species during the 19th century. It traces the formation of a network between colonial institutions and scientists by explaining their motives for cooperation. Then shows how changes in scientific orientation and consolidation of a new epistemic culture among scientists provide technical means of separating plants from their habitats, as well as a value-based justification for doing so. The institutional support provided by the resourceful colonial institutions enabled botanists to transform their scientific ideas into technical systems which in turn provided colonial rule with novel capabilities.

Chapter 5 examines the formation of a specific plant breeding system during the first half of the 20th century. It shows how an epistemic culture emerged, defeated its alternatives, and dominated the process of knowledge production in genetics and led to a technical system built on these bodies of knowledge. It produced a technical (purification-hybrid) system and normative (from chaos to science) justification for separating plants from their habitats. The state, in search of industrializing its agricultural system, was the key ally of scientists in turning a particular scientific vision into a well-established technical system. Thus, this alliance managed to translate scientific knowledge into a specific technical system (gene-oriented plant breeding/scientific plant breeding). Meanwhile, discursive and ideational conventions emerged that defined what plants are and what should be done with them.

Chapter 6 analyses the period between 1950-1980. It focuses on the extension of industrial agriculture through the Green Revolution, which is conceptualized as a network extension. The technical system (modern plant breeding) and the epistemic culture it relied on diffused into developing countries through international research centers. During this period of technological diffusion, genetic erosion emerged as a concerning idea. The scientific debate centered on how to conserve plants (or their

³⁰⁷ Ibid., 41.

genes), that is either in their habitat or in gene banks. The epistemic culture that objected to resourcist cosmovision was eliminated by institutional strategies, and the gene-centric practices were institutionalized. In other words, the technology transfer not only spread gene-centric plant improvement techniques, but also diffused the resourcist cosmovision it built upon.

3.7. Conclusion

This chapter introduced a practice-oriented understanding of normativity to create a space for technology as a causal mechanism in social dynamics. While making the case for technology, it also revealed the dominance of the productivist paradigm within the global governance of plant genetic resources. Through an analysis of the text and implementation of ITPGRFA, it showed how non-discursive practices and seemingly technical decisions shape which practices are institutionally promoted. Although the text of ITPGRFA strongly promotes both productivist and non-productivist plant improvement practices, the implementation practices reify the existing hierarchy between them by confirming the modern plant breeding methods based on the productivist paradigm, while disallowing traditional plant breeding methods rooted in non-productivist paradigm. Through a reinterpretation of the term ‘breeding’ at the implementation stage, the governing body of the treaty redefined what constitutes an appropriate breeding practice. This redefinition excluded farmers’ plant improvement methods on the ground that it involves a treaty sanctioned technical stage, which is direct use. The analysis demonstrates the shortcomings of existing theoretical frameworks, international regime studies and mainstream norm scholarship, in explaining the normativity of practices and conceptualizing the interplay between technology and social relations. Therefore, it argued for an alternative approach that provides a holistic understanding of technical practices and normativity without falling into the trap of either social or technological determinism.

CHAPTER 4

HISTORICAL NETWORK SYNTHESIS IN BOTANY: MAKING OF COLONIAL EPISTEMOLOGIES

4.1. Introduction

This chapter examines scientific and institutional changes in plant improvement and agricultural modernization that took place throughout the 19th century in Europe. Following the conceptual framework outlined in the previous chapter, this section aims to demonstrate an early example of the interplay between science and politics in establishing a highly technical, and equally strategic plant improvement infrastructure. It explores the colonial origins of botanical science by narrating its transformation into a colonial institution, while at the same time it sheds light on the botanical sources of colonial power by demonstrating the role of scientific ideas and technical devices in extending imperial control. The chapter concludes by arguing that the epistemic culture of 19th century scientists laid the ground for the contemporary resourcist cosmovision that informed a reductionist understanding of genetics and a gene-centric plant improvement system.

4.2. Moving Cinchona through Imperial Networks

4.2.1 The Operation for Moving Cinchona

In 1860, a group of plant collectors was tasked by colonial British administrators to undertake a mission in the South American forests. They managed to collect and transport some samples of a tree called Cinchona. These plants were cultivated in colonial plantations established in India. Despite not being commercially profitable, this transplantation process solved many problems of the British empire and set an example for future practices. This mission came to be known as “one of the most

notorious acts of botanical espionage in world history” and provides a striking reminder of what is contested today regarding the management of plant genetic resources.³⁰⁸

Cinchona tree is native to the northern Andean region and currently covers Colombia, Ecuador, Peru and Bolivia. Its bark contains several alkaloids, including quinine, which prevents reproduction of the Malaria parasite. The knowledge of the cure was first noted by the Spaniards, then diffused into Europe by Jesuits and came to be known as “Jesuit’s powder” in the mid-17th century.³⁰⁹ Before its transplantation to India by the British, it had already been in use against the fever but in a rather ‘primitive’ form as the imported barks were in bulk form to be processed by rather traditional methods. Under the Spanish rule, the Cinchona harvest was exclusively sanctioned for its use by the royalty. Over time, however, the product was commercialized, and the activities of collectors and traders in the region intensified.

Although the healing effect of the bark had already been known, the active ingredient had not yet been identified. Various attempts were made for this purpose, the turning point came in 1820. Two French chemists, Pierre Joseph Pelletier and Joseph Bienaimé Caventou, extracted two key alkaloids, quinine and cinchonine, from the bark which made it possible to evaluate the quality of the bark, and regulate the dosage regimes.³¹⁰

The transfer of cinchona from the Andean forests in South America to the British plantation in Southeast India is a highly cited example of the ‘botanical chess game’ that took place throughout the 19th century. It was a strategic relocation of the plant in such a way to make it possible to control its reproduction process. The British Empire utilized its existing scientific and administrative infrastructure to make this transplantation successful. At that time, plantations had already been established under

³⁰⁸ Matthew James Crawford, *The Andean Wonder Drug: Cinchona Bark and Imperial Science in the Spanish Atlantic, 1630-1800* (University of Pittsburgh Press, 2016), 11.

³⁰⁹ Lucile H. Brockway, *Science and Colonial Expansion: The Role of the British Royal Botanic Gardens* (Academic Press, 1979), 109.

³¹⁰ Teodoro S. Kaufman and Edmundo A. Rúveda, “The Quest for Quinine: Those who Won the Battles and Those who Won the War” *Angewandte Chemie International Edition* 44, (2005), 857.

colonial rule, but with cinchona, the influence of botanists and scientists in plant breeding and development became consolidated. Before the British success, there were others, including the Spanish Crown, the French Crown, and the Dutch East India Company, who tried to obtain this highly valuable plant from the region. However, none of them succeeded in ‘controlling’ the plant.³¹¹ The British, on the other hand, did so with the rapid and successful co-operation of scientists, adventurers, and the imperial machine.

Dr. John Forbes Royle recommended for its introduction to India firstly in 1835, and then in the 1850s.³¹² While the earlier recommendation remained unheard, the one in the 1850s found an inhibitive environment. The start of Dutch plantations in Java had a triggering effect on the British. The governor-general of India approved the proposal. However, early formal efforts through British consuls failed to obtain tree samples from national authorities as they began increasing their exports of the cinchona bark and were reluctant to lose their monopoly. Moreover, earlier European collectors made them more suspicious of such initiatives.

As a last resort, the Secretary of State for India, as the head of the India Office of the British Empire, tasked a man named Clements Markham, a junior employee for the India Office, with collecting several species of cinchona from different areas of the Andes in 1859. A gardener from Kew Botanical Gardens, John Weir, was tasked with assisting him. While Markham went after the most valuable species in Bolivia and southern Peru, he also hired another man, named Pritchett, to look for the ‘grey bark’

³¹¹ During the second half of the 18th century, the Spanish Crown recognized the economic value of cinchona in the region and attempted to systematize the collection process and establish plantations for preserving the tree and consolidating its control over it. In another attempt, Hugh A. Weddell collected seeds and young seedlings from the region in 1848 and planted them in the Jardin des Plantes in Paris, but the French failed to commercialize this precious object. In fact, French botanists sent some samples of this plant to Kew Royal Gardens in London, and Kew forwarded them to India, but those that managed to overcome the difficult journey did not adapt to the climate. In 1851, even before the British managed to put their hands on the seeds, the Dutch attempted to transplant cinchona in its plantations in Java but invested in a less adaptive and efficient variety. Starting with the seeds collected by Justus Karl Hasskarl’s mission to Peru, the Dutch managed to cultivate almost 1 million trees by 1862. However, it was soon realized that the variety chosen contained very few alkaloids and was merely ‘fit for firewood’. See Kimberley Alice Walker, “The Making of a Quinologist: Cinchona, Collections, and Science in the Work of John Eliot Howard (1807-1883)” (PhD diss., Royal Holloway University of London, 2023).

³¹² Kew Royal Botanic Gardens, “Introduction of Cinchona to India,” *Bulletin of Miscellaneous Information* 1931, no. 3 (1931): 114.

in northern Peru.³¹³ Kew Garden director William J. Hooker approved the plan, and in parallel asked its long-time friend and Kew collector Richard Spruce, who had already been in Ecuador, to direct his efforts into collecting cinchona. He also sent a Kew gardener, Robert Cross, to assist Spruce's expedition. Spruce and Cross spent several months in a rather isolated area and found *C. succirubra*, a variety known as red bark, and managed to obtain 100,000 dried seeds and 637 young plants to ship them to London Royal Gardens, Kew in December 1860.³¹⁴

The British attempts to cultivate the cinchona tree in India, a new environment, was a truly botanical experiment. It was based on the collaboration between Kew Gardens, the India Office, and colonial botanic gardens. The first site selected for the cinchona plantation was the Nilgiri Hills, under the direction of William G. McIvor. McIvor selected promising areas in the region that are most similar to the natural habitat of the cinchona tree and conducted trials in several areas with different climatic and soil characteristics. Moreover, he developed harvesting methods to increase the amount of quinine obtained. Production also began at the plantations in Bengal. The Peradeniya Botanical Garden in Ceylon began producing cinchona seedlings for distribution to local growers and by 1877 had distributed 5.5 million of them. The Ceylon government channeled its production directly to the London market. The planted area in Ceylon reached 64,000 acres in 1883, while the amount of bark exported from the region was 16,000,000 lb. in 1887.³¹⁵ Moreover, the interruption of the dominant coffee plantations in the region due to 'coffee leaf blight' led producers cinchona planting.

4.2.2 The Justification for Moving Cinchona

By the 19th century, Europeans were better equipped in utilizing natural resources for producing finished products at the industrial scale for commercial markets. Therefore,

³¹³ Brockway, *Science and Colonial Expansion*, 114.

³¹⁴ After this very first expedition, Cross re-commissioned several times, travelled to Ecuador in 1861 and twice to Colombia between 1863 and 1870, and succeeded in bringing *C. pitayensis* seeds to Kew, where they proved to be more productive. See Brockway, *Science and Colonial Expansion*, 116. The aim of the British with this repetitive collecting mission was to cover a wider area and obtain samples of different tree varieties in order to be able to identify the most adaptable ones for the Indian soils and climate and the one with the highest quinine content. See Walker, "The Making of a Quinologist", 34.

³¹⁵ J. H. Holland, "Ledger Bark and Red Bark," *Bulletin of Miscellaneous Information (Royal Botanic Gardens, Kew)* 1932, no. 1 (1932): 16.

removing Cinchona clearly hampered a highly lucrative sector in South America. Moreover, its transplantation in India disturbed existing social and economic dynamics. In the face of such transformative practice and being sensitive to not getting stigmatized, European collectors employed particular discourses for legitimizing their transplantation to establish a normative basis for their operations. In rather general terms, the main argument was that it was a ‘rescue mission’ that had to be carried out purely for the broader good of humanity.³¹⁶ The tree was at the brink of extinction due to unhealthy harvest methods, locals were unaware of its benefits or unable to utilize it, and public health was a prime goal. This narrative of “for the collective good” not only legitimized plant removal from its natural and social habitat but also justified its relocation in a novel setting, at least among Europeans.

The memoirs of Markham and other official accounts of the cinchona mission are quite similar to contemporary concerns over biological diversity and genetic resources. Accordingly, the tree was on the brink of extinction due to the unsustainable harvesting practices of the locals, and the only way to save it was to transport it into India.³¹⁷ Upon observing locals' cutting down fully mature cinchona trees, the epistemic society “accepted as an article of faith... that intervention by the Europeans was necessary to save the cinchona trees from extinction because of overcutting and wasteful practices in the Andes.”³¹⁸

Markham’s memoir extensively refers to his predecessors, earlier European naturalists’ observations and their extinction-discourse for making plants’ transfer to India as a necessary solution. One of them was Alexander von Humboldt who wrote that locals were cutting down eight to nine hundred cinchona trees for obtaining a “modest amount of 11.000 Spanish pounds of bark” which make “the older and thicker trunks are becoming ever scarcer...”³¹⁹ Another one was the British explorer and

³¹⁶ Walker, “The Making of a Quinologist”, 32.

³¹⁷ Pat Roy Mooney, “The Law of the Seed. Another Development and Plant Genetic Resources,” *Development Dialogue* 1-2 (Dag Hammarskjöld Foundation, 1983): 86.

³¹⁸ Brockway, *Science and Colonial Expansion*, 111.

³¹⁹ Alexander von Humboldt, *Views of Nature* trans. Mark W. Person, ed. Stephen T. Jackson, Laura Dassow Walls (University of Chicago Press, 2014), 268.

adventurer William Stevenson observed the collection practices in Peru and called for its protection by the governments.³²⁰

Markham cited the observations of the Spanish Royal Botanist Hipólito Ruiz, who led the cinchona expedition to Peru and Chile in 1777-1778: “[Ruiz] declared that it was very injurious to the trees, many having been destroyed by it... thoughtlessly destructive ...”.³²¹ Despite Markham’s justificatory discourse, Ruiz mentioned the importance of the local knowledge for his success in identifying the highest quality of cinchona and its arrival to the Spanish court.³²² In 1931, the Royal Botanic Garden, Kew, published an issue of its periodical, *Kew Bulletin of Miscellaneous Information*, to remind their role in the introduction of cinchona to India. In it, they justified this operation, like Markham, due to the ‘reckless extravagance’³²³ of locals and the ignorance of local administrations.³²⁴

Another justificatory narrative which normalized the transferring cinchona was centered around the idea that locals were unaware of the benefits of the cinchona. Markham, relying on earlier explorers, argued that Andean people prefer not to use bark against fever; instead, they use what they consider cold substances, such as newly

³²⁰ Crawford, *The Andean Wonder Drug*, 177.

³²¹ Clements R. Markham, *Travels in Peru and India* (London: John Murray, 1862), 25.

³²² Crawford, *The Andean Wonder Drug*, 167. During the second half of the 18th century, Ruiz engaged in a scientific and political struggle with another Spanish botanist, Mutis, over the appropriate management strategy of cinchona in Spanish America. The struggle between these two botanists for making their respective proposals approved is enlightening. Crawford shows that local power struggle and the instrumentalization of science goes beyond the dynamics of center-periphery relations.

³²³ The extinction argument remains thin considering the fact that the Andean export of cinchona bark was almost 1 million kilograms in 1860 and reached 9 million kilograms by 1881. See Brockway, *Science and Colonial Expansion*, 112. It is true that these numbers dramatically fell in the following period; however, rather than extinction, it was more of a result of the inability of local production in a commercial competition with the plantation-based production schemes in colonial lands, less with the extinction. See Holland, “Ledger Bark and Red Bark,” 16. More importantly, later it was understood that indigenous practices were quite effective. For example, McIvor discovered that newly sprouting branches contained greater amounts of quinine, which consolidated the method of cutting the trees completely after 7 years. It is noteworthy that this ‘science-backed’ technical improvement was in line with the ‘primitive’ indigenous methods that Markham criticized strongly and employed as a justification for saving the trees. See Brockway, *Science and Colonial Expansion*, 111.

³²⁴ Kew Royal Botanic Gardens, “Introduction of Cinchona to India”.

introduced lemon.³²⁵ Moreover, by obtaining the seeds from the region, Markham seems to be in a belief that he not only protects the tree and makes the medicine available for the broader public but also does Andean natives a great favor by teaching them a better way of collecting. Since “the demand for quinine will always be in excess of the supply from South America”, his actions would not harm local welfare. On the contrary, competition and new cultivation methods may lead locals to “undertake the cultivation of a plant which is indigenous to their forests... which... they have so foolishly neglected.” It will be a “pleasure to supply them with the information which will have been gained by the experience of cultivators in India.”³²⁶

Despite all the normative discourse, was the British action even legal? If not, were the British aware of the illegality of their actions? Europeans understood that losing their monopoly was not in the best interest of South American authorities. Locals who assisted European collectors were threatened and, in some cases, punished. Hasskarl’s local guide, Clemente Henriques was threatened with having his leg cut off. In some cases, threats went beyond words. A native guide who helped Charles Ledger was later arrested and beaten which likely led to his death.³²⁷ Markham, similar to the contemporary discourse for the open access to plant materials, attempted to undermine local restrictions by arguing that exchanging plants is beneficial for all:

[...] under any circumstances the South Americans, who owe to India the staple food of millions of their people, and to the Old World most of their valuable products... should not desire to withhold from the people of India a product which is essential to their welfare.³²⁸

Nonetheless, it had to be done anyway since saving the cinchona and producing the medicine was a duty for the sake of humanity. Fighting against malaria was beyond selfish goals; instead, it was a universal responsibility. It was, after all, important for 'public health'. Markham, in a way, saves not only the tree but also people who are in need of it as the price of quinine would decrease through the increased production from

³²⁵ Londa Schiebinger, *Plants and empire: Colonial Bioprospecting in the Atlantic World* (Harvard University Press, 2007), 81-82.

³²⁶ Markham, *Travels in Peru and India*, 338.

³²⁷ Walker, “The Making of a Quinologist,” 32.

³²⁸ Markham, *Travels in Peru and India*, 338.

the plantations and thus the medicine will be “within reach of a vast number of people who are now excluded from its use.”³²⁹ Charles Darwin, having believed that “the growth of Cinchona is so important for mankind”, even sent a letter that contains his suggestions for cultivation process to the director of the British botanical garden charged with growing the cinchona tree.³³⁰

Kew officials, colonial administrators and other important figures from the imperial circle mentioned the ease of public access to cinchona as the most important output of the cinchona transplantation in India. Kew director William J. Hooker, for example, argued that “anyone can get any post office a dose of pure quinine for a little less than half a penny” with this successful operation. Markham recalled that “few greater blessings have been conferred on the human race” than cinchona transplantation in India, which “will be one of the measures for which British rule in India will be entitled to the gratitude of the people of India.”³³¹

Considering all these together, the humanitarian narrative that suggests British acted out of a universal concern seems plausible. The argument for the importance of the cinchona transfer for the plant, humanity and science can also be linked with the British attitude of unrestricted exchange of scientific knowledge on the cinchona cultivation. British botanists did not keep the samples for themselves, instead sent them to other imperial botanical gardens “as gifts to imperial carriers of the white man's burden.”³³² Therefore, according to this argument, the British government did not attempt to establish an economic monopoly in quinine production but rather prioritized the importance of the plant for all.

It is quite easy to shake this universalist narrative with a simple question. It is declared that the main aim of the British transplantation was to produce more quinine and make it available to people, but to whom precisely? Malaria was a threat for the colonial rule

³²⁹ Ibid.

³³⁰ Richard Harry Drayton, “Imperial Science and a Scientific Empire: Kew Gardens and the Uses of Nature, 1772-1903” (PhD diss., Yale University, 1993), 341.

³³¹ Brockway, *Science and Colonial Expansion*, 124.

³³² Ibid.

of the British Empire in India, where the disease was widespread.³³³ The efficacy of imported bark was considered 'inconsistent' in Europe, mainly due to the problem of dosage, as the amount of quinine contained in the bark varied depending on the region or the parts of the tree from which the bark was collected.³³⁴ The Indian Rebellion of 1857 forced Britain into more direct control, increasing the number of soldiers and civilians being transported from Britain.³³⁵ Although the British government spent £50,000 and the East India Company £100,000 on imports to India per year, it failed to “keep the colonists healthy.”³³⁶ On the other hand, being highly dependent on imports for such a crucial product was disturbing officials. This necessitated rigorous efforts to solve the problem of malaria and led the British to consider growing it in India rather than relying on imported bark.³³⁷

It is true that the varieties developed by the British were not commercially superior to the Dutch product of Java, which was found to contain the highest amount of quinine. By 1880, the largest share of the trade in quinine belonged to the Dutch. In 1927, out of 812 tons of cinchona bark imported by the United Kingdom, 20 tons came from Peru, while Dutch-controlled Java ranked first with 513 tons. Only 53 tons came from British plantations in South India.³³⁸ However, their aim had never been to compete with the Dutch. Cinchona variety of *C. Calisaya* collected by Charles Ledger, which brought success to Dutch, were first offered to the British. However, they showed no interest in it.³³⁹ For some, this was a neglect, a fatal error.³⁴⁰ For others, it was quite consistent with British attitude towards the Dutch. Accordingly, the fact that the Dutch

³³³ Ibid., 104.

³³⁴ Ibid., 108.

³³⁵ Kavita Philip, “Imperial Science Rescues a Tree: Global Botanic Networks, Local Knowledge and the Transcontinental Transplantation of Cinchona,” *Environment and History* 1, no. 2 (1995): 173-200.

³³⁶ Kaufman and Rúveda, “The Quest for Quinine,” 880.

³³⁷ Brockway, *Science and Colonial Expansion*, 106.

³³⁸ Holland, “Ledger Bark and Red Bark,” 16.

³³⁹ Warren Dean, *Brazil and the Struggle for Rubber: A Study in Environmental History* (Cambridge University Press, 1987), 26.

³⁴⁰ Holland, “Ledger Bark and Red Bark,” 2-5.

came first in quinine production with better plants did not upset the British: “two empires cooperated when market forces favored cooperation, and in the scientific sphere the cross fertilization of plants and ideas was helpful to development of both.”³⁴¹

The planning of the plantations in India shows their real motive with this theft. Regardless of the quality and quantity of it, they attempted to secure a steady supply of cinchona to people who maintain British rule, rather than make it accessible for the local population. The quinine powder obtained from the first plantations was not made available to the public, but sent directly to Madras, Bombay and Colombo “for distribution to government employees, including the army, and to private planters for mass treatment of their ‘coolie’ laborers.”³⁴² Similarly, the quinine produced at the Calcutta Botanical Garden in Bengal was sanctioned for the British army and officials. Against the backlash from locals who criticized the British administration for denying access to the drug to the general population, the British sent experts to help locals to build their own plantations and supplied them seedlings. In a way, the British preferred or hoped that quinine produced by private entrepreneurs would be available in the local market while their own production would be safely reserved for public officials.³⁴³

However, the inability to compete in the international markets pushed private producers, who were producing for the local population, away from cinchona plantations in India. It was simply not commercially meaningful for them to keep supplying the local market. As a result, production levels declined rapidly. Exports dropped from 16 million lbs. in 1887 to 20,000 in 1915.³⁴⁴ Soon, the cinchona plantations in Ceylon were replaced with tea plantations whose first seeds, seedlings and processing know-how were obtained, yet again forcefully, from China. As a result, and contrary to the legitimizing narrative of public health, the local population often did not have easy access to quinine. In the first 20 years of the transplantation of the

³⁴¹ Brockway, *Science and Colonial Expansion*, 121.

³⁴² Ibid.

³⁴³ Ibid.

³⁴⁴ Holland, “Ledger Bark and Red Bark,” 16.

cinchona, it is true that the number of deaths from Malaria declined in India, but firstly among colonial officials. This is because the British colonial administration kept on producing quinine for distribution to administrative and military personnel in the region despite the lack of economic incentives.

British failure to capture global market is more of a political decision rather than a scientific mistake. The administration was capable of producing enough quinine for its own needs anyway, no matter how efficient the cinchona trees they have. Then, for the British Empire, malaria was a threat, not for its impact on the public health, but if it deprived the colonial officials from effectively conducting their tasks. This first act of biological theft, or biopiracy, paid off much more than its commercial value. Colonial rule in India was secure, and its further spread into Africa became possible.³⁴⁵ Correspondence between two British botany figures shows the underlying motive for the removal of the tree from South Africa:

To England, with her numerous and extensive Colonial possessions, it [quinine] is simply priceless; and it is not too much to say, that if portions of her tropical empire are upheld by the bayonet, the arm that wields the weapon would be nerveless but for Cinchona bark and its active principles.³⁴⁶

4.3. Moving Rubber through Imperial Networks

4.3.1 The Operation for Moving Rubber

The Cinchona mission increased the British experience in moving plants between continents and consolidated the importance of the botanical gardens and scientific networks for imperial needs. The Rubber was the case in which British managed to synthesize its expertise in botany and economy to master in the chess game.

Europeans had been familiar with rubber since the time of Columbus. However, the rubber in its natural, unprocessed form was unstable in the sense that it would harden in the cold and soften in the heat. This was the main obstacle that prevented its widespread use. Soon, in 1839, Charles Goodyear arrived with a technical

³⁴⁵ Brockway, *Science and Colonial Expansion*, 127.

³⁴⁶ Letter from the superintendent of the Government Central Museum in Madras, Surgeon-Major Bidie to Thistleton Dyer, the Assistant Director of Kew cited in Kavita Philip, "Global Botanic Networks," 188.

breakthrough called vulcanization, which made rubber more stable. Then, rubber began to be used for electrical insulation in telegraph wires following 1870s. The introduction of air-filled pneumatic tire by John Boyd Dunlop in 1888 and the automotive revolution led by Henry Ford made rubber the most important raw material next to steel and iron.³⁴⁷ Thus, as its scope of use expanded within the industry, it fueled the demand for rubber in the West.

Among more than 500 Rubber-bearing plants in various parts of the world, very few can provide the amount demanded by industrial production. In Africa, latex was obtained from *Funtumia* trees and *Landolphia*, but these were vulnerable to depletion due to destructive tapping methods.³⁴⁸ In the mid-19th century, it was realized that the most efficient plant for rubber production was a tree, *Hevea Brasiliense*, which, sadly for its inhabitants, was in South America.

Hevea, besides being highly productive and prone to be tapped quickly, provided the best quality latex as a raw material. Newly independent Brazil began exporting wild rubber in increasing volume from the 1830s. The opening of the Amazon to foreign commercial activities around 1850 enabled British operations in the river transportations, thus increasing international trade, particularly the export of wild rubber.³⁴⁹ Thanks to the facilitating role of the Amazon River in transportation, Rubber, harvested under the control of local strongmen in the forest, began to be collected in the city of Manaus, from where it transferred to the ports of Brazil, mostly in the city of Para, then it was spread around the world by Western merchants. The commercial networks around the Amazon intensified, and the trade in the region increased, initiating similar patterns in Peru. The Peruvian Amazon Rubber Company was established with British investors.³⁵⁰ Britain's rubber imports increased from 211

³⁴⁷ Corey Ross, *Ecology and Power in the Age of Empire: Europe and the Transformation of the Tropical World* (Oxford University Press, 2017), 99.

³⁴⁸ Ibid.

³⁴⁹ Dean, *Brazil and the Struggle for Rubber*, 11.

³⁵⁰ Francesca Bray et al., *Moving Crops and the Scales of History* (Yale University Press, 2023), 137.

kilograms in 1830 to 10,000 kilograms in 1857 and 58,700 kilograms in 1874.³⁵¹ By 1900, Brazil alone accounted for 90% of global rubber exports.³⁵²

Even in its wild form, *Havea* was an almost unlimited resource. It was much more durable than the other rubber-bearing plants in Africa. However, tapping the *Havea* was a time-consuming process, which included clearing the paths in the forests, finding the tree, tapping and closing the wound.³⁵³ This problem is further exacerbated with the limited amount of another resource, that is, labor. The main reason for the shortage of labor was the low population density in the Amazon. This structural condition, combined with the increased demand, resulted in poor working conditions for the locals. Moreover, the debt-bondage relationship established between the workers and local strongmen forced them to keep on working. As a result, this unhealthy working environment led to the displacement or disappearance of a significant number of them.³⁵⁴

At the same time, the wild rubber collection systems in Africa were becoming increasingly unsustainable. One reason for this was the depletion of the resources due to harmful tapping methods, and the other was the increasing dissatisfaction and vocalized criticism against the inhumane treatment of collectors, particularly the 'red rubber system' in the Free State of Congo under Leopold II of Belgium. From a more commercial aspect, African production systems of wild rubber were unable to meet the increased demand of the rising industries.³⁵⁵ In short, the demand was increasing, profits were tempting, and competition was rising, and this necessitated a transition from wild rubber to plantations through moving plants, rather than people, in order to ensure that supply meets with the industry.

Even before the boom in demand, the idea of rubber plantations had already been put forward in the 1850s in Brazil. It was offered as a solution not only for commercial

³⁵¹ Dean, *Brazil and the Struggle for Rubber*, 9.

³⁵² Ross, *Ecology and Power*, 99.

³⁵³ Dean, *Brazil and the Struggle for Rubber*, 36.

³⁵⁴ Bray et al., *Moving Crops*, 138.

³⁵⁵ Ross, *Ecology and Power*, 103.

problems but also to improve the living conditions of the Brazilian people.³⁵⁶ Silva Coutinho, a rubber expert, sent some samples to the National Museum in Rio de Janeiro, where they were cultivated. In 1867, the Brazilian administration sent Coutinho to the Universal Exposition in Paris to show that the Brazilian Rubber, *Hevea Brasiliensis*, was superior to other rubber-bearing plants.³⁵⁷ Brazil was aware of the wealth that lies within the forest, but others were too. Coutinho's efforts caught the attention of James Collins, curator of the Pharmaceutical Society Museum in the UK, who published two articles on rubber. He made references to the famous Cinchona transplantation a decade earlier. These articles did not escape the attention of Markham.

On Markham's initiative, the India Office requested Collins to prepare a report that contains an evaluation of the rubber-bearing species in 1871. Collins prioritized the *Hevea* species as the best choice. Markham shared his plan with Joseph D. Hooker, now director of Kew Botanical Garden, son of William J. Hooker, with whom he had worked on the Cinchona operation. Hooker suggested that Henry A. Wickham, who had been in the region, might be able to undertake this mission. The India Office formally shared the plan with the director of Kew, and Hooker indicated that Kew could nurse the plants they received for their voyage to the plantations. The network had been re-established. Meanwhile, Markham contacted the Foreign Office to send the Collins Report to British officials in Belem. He also contacted Robert Cross, with whom he had worked on the Cinchona mission and tasked him with collecting seeds. Wickham completed the collection mission and sailed with more than 70.000 seeds to London, which were planted at Kew, but only 2700 seedlings grew out of them. In August 1876, some of these were sent to Peradeniya Botanic Garden, Ceylon. A smaller number of seedlings were reached to Singapore around the same time. Further shipments set sail in the following years. However, the development process required the full capacity of the British Botany. It took almost 25 years for plantation-based rubber to reach a significant volume in the market.

³⁵⁶ Dean, *Brazil and the Struggle for Rubber*, 41-42.

³⁵⁷ *Ibid.*, 11.

There were several obstacles to the adaptation and economic ‘rationalization’ of *Hevea* on plantations. The first one to be overcome was devising a novel technique that would increase the amount of latex extracted from the tree. Several unsuccessful attempts in Ceylon were overcome by Henry Ridley, trained by Joseph Hooker at Kew, who was in charge of the botanical gardens in Singapore. Ridley achieved a technical breakthrough by developing the ‘wound response’ method. Following this, John Parkin of the Ceylon Botanic Garden developed a technique for the processing of latex that shifted the necessary ‘smoke process’, which had been previously done by collectors, to the later stages in the chain, thus allowing the division of labor and the industrialization of the production process. Another technical novelty intensified the number of trees in a field, from 2-3 per hectare in the Amazon to 80 per hectare in the plantations. As a result of these technical improvements through the science of botany, the amount of latex that a collector can harvest increased. This development made further plantations feasible as in the period between 1905 and 1915, thousands of hectares in Ceylon, Malaya and Sumatra were converted into rubber plantations. Particularly, British Malaya was a key location for the new plantations, while some of the tea plantations in Ceylon were shifted to rubber.³⁵⁸

So far, so good, but have these developments solved the lack of labor that made it necessary to transport the plant from the Amazon? Despite all these advances, production was still labor intensive, i.e. mechanization had not yet been introduced extensively. Moreover, the labor force that can be cultivated by the local population was reluctant to work in this activity. However, contrary to South America, Britain was able to tap into other sources of labor for the South Asian plantations. Chinese laborers were brought to the region during the establishment of the plantations, followed by a large group from Tamil community. These labor migrations were carried out in the form of indentured service or debt-bondage relationships and took place under highly exploitative conditions.³⁵⁹ For example, clearing the forest for the plantations resulted in high mortality rates among the workers due to malaria. Yet, the

³⁵⁸ Ross, *Ecology and Power*, 114-15.

³⁵⁹ Ross, *Ecology and Power*, 112.

solution had already been devised for this. Large amounts of quinine, produced in India, were shipped to the region for the laborers.

4.3.2 The Justification for Moving Rubber

Rubber had no use for public health, then, what about the normativity of this practice? As in the case of Cinchona, Markham again pointed out the dangers posed by the harmful tapping methods of natives on the sustainability of the tree and the continuity of supply. Therefore, it “... was necessary to do for the India-rubber... what had already been done with such happy results for the cinchona trees.”³⁶⁰ In other words, *Havea* had to be saved.

But this time, another ‘norm’ had been in the service of the empire, which seems to have had quite widespread validity as it has today. Within the contemporary regime that governs plant genetic resources, access and benefit sharing rules usually exclude access with the purposes of research and science. Researchers, for most of the time, are granted the ability to conduct collecting missions and access existing collections in line with the principles of open access. This is for the greater good of humanity since open access to plant genetic resources as a fundamental principle enables the evaluation of plants for useful traits and for the development of new and better varieties and thus for solving various global problems. Although these scientific practices usually end up as raw materials for commercial products, the open access for science and research remain uncontested.³⁶¹

Wickham was aware of the difficulties Markham and other Europeans had experienced and that his activity might be beyond what is permissible. He was concerned that the rubber seeds and seedlings he had with him might be found upon inspection at customs. Therefore, he, as a solution, asked the custom officer for a fast passage on the ground that the ship’s cargo consists of “exceedingly delicate botanical specimens

³⁶⁰ Clements R. Markham, “The Cultivation of Caoutchouc-yielding Trees in British India,” *Journal of the Society of Arts* 24, no. 1920 (1876), 476.

³⁶¹ Ryan Nehring, “Digitising Biopiracy? The Global Governance of Plant Genetic Resources in the Age of Digital Sequencing Information,” *Third World Quarterly* 43, no. 8 (2022): 1970-87.

especially designated for delivery to Her Britannic Majesty's own Royal Gardens of Kew."³⁶²

Wickham might have dramatized his customs experience in a move to convince his employers and the broader British botanical society that he played a significant role in this operation.³⁶³ Dean, while not commenting on the validity of Wickham's story, pointed out that his argument for deceiving the customs officer was based on Article 643 of the Brazilian custom regulations of that time, which was in effect since 1860.

Products destined for Cabinets of Natural History, collected and arranged in the Empire by professors for this purpose expressly commissioned by foreign Governments or Academies, or duly accredited by the respective Diplomatic or Consular Agents, national or foreign, will be dispatched without opening the volumes in which they are encased, a sworn statement by the naturalist sufficing, and duties will be charged according to the value which he gives them, in accordance with a list in duplicate which he must present.³⁶⁴

Dean argues that the article cited above possibly intended to cover dried plant specimens that could not be reproduced, thus the seeds collected by Wickham should remain outside this interpretation. Although the cargo was bound to the British Royal Botanical Gardens, the purpose of this transfer was clearly commercial than scientific, since British botanical gardens did not carry out purely scientific activities such as identification, but rather propagation and acclimatization for their cultivation in the Southeast Asian plantations.³⁶⁵

Wickham's legitimization strategy of mimicking a natural historian was quite widespread back then. Since the 17th century, collectors of useful species, particularly in the Spanish-controlled regions, paid great attention to hide their real objectives by identifying themselves as botanists or physicians. For example, Charles Plumier, a

³⁶² Henry A. Wickham, *On the Plantation, Cultivation and Curing of Para Indian Rubber* (London, 1908), 48-53, quoted in Dean, *Brazil and the Struggle for Rubber*, 19.

³⁶³ In his late 80s, he even went further into dramatization: "The seeds, he told a reporter, had been loaded aboard the Amazonas by stealth, under the nose of a gunboat 'which would have blown us out of the water had her commander suspected what we were doing.'" Dean, *Brazil and the Struggle for Rubber*, 21.

³⁶⁴ Dean, *Brazil and the Struggle for Rubber*, 19.

³⁶⁵ *Ibid.*, 19-20.

priest who was also commissioned by France to collect useful plants, was travelling under the title of 'Botaniste du Roi' (the king's botanist) before he lost his life in pursuit of cinchona. At the end of the 18th century, Nicolas-Joseph Thiery de Menonville, again commissioned by France, travelled to the Spanish-controlled territory of the present-day Mexico to obtain cochineal, an insect used to make red dye. France aimed to break the Spanish monopoly by producing the insect in its colonies, yet it was not 'appropriate' to fund this theft openly. Menonville, to move freely, obtained a passport that identified him as a 'physician'. When he crossed into Spanish-controlled territory, despite declaring himself as a 'French doctor', he was ordered to leave the territory by an official not 'to open to strangers the secrets of the country'. Nevertheless, he continued his way secretly, by using less visited roads, and reached his goal at the end. Even those scientific expeditions that were authorized by the Spanish Crown often went beyond their scientific purposes. For example, La Condamine made a great effort to collect seeds of plants such as Cinchona and Rubber during his expedition, but he paid an even greater effort for doing this without attracting too much attention.³⁶⁶

The case of Rubber is a telling example of the ways in which the British colonial rule obtained novel capabilities by combining the tools at its disposal. The Amazon rubber trade had already been under the control of British merchants; however, it was somewhat of an informal empire. Unlike the disturbing Brazilian authority in the Amazon, Britain was the sole rule-maker in its colonies; against the labor shortages in the Amazon, they were able to transport vast number of labors into the Southeast Asia.

Imported men, an imported plant, and imported quinine... all combined to make the Malay States an embodiment of the ideal colony, and to make rubber the most satisfactory plantation crop in all of British-controlled Southeast Asia.³⁶⁷

The Rubber case also illustrates the importance of Kew, that is, of scientific networks, in moving plants out of their habitats. The process of taking the tree from the Amazon, making it ready for cultivation in different conditions, choosing the right places for plantations, and developing the best methods for harvest was developed by Kew and

³⁶⁶ Schiebinger, *Plants and Empire*, 37-43.

³⁶⁷ Brockway, *Science and Colonial Expansion*, 164-65.

led by the scientist-botanists trained within the Kew network. This was the prime time of Kew as an imperial agent.

Brazilians failed to replicate successful British plantations despite decades of expertise and its natural habitat. Why? Many reasons can be given, but one interesting reason is quite ecological. As already mentioned, wild rubber is scarcely distributed in Brazilian forests. This is a natural defense mechanism that is produced by the *Hevea brasiliensis* against a fungus that shares the same habitat as the tree and causes leaf blight. If *Hevea* is planted intensively, fungus spreads rapidly and affects the entire population, slowing the growth of the tree and reducing the amount of latex.³⁶⁸ However, the success of British botany over others cannot be explained solely on ecological grounds. It was rooted in a new scientific culture, with its practitioners, technical tools and a colonial logic to combine them into an ordering machine.

4.4. Imperial Botany as the ‘motor of colonialism’

Science is often praised for its disinterested nature, free from the pursuit of power. The scientification of botany, from a free time activity to a disciplined knowledge production process, was often praised on the grounds that it ordered our knowledge of nature and offered ways of knowing it. Around mid-18th century, European naturalists began using Linnaean system³⁶⁹ which enabled them collecting, describing and cataloguing plants in a coordinated and organized way. Swedish naturalist Carl Linné tasked himself with a god given mission to organize beings. As a highly religious man, he considered himself as the second Adam: “God created; Linnaeus organized” was his motto.³⁷⁰ Linnaeus gave scientists a powerful tool to organize their collections. Beginning with the 18th century, botany turned into an imperial science as political authorities began establishing new scientific institutions or subsumed

³⁶⁸ Reinhard Lieberei, “South American Leaf Blight of the Rubber Tree (*Hevea* spp.): New Steps in Plant Domestication Using Physiological Features and Molecular Markers,” *Annals of Botany* 100, no. 6 (2007), 1125-42.

³⁶⁹ Classification system (taxonomy); Binomial nomenclature (two-term naming system i.e. *Homo sapiens*). Below more on this system and its impact on knowledge production.

³⁷⁰ Peter Harrison, “Linnaeus as a second Adam? Taxonomy and the religious vocation,” *Zygon: Journal of Religion and Science* 44, no. 4 (2009), 879-93.

existing ones.³⁷¹ Scientists of the imperial botany began receiving vast number of species that were collected from colonies and shipped by royal navies. The biological richness of the colonial territories was collected, studied, and developed for their commercial, agricultural, and medicinal value. Botanical gardens, glasshouses, herbariums and museums served as collections where scientists stored, conserved, and further developed life forms. Thus, plants were developed, diversified and began providing solutions to the social and economic problems of the empires while having moved between periphery and the center. Botanists began serving as “agents of empire,”³⁷² their ways and tools of knowing the world turned into “tools of empire.”³⁷³ Through these tools, they collected, described, categorized, and utilized plants for imperial objectives, thus further extending their power.³⁷⁴

European colonial empires carried out this institutionalization in different periods and with different strategies. Systematization of the nature for its utilization was initiated by the Spanish Empire in 17th century, and French in 18th century.³⁷⁵ The British government began using Kew as an imperial agent around mid-19th century by turning it into a public institution

In France, using naturalists for advancing the national interest took place earlier, and in a centralized manner, in which explorations were directly funded by the state institutions. The cooperation between the state and science began operating as a highly effective “scientifico-colonial machine” at a very early stage. This scientifico-colonial machine was “highly bureaucratized and centralized and, although composed of diverse parts, it functioned in a coordinated way to advance the colonial, national, and

³⁷¹ Banu Subramaniam, *Botany of empire: Plant worlds and the Scientific legacies of Colonialism* (University of Washington Press, 2024).

³⁷² David Mackay, “Agents of Empire: The Banksian Collectors and Evaluation of New Lands,” in *Visions of Empire: Voyages, Botany, and Representations of Nature*, ed. David Philip Miller and Peter Hanns Reill (Cambridge University Press, 1996), 38-57.

³⁷³ Daniel R. Headrick, *The Tools of Empire: Technology and European Imperialism in the Nineteenth Century* (Oxford University Press, 1981).

³⁷⁴ Schiebinger, *Plants and Empire*.

³⁷⁵ James E. McClellan and François Regourd, “The Colonial Machine: French Science and Colonization in the Ancien Régime,” *Osiris* 15, no. 1 (2000): 31–50; Crawford, *The Andean Wonder Drug*.

dynastic interests of France and the Bourbon monarchy.”³⁷⁶ For this purpose, several state-funded scientific institutions were established and directed towards utilization-oriented botanical activities.³⁷⁷ These institutions were tasked with training and sending botanists into collection missions to harness the richness of nature to improve France's trade balance.³⁷⁸ While botanists ensured the circulation of plants by using state institutions in their disposal, the network between the French navy, the botanical gardens in the center and the colonial botanical gardens in distant colonies were operationalized through administrative mechanisms.

4.4.1 The British Imperial Botany

It is possible to tell the story of Britain's imperial rule by zooming in on a garden which synergizes a small group of scientists, political figures and bureaucrats into a network that extended imperial rule through collecting and transplanting exotic plants.³⁷⁹ The role of science, particularly the dominant paradigm over the natural science between the 17th and 19th centuries, is known to have provided technical and intellectual solutions for imperial rulers.³⁸⁰ There were several actors in this process, but one among others served as the broker of this vast network, which is the Botanic Gardens, particularly Kew.

Kew Gardens transformed from a royal botanical garden that served the Crown, to quasi-public institutions that provided exotic plants for urbanites, and finally to scientific and botanical state institutions that assisted the empire. Although Britain was not the only one in using science and technique for colonial extraction, its network of science and colonial state apparatus was highly effective in exploring, collecting,

³⁷⁶ Ibid., 32.

³⁷⁷ Jardin du Roi (1635), Académie Royale des Sciences (1666), Académie Royale de Marine (1752), Observatoire Royal (1667), the Société Royale de Médecine (1778), the Société Royale d'Agriculture (1761), Compagnie des Indes. See McClellan and Regourd, “The Colonial Machine,” 31.

³⁷⁸ Schiebinger, *Plants and Empire*, 36.

³⁷⁹ Drayton, “Imperial Science,”.

³⁸⁰ Mary Louise Pratt, *Imperial Eyes: Travel Writing and Transculturation* (Routledge, 2007).

transporting, improving, and transplanting exotic plants that it “turned botanical imperialism into something of an art.”³⁸¹

Colonial botany as an imperial institution emerged from the transformation of the existing networks of scientists and amateurs that formed various ‘learned communities’ in several branches of natural sciences.³⁸² Between the 18th and 19th century, the number of such scientific societies increased, and these learned communities enabled production and dissemination of scientific knowledge to a far greater extent compared to inter-personnel exchanges.³⁸³ The first such community, The Royal Society, was established in 1662 as a private club whose members ranged from philosophers, natural scientists, physicists, and aristocrats, including Isaac Newton, Michael Faraday, Robert Boyle. Despite not receiving state funding, it was a key actor in advising governments in related matters. Among supervising several quasi-public tasks in Britain, the Royal Society funded some of the most crucial early British expeditions.³⁸⁴

One figure, Sir Joseph Banks, who served as the president of the Society from 1778 to 1820, was particularly significant for the rise of botany as a discipline of science and royal botany as a colonial institution.³⁸⁵ His interest in botany increased as he observed first-hand the richness of nature when he joined Cook’s expedition. During this expedition, when they anchored in a plant-rich bay, he persuaded Captain Cook to

³⁸¹ Raj Patel and Jason W. Moore, *A History of the World in Seven Cheap Things: A Guide to Capitalism, Nature, and the Future of the Planet* (University of California Press, 2017).

³⁸² Brockway, *Science and Colonial Expansion*, 63.

³⁸³ *Ibid.*, 71.

³⁸⁴ Including James Cook’s expeditions of which 1768-1771 resulted with annexation of Australia. One of the early operations of the British network set sail from Portsmouth on board of *HMS Bounty* en route to Tahiti in 1788. Despite ending up with a failure that inspired a novel trilogy and was adapted in at least three movies, it was the first demonstration of cooperation among several agents. HMS *Bounty* was tasked with collecting breadfruit samples from Tahiti to be transferred to the West Indies, where they were to be grown as a cheap food source for slaves in Britain’s colonies. Caletous Juma, *The Gene Hunters: Biotechnology and the Scramble for Seeds* (Princeton University Press, 2014), 2.

³⁸⁵ Kenneth Morgan, “Sir Joseph Banks as Patron of the *Investigator* Expedition: Natural History, Geographical Knowledge and Australian Exploration,” *International Journal of Maritime History* 26, no. 2 (2014): 235–64; Edwin. D. Rose, “From the South Seas to Soho Square: Joseph Banks’s Library, Collection and Kingdom of Natural History,” *The Royal Society Journal of the History of Science* 73, no. 4 (2019): 499–526.

name it 'Botany Bay' instead of Cook's suggestion of 'Stingrays'. As the president of the Society, he promoted the prioritization of botany, zoology and geographical observation vis-à-vis physical science and mathematical laws. This privileged position of botany eventually led to a great schism within the members of society. However, Banks' strong ties with the monarch and his role as the botanical adviser to the Crown secured him a life-long presidency of society, and his advice was well-executed by the governments.³⁸⁶

During Banks' presidency and with his encouragement, another epistemic community, The Linnean Society, was established in 1788. Distinct from the Royal Society, this newly founded society was exclusively interested in Botany. Its founder, James Edward Smith, was a physician with an amateur interest in botany, which was not common in the pre-Victorian era. Smith was encouraged by the Banks to collect Swedish naturalist Linnaeus' notes after he died in 1778. This was one of the crucial points in which natural history and botany aligned. The Linnean Society, along with other learned societies, was a hub of amateur botanists and aristocrats bound by their interest in natural sciences and their close connection with and influence over the government. It formed the nucleus of the later imperial science of botany and provided it with an epistemic consensus on how to know nature, which centered on the circulation of decontextualized objects and their knowledge.³⁸⁷ Natural History became one of the most important and widely practiced branches of science during the 19th century.³⁸⁸

The Royal Botanic Gardens at Kew were established in 1759 by the members of the royal family as a private initiative. Joseph Banks managed the Gardens from 1772 until his death in 1820.³⁸⁹ During these years, through Banks' personal efforts, the garden filled with varieties of plants. Banks employed several collectors to be carried on board

³⁸⁶ Including the relocation of British convicts to Australia, which was executed in 1788 and extended European culture into the region. McCracken, *Gardens of Empire*, 2.

³⁸⁷ Brockway, *Science and Colonial Expansion*, 80.

³⁸⁸ Endersby, *Imperial Nature*, 6.

³⁸⁹ Brockway, *Science and Colonial Expansion*, 78.

navy ships and brought the exotic plants they collected to the royal garden.³⁹⁰ In the later period, collectors within this network were known as Banksian collectors.³⁹¹ Banks personally funded some of these missions, while in some other cases persuaded imperial institutions, such as the treasury, the East Indian Company or the Royal Navy, to do so. During this early period of colonial botany, plant movement remained one-way, in which plants were collected from the periphery, brought into the center and located in the Kew Gardens. The distribution of plants from the center to the periphery was yet to come.³⁹² This is because botany was considered neither a science nor useful for the empire yet, and natural history was a prestigious pursuit of filling the royal gardens. The economic botany was not in sight. Banks's attempts were directed towards increasing the diversity of plants in the Royal Garden. For sure, Banks was in search of advancing his nation and its interests, but it was too soon for the institutionalization of this search. With Banks's death, the future of the Kew began to look insecure as the transfer of plants came to a halt.³⁹³

Two important factors shaped the path for the future of Kew. The first was the growing prestige of botany and natural history among the broader public and scientific community. The second was the increasing demand for using botany in the quest for imperial interests.

Botany became a significant social activity and somewhat of a hobby among the British public. For an amateur, it became possible to observe like a naturalist and describe with Linnaean systematics just as professionals do. These semi-amateur botanists began sending reports of their observations and descriptions from the countryside of London and distant habitats of the colonies, which were collected in the center of the empire, Kew. The growing interest in botany among the British public began to legitimize activities of naturalists and the botany.

³⁹⁰ Sampson, "The Royal Botanic Gardens," 405.

³⁹¹ Mackay, "Agents of Empire," 38-57.

³⁹² Sampson, "The Royal Botanic Gardens," 405.

³⁹³ Endersby, *Imperial Nature*, 27-28.

In a way, popularization of Natural History followed by a strong support for its activities.³⁹⁴

Despite, or perhaps because of, the growing public interest in botany in the first decades of the 19th century, established scientific circles began calling botanical activities unscientific, useless and unproductive. For some more serious scientists, the botanist only observed the plants and remained there. Their works were popular, but they were easily accessible for “minds of every cast” contrary to mentally and intellectually demanding “serious studies of physical science”. Such criticisms were fueled by the declinist movement, which argued that British science was lagging behind that of France, where scientific research was directly funded by the government. For example, John Lindley, a botanist, criticized the management of Kew for serving the needs of the Royal family instead of national causes, thus offering its takeover by the government.³⁹⁵ Botany and collections have served for the pleasure of urbanites, elites and royals so far. However, soon, the Kew network had to adjust to the changing priorities of the British Empire. In line with the mercantilist understanding of the era and rising entrepreneurial botany, botanical research was tailored in a way to explore, collect and improve economically significant raw materials to introduce them into commercially viable activities.³⁹⁶

William Aiton, who took over after Banks, was under heavy criticism for securing the exclusivity of the gardens by not making them accessible to the broader public or private entrepreneurs. Banks as the founder of this ‘illiberal system’ at Kew, Aiton as its maintainer, and the Crown as its beneficiary were all under attack. Politicians, private entrepreneurs and scientists who were unhappy with the state of botany allied against Kew. Populist rhetoric was growing strong based on a demand for reforming Kew to make it in line with the national interests.³⁹⁷

³⁹⁴ Morgan, “Sir Joseph Banks,” 19.

³⁹⁵ Endersby, *Imperial Nature*, 38-39.

³⁹⁶ Drayton, “Imperial Science,” 194; Mark Nesbitt and Caroline Cornish, “Seeds of Industry and Empire: Economic Botany Collections between Nature and Culture,” *Journal of Museum Ethnography*, no. 29 (2016): 53–70.

³⁹⁷ Drayton, “Imperial Science,” 232.

The government was busy with austerity measures and looking for ways to reduce the amount of money spent on royal gardens. As a result, the Royal Gardens Committee was established by the Treasury in 1838 to be headed by declinist Lindley, who was tasked with preparing a report on the matter. In his report, Lindsey reiterated his previously declared views for turning the royal gardens into public gardens, as had been the case in other European nations. He argued that, for years, either the treasury or the admiralty had funded collection missions and maintained them at the gardens, thus, the gardens had already been publicly funded. More importantly and quite contrary to the expectation of some critical voices, Lindsley recommended that the Royal Gardens should be funded more. The report also criticized the Banksian era informal networks between the Royal Gardens in England and Botanical Gardens at the colonies for their diminished utility, “no unity of purpose,” and lack of commercial benefits for the nation. For this, it was necessary to establish a centrally controlled system through a National Botanic Garden as the center that links all other in a common cause that is “aiding the mother country in everything that is useful.” In short, what Lindley recommended, in Drayton’s words, was to turn “the informal empire of economic botany... into a formal bureaucratic instrument for efficient utilitarian colonial government.”³⁹⁸

In 1841, Kew Garden became a public institution under the directorship of William J. Hooker. In the following years, Kew expanded in land, prestige and facilities, but also responsibilities. William Hooker had to design Kew to make it able to undertake several duties simultaneously: serving the public audiences, assisting the state for the national interests, and enabling scientists for research and it had to do so in a cost-effective way.³⁹⁹ Therefore, the three main functions of Kew were economic, scientific and social.⁴⁰⁰ Its social function for the people necessitated the creation of a recreational public garden where Londoners could roam freely. Since the popular support was crucial for justifying their value to the nation, William Hooker began with this task of display. He reported to Parliament that the number of visitors to the public

³⁹⁸ Drayton, “Imperial Science,” 238-239.

³⁹⁹ Drayton, “Imperial Science,” 281.

⁴⁰⁰ Donal P. McCracken, *Gardens of Empire: Botanical Institutions of the Victorian British Empire* (London: Leicester University Press, 1997).

garden rose from 9174 in 1841 to 179.627 in 1850,⁴⁰¹ and it further went up to more than 300.000 visitors in 1851.⁴⁰²

William Hooker wanted to focus more on botanical research and to turn Kew into a center for botanical research, “as the botanical advisory center for Victorian imperial expansion.”⁴⁰³ His aim was to build necessary facilities for this purpose, which would enable him to conserve, propagate, evaluate and find ways of utilizing plants. This, of course, included educating botanists and training gardeners. But first of all, master collection was crucial to making existing collections available for researchers. This collection would facilitate the description of useful plants. Books, on the other hand, were other crucial tools of this description process. Researchers, without a vast collection and books at hand, were bound to remain ignorant in botany.⁴⁰⁴ Therefore, an herbarium,⁴⁰⁵ and a library emerged as the priority; however, in order to obtain the funding, he first had to prove the significance of theoretical botany for the economic one.

As a result of his and his political supporters’ efforts, Hooker managed to persuade the treasury to provide the necessary funds for establishing the Herbarium and the Library in 1854 which completed in 1855.⁴⁰⁶ Moreover, Hooker personally established ties with the Royal Navy, the Colonial Office and the India Office in order to send out trained collectors for exploration, collection and transfer of plants. At Kew, received plants were studied, improved and sent back to colonial gardens, which made it “a

⁴⁰¹ Brockway, *Science and Colonial Expansion*, 81.

⁴⁰² Drayton, “Imperial Science,” 309.

⁴⁰³ Christophe Bonneuil, “The Manufacture of Species: Kew Gardens, the Empire and the Standardisation of Taxonomic Practices in Late 19th Century Botany,” in *Instruments, Travel and Science: Itineraries of Precision from the 17th to the 20th Century*, ed. Marie-Noëlle Bourguet, Christian Licoppe, and Otto Sibum (London: Routledge, 2002), 200-01.

⁴⁰⁴ Jim Endersby, “From Having No Herbarium: Local Knowledge versus Metropolitan Expertise: Joseph Hooker’s Australasian Correspondence with William Colenso and Ronald Gunn,” *Pacific Science* 55, no. 4 (2001): 347.

⁴⁰⁵ “Collection of dried, preserved, and systematically classified plants”. Rolf H. J. Schlegel, *Dictionary of Plant Breeding* (CRC Press: 2020), 230.

⁴⁰⁶ H. C. Sampson, “The Royal Botanic Gardens, Kew, and Empire Agriculture,” *Journal of the Royal Society of Arts* 83, no. 4295 (March 15, 1935): 416; Drayton, “Imperial Science,” 316-318.

depot for the interchange of plants throughout the Empire.⁴⁰⁷ This infrastructure established by William Hooker was most effectively used under the next director, Joseph Hooker. Thus, the one-way transfer of plants under the Banks was now two-way, with Kew playing a role in distribution.

4.5. Moving Plants by Leaving the Knowledge Behind

It is time for a quick revisit of the story of cinchona. The tree solved some of the most serious problems that European imperials faced, just as rubber became a key raw material for capital accumulation. The imperial scientific institutions managed to control and utilize these resources effectively. This utilization not only empowered the imperial state, but also disempowered locals, which made them more vulnerable in the face of advancing Europe. The imperial civilizing mission rhetoric embedded within these activities portrays natives as incapable of utilizing these resources, but capable of making them extinct.⁴⁰⁸ Therefore, the West had to save these plants and put them in the service of humanity by using its superior scientific knowledge and other relevant resources.⁴⁰⁹ The history of quinine, when told from a Euro-centric perspective, emphasize the struggles and achievements of European naturalists and scientists in making one of humanity's most important discoveries. In these accounts, the local, both in terms of actors and bodies of knowledge, rarely find a place.

Who really saved people from the fever of Malaria? Markham's ambition and determination, the support of the Kew director Hooker, and the technical assistance of other Kew-trained botanists were crucial. Several British botanists taught the political authorities how important the tree is, how to utilize it, how to move it, and how to make it efficient in its new habitat. For sure, the British officials were quick to realize the importance of this plant and provided the necessary financial resources. Their support for the man of science was crucial. But how about the Dutch? Before all other

⁴⁰⁷ Brockway, *Science and Colonial Expansion*, 85.

⁴⁰⁸ The contemporary version of this narrative suggests that unrestricted access to plant genetic resources is for the greater good of humanity, while at the same time, economic and political benefits obtained from this access should not be contested simply because they are necessary for encouraging innovation.

⁴⁰⁹ Bray et al., *Moving Crops*, 145.

imperials, they took a chance on the seeds of *C. pahudiana* that Hasskarl had brought to them while risking his own life. Although Hasskarl's variety was found to be inadequate and abandoned, nonetheless it supplied the Dutch much needed experience. It also triggered the British officials to act more decisively. In the end, it was Dutch's later, more successful, breeding activities that eventually spread this cure all over the world. It was Charles Ledger's *C. Calisaya* variety that he collected from Bolivia which enabled the Dutch to master in quinine production in Java and dominate the international market. The famous Charles Ledger was clearly an important naturalist who deserves to be remembered.

There are several other European scientists, politicians and naval officers whom we could easily name, but these are already well-known figures. However, what is often overlooked is the contribution of local actors and their knowledge systems. In fact, Ledger never dismissed the contribution of another 'kind' of hero. A local guide who was punished for assisting Ledger has already been mentioned earlier in this text. Manuel Incra Mamani (Icamanahí) was tortured by Bolivian authorities for his role in the smuggling of cinchona seeds, which led to his death.⁴¹⁰ He was a native bark collector, who worked with Charles Ledger for several years prior to his demise.⁴¹¹ His knowledge of the region, varieties of cinchona and their habitat was so vast that it was only through this knowledge that the Ledger's seed made their way into Dutch hands in Java. Manuel Incra Mamani was aware of the danger he put himself in collecting cinchona samples from the region, thus had rejected many previous offers, yet his close cooperation and friendship with Ledger prevented him from refusing.⁴¹²

In 1861, Ledger asked him to obtain the seeds of the best variety, known as True Cinchona. This request was only realized in 1865. This was because a severe cold in the spring caused most of the cinchona flowers to dry off. Although much less valuable varieties survived the cold, it took four years for the 'True Cinchona' to flower again

⁴¹⁰ Schiebinger, *Plants and Empire*, 3.

⁴¹¹ Holland, "Ledger Bark and Red Bark," 1.

⁴¹² Walker, "The Making of a Quinologist,".

and to produce seeds for collecting.⁴¹³ If Mamani had not possessed this knowledge that makes him able to describe very small differences between varieties of the tree, Ledger would have had to collect many different varieties in his search of True Cinchona. At that time, botanical science still did not have detailed descriptions and classifications of all cinchona varieties. Identifying the most valuable Cinchona varieties could then only be done by a detailed chemical analysis of the quinine, which could only be done in Europe, as the necessary equipment could not be carried out or set up in the region. For a European collector, therefore, it was not enough to have a vast knowledge of botanical science regarding cinchona. It was also a matter of luck to a great deal. But Mamani had a unique expertise in this knowledge system which European collectors lacked. He was able to distinguish the most valuable species:

While on a trek together, Ledger had asked if they would find the ‘true’ bark of cinchona, i.e. the best variety. Icamanahí had stated: ‘No Señor, the trees here about do not see the snow-capped mountains.’ Ledger recorded that he ‘could hardly contain my laughter, but when I went to bed a few hours later, I could not sleep for thinking of Manuel’s answer.’⁴¹⁴

Mamani collected seeds from 50 different trees in a densely forested area. Ledger was aware of the difficulty of this job.⁴¹⁵ He wrote John E. Howard that: “I feel convinced in my own mind that no white man would or could succeed in getting such splendid seed as my faithful Manuel did. It is so clear that he got the true Calisaya ‘rojo’.”⁴¹⁶

What is more remarkable is the highly utilitarian and selective learning practices of European travelers. Despite their dependence on local knowledge for knowing the new world, Europeans easily excluded local ways of knowing nature, thus the broader environment within which the process of knowledge production takes place. For example, La Condamine, who encountered a native named Fernando de la Vega, only noted him anonymously as a cinchona collector (cascarillero). On his second visit, he noted that this man had the best knowledge of cinchona trees and that he even had

⁴¹³ Holland, “Ledger Bark and Red Bark,” 2.

⁴¹⁴ Walker, 39.

⁴¹⁵ Holland, “Ledger Bark and Red Bark,” 2.

⁴¹⁶ John Eliot Howard, “On Cinchona Calisaya var. Ledgeriana, How., and C. Ledgeriana (Moenes),” *Botanical Journal of the Linnean Society* 20, no. 129, (1883): 318.

given him a cinchona bark. Although this anonymous collector is now mentioned by his name, for La Condamine he is still a collector, albeit a more skilled one. The problem with this narrative is that Vega had been living in Loja, one of the centers of Andean medical culture and a home to several practitioners of it. Vega was more than just a skilled collector. He was a healer (curandero) who knows how to process the cinchona tree to produce medicine.

As is the case with many other European and non-European interactions, Vega's highly technical skills and methods did not make it to the written records of history. It was not an individual choice, but rather a systematic omission of a 'primitive' knowledge system. This is because the encounter between La Condamine and Vega is in fact the encounter of two distinct ways of knowing nature: "European natural history and Andean medicine."⁴¹⁷ The Europeans' firm belief in the superiority of their own ways of knowing led them to ignore alternative "epistemic cultures" that produces distinct ways of knowing and competent practices in line with them. They were incommensurable, not the practices per se, but the distinct systems of knowledge that enact them. While Europeans explorers got the indigenous healing practices, they decontextualized them by removing other, accompanying, practices that maintain their embeddedness to the broader cosmology. Local practices, when stripped away from the worldview that sustains them, became easier to replace or co-opt.⁴¹⁸

The 'discovery' of rubber and its subsequent improvement by the industry through synthetic vulcanization rests on a similar narrative, one that relies on the primitiveness of the native practices and their inability to utilize this god given natural resource. Just as the epistemic consensus in the case of cinchona, it became an article of faith among enlightened that "indigenous material would have remained useless if European or American inventors had not 'cured' it through vulcanization".⁴¹⁹ Goodyear transformed rubber from a 'sticky resin' to "one of the 'Big Five' great necessities of

⁴¹⁷ Crawford, *The Andean Wonder Drug*, 39-40.

⁴¹⁸ Crawford, *The Andean Wonder Drug*, 35-38.

⁴¹⁹ Jens Soentgen, *Indigenous Knowledge and Material Histories: The Example of Rubber* (Cambridge University Press, 2024), 46.

the modern world.”⁴²⁰ This recurring theme explicitly ignores indigenous knowledge and agency from the history of rubber, along with local practices such as the organic vulcanization.

Without the local practices and so-called traditional knowledge that sustain them, the ‘discovery’ and utilization of these raw resources would not have been so easy. However, for the West-centered historiography of the 19th century, products of non-western knowledge systems could easily be ignored. It was the time of great discoveries and innovations, and of sudden ruptures that radically transform traditions. For example, the separation of the alkaloid quinine by two Frenchmen in 1820 was “considered a moment of great discovery in the standard histories of medicine”, as if the medicine did not exist before.⁴²¹ For Markham, this was “one of the greatest conquests made by man over the vegetable kingdom.” The science enabled Europeans to control chemicals for extracting the quinine alkaloid, thus succeeded in turning cinchona bark, a primitive healing substance, into a medicine that “is the most precious of all those known in the art of healing.”⁴²² While the science was producing new means of intervention on the nature, its narrative was reconstructing the meaning of nature by replacing the tree and the bark with the quinine, which makes it unnecessary to dive deeper into the “period in which quinine didn't exist.”⁴²³ In other words, the cinchona tree was important only because of the quinine.⁴²⁴

4.6. Giving Order to Kingdom of Plants by Removing Chaos

4.6.1 Information Overload

The rapid erasure of the local knowledge can only be partially explained through the European superiority in discourse and institutions alone. More than written records,

⁴²⁰ Stefan Zweig, *Brazil: Land of the Future* (New York: Viking Press, 1941), quoted in Soentgen, *Indigenous Knowledge*, 36.

⁴²¹ Rohan D. Roy, *Malarial Subjects: Empire, Medicine, and Nonhumans in British India, 1820–1909* (Cambridge University Press, 2017), 31.

⁴²² Markham, *Travels in Peru and India*, 20.

⁴²³ Bray et al., *Moving Crops*, 145.

⁴²⁴ D. Roy, *Malarial Subjects*, 30.

ships and agents were needed to sterilize the material practices from their social environment and the knowledge system that surrounded it. This was made possible through the imposition of another system of knowledge production.

Mary Louise Pratt critically engages with the European travel writings in order to answer how such writings produced “the rest of the world” for European readers during its expansionism, and through which “signifying practices it encoded and legitimated the aspirations of expansion and empire.”⁴²⁵ Beginning with the 18th century, travelers’ accounts represented and produced a distinctly Euro-centered, yet novel version of the global or ‘planetary consciousness’ which served as background ideas for European elites’ to reflect on themselves and their relations with the rest of the world. This particular consciousness emerged from and consolidated through the “new knowledge-building project of natural history.”⁴²⁶ Although natural history and its naturalists had been around for millennia, this enlightened one had a distinct orientation of disengaging subjects, except those at the center of epistemic culture, from what they observed.

According to Pratt, the year 1735 is the point of rupture for two orientations that build this consciousness, which are the shift from maritime to inland exploration and a classificatory system of the natural world. Two separately initiated, nonetheless integrated, key events were particularly significant for this new project to be institutionalized as the dominant “structure of knowledge” of its time. One was the emerging orientation towards describing the objects of nature in their full details based on visible properties, thus ignoring non-visible stories around it. The other was a technical tool, a product of science, to accomplish such tasks of describing nature authoritatively, through systematic classification.

While earlier totalizing consciousnesses were mostly written in navigational terms and practices through mapping the voyage around the world (circumnavigation) or exploration of the coastal areas with a view from far away, the lens of natural history

⁴²⁵ Pratt, *Imperial Eyes*, 4.

⁴²⁶ *Ibid.*, 24.

was directed specifically towards the “internal ‘content’ of those land.”⁴²⁷ The shift towards exploring the natural habitat of interiors started in the year 1735, in which the very first ‘international’ scientific expedition set sailed not just to navigate survey coasts, but to go inside the Spanish controlled Peru. The main objective of the Spanish-French Geodesic Mission was to resolve the hotly debate taking place between Newtonian (British) and Cartesian (French) naturalists regarding the exact shape of the earth. The group consisted of French scientists, headed by mathematician Louis Godin, and others, including Charles de la Condamine.

While in earlier times those who explored non-European lands had been seen as men of fortune, travelers were now seen as men of science engaged in a pure scientific pursuit.⁴²⁸ La Condamine and his successors did not, of course, create Natural History, but the Enlightenment naturalists, unlike the ancient and early modern naturalists, made the observer less powerful in the process of description as they initiated the efforts of systematization. This was necessary since their expeditions into the interior made them encounter new objects. Royal museums, botanical gardens and scientists in Europe were flooded with many, yet unnamed, ‘exotic’ species from all over the world.⁴²⁹ Unlike previous travelers, La Condamine's account not only contained his adventures, difficulties and miracles but also described nature, thus offered a representation of nature through words. All this created an ‘information overload’ that had to be managed.⁴³⁰ Such information included communities, their cultures, words and languages, new objects and materials, their local nomenclature, their use and utilization, and their culturally embedded meanings.⁴³¹ These, of course, found their way into the traveler’s accounts, but a method seemed necessary to catalogue new objects. At this point, the systematization effort was finally resolved with a widely

⁴²⁷ Ibid., 30.

⁴²⁸ Ibid., 85.

⁴²⁹ Peter Naumann, “What’s in the Box? Linnaeus’s Legacy,” *Journal of Museum Ethnography* 18 (2006): 77–94.

⁴³⁰ Staffan Müller-Wille and Isabelle Charmantier, “Natural History and Information Overload: The Case of Linnaeus,” *Studies in History and Philosophy of Biological and Biomedical Sciences* 43, no. 1 (2012): 4–15.

⁴³¹ Naumann, “What’s in the Box?,” 81.

accepted scheme that simplified information by necessarily decontextualizing it. The claim to scientification and systematization necessitated classification and the exclusion of the subjective judgement of the observer. This scheme, based on a particular knowledge system and technical tools, allowed Europeans to domesticate and naturalize the non-European world, which was alien to them.

4.6.2 Information Processing Devices of Natural History

The history of quinine began when the first European came across the tree *Cinchona* and named it as such. In Markham's words, "the first man of science who examined and described this important plant" was La Condamine.⁴³² The emphasis on the description of the tree by a French man of science is quite significant as it effectively distinguishes the scientific knowledge from other, non-scientific knowledges, including the earlier descriptions provided to Spaniards by the locals. All other names, along with their contexts, became obsolete with this simple naming practice.

Life on Earth has diversified over many years due to natural forces and human influences, which resulted in the plurality of species and varieties. Earlier attempts to classify this diversity have failed to achieve widespread acceptance. In 1735, Swedish naturalist Carl Linné (Linnaeus, in Latin) published his *The System of Nature*, in which he offered a classification system for all living things that are known or about to be known to Europeans. It was a technical tool that would categorize plants and animals based on their visual/physical properties into their hierarchically ordered places. He later fine-tuned its system in the following years that distinctly produced a naming scheme, known as binomial nomenclature.⁴³³ With the introduction of Linnaean nomenclature, plants that were either previously observed or newly obtained by Europeans, come to be named simply in two Latinized words, first one for a generic name (genus) and the second one for a specific epithet, or as called by Linnaeus a trivial name (species): *Homo Sapiens* for wise human.⁴³⁴

⁴³² Kavita Philip, "Global Botanic Networks," 188.

⁴³³ Naumann, "What's in the Box?," 81.

⁴³⁴ Staffan Müller-Wille, "Walnuts at Hudson Bay, Coral Reefs in Gotland: The Colonialism of Linnaean Botany," in *Colonial Botany: Science, Commerce, and Politics in the Early Modern World*, ed. Londa

Linnaeus was in search of a solution for a problem which disturbed European naturalists at that time: the heterogeneity of knowledge sources. This prevented the collection, classification and circulation of information. Therefore, he produced two ‘information-processing devices’, which created a ‘discursive unity’ among European scientists and made the accumulation of knowledge possible.⁴³⁵ What made Linnaeus’ system spread was that it allowed for the rapid description of species since it relied on observable, visible properties. This was the most important requirement for a classification scheme to be accepted in a period in which there was a rapid flow of new information and a demand for its circulation. Moreover, the description practice could be performed by any observer who possesses some basic knowledge. If the observed object was not included in existing catalogues, then a new species had been discovered. By the mid-19th century, the Linnaean system was widely recognized as the dominant tool of the European epistemic culture as “no botanist could claim to produce scientific knowledge who did not follow its rules.”⁴³⁶ The Linnaean system was considered highly effective as “a model for bringing order to all forms of knowledge.”⁴³⁷ Equipped with it, naturalists were “...making order out of chaos – both the chaos of nature, and the chaos of earlier botany.”⁴³⁸ The order of scientific knowledge, however, can only be achieved through “stripping away unnecessary complexity” that feeds into that chaos.⁴³⁹

[...] locating every species on the planet, extracting it from its particular, arbitrary surroundings (the chaos), and placing it in its appropriate spot in the system (the order-book, collection, or garden) with its new written, secular European name.”⁴⁴⁰

Schiebinger and Claudia Swan (University of Pennsylvania Press, 2005), 34; Schiebinger, *Plants and Empire*, 198.

⁴³⁵ Staffan Müller-Wille, “Linnaean Paper Tools,” in *Worlds of Natural History*, ed. Helen Anne Curry, Nicholas Jardine, James Andrew Secord, and Emma C. Spary (Cambridge University Press, 2018), 205.

⁴³⁶ Müller-Wille, “Walnuts at Hudson Bay,” 34.

⁴³⁷ Naumann, “What’s in the Box?,” 81.

⁴³⁸ Pratt, *Imperial Eyes*, 25.

⁴³⁹ Jane Calvert, “Synthetic Biology: Constructing Nature?,” *The Sociological Review* 58, no. 1 (2010): 102.

⁴⁴⁰ Pratt, *Imperial Eyes*, 31.

It was quickly adopted by scientific circles for several reasons. This new system of classification enabled scientists to sterilize their observations from the contextual components they had to carry with them in the past. With this, they were able to leave behind what they could not take with them to Europe. It gave them the power to stabilize the names in a way to render the knowledge more easily and universally exchangeable, at least within European epistemic culture, since the name of the life form and its place within its Kingdom was “intended to remain stable and universally applicable once introduced.”⁴⁴¹ In a Latourian sense, then, it was a technical tool to translate living things, that had been evolving and transforming, into immutable objects that remain fixed once inscribed into certain schemas.⁴⁴²

Natural History, equipped with the Linnaean systematics, “extracts all the things of the world and redeploys them into a new knowledge formation whose value lies precisely in its difference from the chaotic original.”⁴⁴³ It necessarily purged botanical knowledge from “... all [its] context dependent meaning, resulting in a taxonomic system that consisted of... extensional relations of signifiers to signified, of names to exemplars.”⁴⁴⁴ Natural History was clearly transformative in the sense that it translated things with multiple meanings into what Rheinberger calls as “epistemic things” that has no precise meaning outside the pre-established cognitive frameworks in the case of basic science, or into “technical things” that can only be related in no other way than what it has designed for in the case of applied science.⁴⁴⁵ This purge created the necessary epistemic consensus that would make botany a science, which might have served as a mediator between different epistemes or ‘knowledge frameworks’ to make

⁴⁴¹ Müller-Wille, “Walnuts at Hudson Bay,” 34.

⁴⁴² Bronwyn Parry, *Trading the Genome: Investigating the Commodification of Bio-information* (New York: Columbia University Press, 2004).

⁴⁴³ Pratt, *Imperial Eyes*, 32.

⁴⁴⁴ Müller-Wille, “Walnuts at Hudson Bay,” 46.

⁴⁴⁵ Hans-Jörg Rheinberger, *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube* (Stanford University Press, 1997); Daniel Navon, “Reiterated Fact-Making: Explaining Transformation and Continuity in Scientific Facts,” *American Sociological Review* 89, no. 5 (2024): 849–75.

them “...commensurate through symbolic representation.” However, botany ended up as the “motor of colonialism” in the end.⁴⁴⁶

The Linnaean systematics was the “disembodying moment” for plants that made them fragmented, de-materialized and de-contextualized, which enabled European naturalists to construct nature from scratch rather than struggling to combine all incommensurable pieces of multiple knowledge systems.⁴⁴⁷ This technical tool was particularly significant for ignoring non-European knowledge systems since life forms

entered a system of representation [that] reduced [them] almost completely to mere reference by number, name, and citation; thus recording the morphology, geographic distribution, natural habitats, and uses of [...] plants seems to have been in vain [...]⁴⁴⁸

As a result, natural history following a Linnaean taxonomy separated nature and culture epistemologically in a move to clear the history of plants from human practice that are predating the European contact.⁴⁴⁹ This classificatory scheme served as the “descriptive apparatuses of natural history” that constructed globally circulated meanings of natural objects. It is through this device that natural history helped Europeans to claim their discoveries and displace vernacular peasant knowledges.⁴⁵⁰ Although the tools of Linnaeus reduced information overload and refined the chaos into veritable information that supplied the core of scientific botany’s main research object, the ‘natural’ system,⁴⁵¹ the eye of the natural historian was more than mere observer who simply narrates what is out there in its god given form. Species were discovered only because they were new to the eyes of the European observer, and they were named in most cases after the observer or his sponsors, and in some cases lovers

⁴⁴⁶ Müller-Wille, “Walnuts at Hudson Bay,” 48.

⁴⁴⁷ Jairus Rossi, “Genes Are Not Information: Rendering Plant Genetic Resources Untradeable through Genetic Restoration Practices,” *Geoforum* 55 (2014): 66–75.

⁴⁴⁸ Müller-Wille, “Walnuts at Hudson Bay,” 46.

⁴⁴⁹ Museums are lively examples of this heritage in the sense that species of nature and materials of human are separated into distinct exhibition areas, as well as art and natural history collections. See Nesbitt and Cornish, “Economic Botany Collections between Nature and Culture,” 53.

⁴⁵⁰ Pratt, *Imperial Eyes*, 4.

⁴⁵¹ Müller-Wille and Charmantier, “Natural History,” 4–15.

and spouses,⁴⁵² instead of “... the people who already lived among them and used them in their everyday lives.”⁴⁵³ For example, the cinchona variety that brought success to Dutch was named after Charles Ledger, rather than Manuel Incra even though Ledger made it quite clear it was Incra’s knowledge and expertise that made it possible in the first place. This naming practice that erased non-European, even when the original contributor risked his life, was not inappropriate, instead, it was the norm.

This system of classification and the lens of natural history had made the knowledge of nature scientific and universal on the grounds that it was purified from the subjective positions of the observer. For a European explorer, the purpose of leaving the home was only to return with the “information that can be used in theses or in articles to make his points”. Therefore, not just any information, but the useful information which the epistemic community could process in line with their technical schema was valuable. To avoid “accusation processes that are made from within scientific networks against their outside”, the observer had to make the raw information processed at the Centre. And the simplest way for an observer to do this was to erase “sociologies of all the people” as they are “‘local’, ‘closed’, ‘stable’, ‘culturally determined’”. Therefore, the context of the adventure was no longer wanted. It was a necessity to ignore such social burden. This process of decontextualization and objectification created “an absolute divide between, on the one hand, all the cultures that ‘believe’ in things, and on the other hand, the one culture, ours, that ‘knows’ things (or will soon know them).”⁴⁵⁴

In the early days of Natural History, before the rise of imperial botany and its tools, knowledge of plants was more valuable than the plants themselves. Moreover, it was not technically possible to transport the plant, in its totality, with all their accompanying ties. It was a costly task with a considerable risk of failure. On the other hand, depending on the need, this was not always necessary. The specific form of

⁴⁵² Schiebinger, *Plants and Empire*, 198.

⁴⁵³ Vibe Nielsen, “The Colonial Roots of Botany – Legacies of Empire in the Botanic Gardens of Oxford and Kew,” *Museum Management and Curatorship* 38, no. 6 (2023): 707.

⁴⁵⁴ Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Harvard University Press, 1987).

knowledge of plants that is sought after would determine which properties of the plant had to be transported and conserved. In some cases, even the reproduction of the plant did not require the mobility of the entire context around the plant. For classification and propagation purposes, proxies of plants, that are “parts of organisms or representations of them (grafted tissues, collections of seeds, herbarium sheets, and botanical illustrations)” might serve the end by themselves.⁴⁵⁵

Collecting the knowledge of the plant and some of its parts through decontextualization, rather than the whole organism, is not a new practice. Several tools have been designed to transmit this de-historicized, dematerialized knowledge of plants. Similar to Endersby’s approach, Parry, following Bruno Latour’s conceptualization, calls these tools inscription devices. Those inscription devices, such as technological artefacts, were devised for

bringing natural entities, or at least some of their key properties, home” in order to make nature easily translated into “new, more artifactual forms (specimens, botanical illustrations, stuffed animals, and so on) that might effectively “stand in for” or “represent” the organism in question.⁴⁵⁶

These devices included plant parts, seeds or their visual and verbal representations; Wardian cases that make them stable and mobile; Greenhouses that make them secure; or Herbariums that make them accessible and comparable. These devices in the more recent times take the form of seed banks, gene banks, and most recently, data banks. All in all, these are “innovative means of decontextualizing, fragmenting, extracting, fixing, and thus mobilizing notoriously unstable natural materials.”⁴⁵⁷

This was indeed the case for Europeans to consolidate their knowledge of nature. Visual representation in the form of botanical illustrations was one of the earliest examples of such tools.⁴⁵⁸ These illustrations were more than drawings of plants,

⁴⁵⁵ Parry, *Trading the Genome*, 23.

⁴⁵⁶ Parry, *Trading the Genome*, 23; Endersby, “From Having No Herbarium,” 343-58; Latour, *Science in Action*.

⁴⁵⁷ Parry, *Trading the Genome*, 23.

⁴⁵⁸ Karin Nickelsen, “Image and nature,” in *Worlds of Natural History*, ed. Helen Anne Curry, Nicholas Jardine, James Andrew Secord, and Emma C. Spary (Cambridge: Cambridge University Press, 2018), 221–35.

rather, they were representations of the knowledge. For this function, they were demanded not just for their beauty but also for their usefulness in botanical education and research. As such, those who benefit from them formed a language and a way of sharing knowledge. Through these drawings, knowledge itself and the naturalist were able to communicate with the rest of the epistemic culture.

... they were sites where scholarly conventions, aesthetic preferences and issues of prestige merged... Epistemologically speaking, they were indispensable for the generation, communication and stabilisation of knowledge about nature. Images defined how nature ought to be seen. And it was the nature of these images, pleasant and useful, that made them so successful in this respect.⁴⁵⁹

Spanish naturalists produced 12,000 botanical illustrations over 30 years in the late 18th and early 19th centuries. Bleichmar explains this ‘visual obsession’ of the Spaniards as a reflection of the dominant scientific practices in Europe among those enlightened naturalists. But more than this, it was a problem-solving device, as a means of ensuring that “individuals looked at plants in the same way and saw the same thing”, and for mobilizing plants to close the vast distance between their home in the periphery and the new host in the Centre.⁴⁶⁰

Another tool that granted Kew novel capabilities in Botany was the establishment of Herbarium during William Hooker’s tenure. Although the transportation network and tools for mobilization were well developed, it was not always possible to maintain living plants in the Gardens as it required much space and maintenance work. Herbarium served as a storing house for cataloguing and evaluating dried species effectively and as a research base. Endersby, following Latour’s three iterated practices that enable control over objects, argued that:

So, rather than collecting the actual plants, Hooker needed dried specimens as a substitute for them; they had... to be made stable (by drying them) in order

⁴⁵⁹ Ibid., 35.

⁴⁶⁰ Daniela Bleichmar, “Botanical Conquistadors,” in *Worlds of Natural History*, ed. Helen Anne Curry, Nicholas Jardine, James Andrew Secord, and Emma C. Spary (Cambridge: Cambridge University Press, 2018), 243.

to become mobile so that, once they had reached Kew, they were combinable into Hooker's imperial taxonomic scheme.⁴⁶¹

At the same time, Herbarium strategically placed the Kew between the researcher and the knowledge by granting control over access to such valuable storage of knowledge. Thus, it also institutionalized a hierarchy between the botanists at the center and those at the periphery. In a sense, it granted those who have access to Herbarium the epistemic authority of describing plants since only he can compare it through his vast collection, while those lack such infrastructure tasked with collecting and sending. For example, Joseph Hooker, in his correspondence with his collectors in New Zealand, argued that description and classification could only be done by those at the Centre. This was simply because the collector had no herbarium and, therefore, no way of comparing knowledge and making a systematic description. Despite the collector's insistence that he had local context and knowledge, his name did not make it into the catalogues of natural history. This shows how easy it is for the Centre to ignore those with local knowledge, even when they remain within the established scientific circle. It is, therefore, not surprising that the plant collected by Manuel Incra was not given his name.⁴⁶²

The Herbarium's power, especially the one under Hooker, was not limited to its own network. I was also able to define organizing principles within the broader epistemic culture. Increased trade and expanding colonies led to a boom in new species descriptions. Combined with the simplicity of the Linnean system, not only botanists but also amateurs of all sorts began making descriptions. The increasing number of botanical gardens outside Europe also contributed to this trend. Such amateur descriptions, in some cases, resulted in misplaced descriptions. These developments initiated a significant debate among botanists regarding the delimitation of species. Species were the smallest, stable units in the Linnean system, and Linnaeus was, as a religious man, believing the fixity of species. However, it was clear that some individuals within species were different than the overall population. There were, in other words, different types within species.

⁴⁶¹ Endersby, "From Having No Herbarium," 346-47.

⁴⁶² Ibid.

One group, the so-called splitters, argued for narrowly delimited species and suggested that there is more than one stable type within species. The other group, called lumpers, was in support of broadly delimited species and argued that these minor differences were neither sufficient nor necessary to describe them as new species. There was another scientific debate over the right methodological tools and criteria that should be employed in distinguishing species and deciding over differences. Some suggested studying living plants, others supported experimental methods in gardens, and another group supported examining and comparing dried plants that are collected in herbariums.⁴⁶³

The debate ended with the victory of institutionally strong botanists who reside in central institutions and control huge herbariums. These botanists, most predominantly J. Hooker from Kew, insisted on, and managed to, secure validity of broad species concept, and consolidated the herbarium as the “essential tool of the taxonomist” in distinguishing species.⁴⁶⁴

Hooker started a crusade against “splitters”, or what he calls as “species-mongers”. According to Hooker, these group tend to destabilize ‘the order of botany’ and kill ‘botany as a science’ by “burdening it quantitatively with new names.” In addition to causing disorder, their understanding of species had “no use to botanist, general or special” nor it does any “philosophical meaning.”⁴⁶⁵ Against this group, Hooker diffused his broad species concept through publishing. By using their institutional power base and personnel network, J. Hooker and G. Bentham gathered funds to publish several highly influential books that became main sources of reference among botanists, and newly beginners. These became disciplinary tools of botany that imposed a particular conceptualization of species.

For the next Kew director, William T. Thiselton-Dyer, “a general agreement amongst the staffs of the principal botanical institutions” was much more important than what or how local botanists describe, since it is those at the central institutions who check

⁴⁶³ Bonneuil, “The Manufacture of Species,”.

⁴⁶⁴ Ibid., 189.

⁴⁶⁵ Ibid., 200.

and approve new descriptions, thus approve the validity of local botanist. Therefore, lumpers successfully put voices from the periphery into “subaltern positions” by turning “their herbaria into the centers of the order...”⁴⁶⁶

Ensuring stability through imposing centrally designed standardized practices was key for maintaining the order of botany. However, it was more than an act of epistemic border drawing. It was also related to the needs of the imperial network to which Kew belonged. The description and classification practices provide and maintain an epistemic unity among botanists at the colonial gardens and those at the herbarium, thus enabling collective research and cumulative knowledge. Furthermore, there should be a close link between the botanical name of the plant, its description and its ‘commercial value’, to ensure “development and stabilization of imperial trade.” Accordingly, “only a large botanical metrological institution”, such as Kew, could act as the central standard of reference, thus maintain the taxonomic accuracy and the link between science and commerce.⁴⁶⁷

4.7. Conclusion

This chapter followed an infamous journey, known as the original act of biopiracy, that took place in the 19th century. British botanists managed to transplant two plant species from their native habitats and successfully developed them in plantations. These plants were cinchona and rubber. The first one solved the problem of malaria, thus enabled colonial expansion in Africa and enhanced British control in India. The second one fueled the industrial revolution, opened new markets, and extended capitalist relations of production. The British succeeded in collecting, transporting, utilizing, and improving plants in a far better way than others. These activities required the ability to recognize and control plants, which was done through botanists and their newly established epistemic culture. The epistemic culture that dominated the 19th century botany transformed the methods and aims of scientific practices, leading to the production of a knowledge system rooted in utilitarian logic. British imperial institutions and their vast resources had been crucial for the success of botanists and

⁴⁶⁶ Ibid., 206-207.

⁴⁶⁷ Ibid., 207.

naturalists. Kew Botanic Gardens and its naturalists, once serving for the royal family, had been reformed as a public institution, thus added into the tool kit of the British Empire. The rise of botany as a science and expansion of imperial institutions was one of the revealing examples of the co-production process between the knowledge on nature and institutions of social order. This chapter concludes that the process of knowledge production is conditioned by epistemic cultures, which in turn is shaped by political and institutional contexts.



CHAPTER 5

HISTORY OF TECHNOLOGICAL REVISION: BREEDING SCIENCE AND POLICY

5.1. Introduction

The previous chapter explained how plants emerged as useful objects for achieving imperial objectives, including political, economic, and social ones. Scientists managed to separate plants from their natural habitats through decontextualization to make them easier to store, move and recombine. In the 20th century, this trend of decontextualizing plants for enhancing their usefulness was further exacerbated with the emergence of a new epistemic culture that transformed plant breeding strategies. This chapter begins by introducing the debates over evolutionary theory in the second half of the 19th century and shows how a particular Darwinian interpretation was established by his followers. Following this, it introduces the famous experiment of Gregor Mendel and shows how his followers institutionalized a gene-centric mechanism of inheritance. It then explains how the intervention of state directed these scientific results to produce plant breeding strategies in line with the national interests and productivist paradigm.

5.2. Evolution at a Crossroads: Lamarck and Darwin

The 19th century has been dominated by debates over the nature of beings, that is, whether things remain true to their essential properties (i.e. fixed/steady state) or evolve from that stable base. This started the era of evolutionary theory, which in its contemporary form, offers “explanations for why/how traits exhibited by individual

organisms vary and why/how the subsequent distributions of traits in a population change.”⁴⁶⁸

In this line of debate, the first take is usually attributed to Jean-Baptiste Lamarck (1744-1829) with his *Philosophie zoologique* published in 1809. Lamarck was against the idea of fixity of species but rejected the possibility of their extinction. Instead, he argued that species evolve into distinct species. The stability or the fixity of the species was a common idea back then, but there was a need to explain the existence of species which, in some cases, slightly differed from each other.⁴⁶⁹ Therefore, Lamarck argued that, as it was quite widespread in those days, individuals were adaptive to the conditions they face by producing behavioral innovations to cope with them. Over time, using organisms/organs in a particularly beneficial way that grants its user advantages improves the organ progressively and creates functional differences and novel traits that are acquired in a lifetime.⁴⁷⁰ The behavioral innovation that sparked out of this interaction between the organism and the environment supply individuals with useful and adaptive changes that can be transmitted from parents to their offspring.⁴⁷¹ Lamarckian view on adaptive changes and their transmission into next generation came to be named as the soft inheritance which refers to the effects of use/disuse, and more broadly the environment within which the organism develops. In his view, the main mechanism of evolution was the adaptation of the species to the factors that surround them and subsequent functional differentiation.⁴⁷² The idea of the inheritance of acquired characters was not a Lamarckian invention as it had already been quite a widespread idea at that time, even for Darwin himself. Nonetheless, the

⁴⁶⁸ Lilach Gilady and Matthew J. Hoffmann, “Darwin’s Finches or Lamarck’s Giraffe: Does International Relations Get Evolution Wrong?,” *International Studies Review* 15, no. 3 (2013): 309.

⁴⁶⁹ On the delimitation of species see Chapter 5.

⁴⁷⁰ For a modern version of this Erna’s debates with Frankel see Chapter 6.

⁴⁷¹ Some striking examples as proofs are offered by Lamarck, including the blacksmiths with strong arms who transmitted this property into their sons; or giraffes whose necks had to get longer to reach leaves at the trees. William C. Summers, “Heredity,” in Branner’s *Encyclopedia of Genetics* ed. Stanley Maloy and Kelly Hughes (Elsevier, 2022), 2; Gilady and Hoffmann, “Darwin’s Finches,” 304-63.

⁴⁷² Ernst Mayr, *The Growth of Biological Thought: Diversity, Evolution, and Inheritance* (Harvard University Press, 1982).

history of modern evolution theory rests on a clear-cut dichotomy between the totally wrong Lamarck and the prophetic Darwin.⁴⁷³

While the path opened by Lamarck had been rediscovered in the mid-19th century, another shot had been fired, this time by Charles Darwin (1809-1882) with his ‘On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life’ published in 1859. While Lamarck focused on the variation through an organism’s interaction with the environment as the origin of species, Darwin prioritized natural selection as the mechanism behind it. In other words, Lamarck theorized a mechanism of variation and accepted its blended transmission into the next generation. On the other hand, Darwin focused on the mechanism that determines which traits will be transmitted and similarly accepted the blended transmission. For Darwin, contrary to Lamarck, species that fail to reproduce and transmit their variations become extinct. Darwin rejected borrowing any idea from Lamarck, but he accepted that his conclusion was in line with Lamarck’s.

5.2.1 Neo-Darwinians and Decontextualization

At the end of the 19th century, neo-Lamarckian views on the inheritance of acquired traits became less significant as the ultimate scientific convention with the birth of a new class of scientists who worked on cytology and chromosomes. The end of the Lamarckian view did not directly come from Darwin but from his followers. While Darwin retained some room, a large one, for the influence of factors that aligned with the soft inheritance (especially in pangenesis), his followers constructed a stricter interpretation of the natural selection that excludes agency of the organism, and reinterpreted the mechanism of inheritance in which development of individual traits were excluded from heritable subjects, which created a clear cut separation of the nature from nurture, evolution from development. Therefore, neo-Darwinians produced “a severely slimmed down version of Charles Darwin’s ideas.”⁴⁷⁴

⁴⁷³ Eva Jablonka and Marion J. Lamb, *Evolution in Four Dimensions, Revised Edition: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life* (MIT Press, 2014), 13.

⁴⁷⁴ Denis Noble, “The Illusions of the Modern Synthesis,” *Biosemitotics* 14, no. 1 (2021): 5–24.

As is usually the case in the stark radicalization of pioneers' ideas through their followers, neo-Darwinians were more Darwinist than Darwin himself regarding the role of natural selection in directing variations. For them, the natural selection was almost an algorithmic design that “that expels all manner of adaptive agency from within the organism and relocates it in an external force.”⁴⁷⁵ One of the earliest source for the later revision of Darwinism was related to the difference between Darwin and Alfred Russel Wallace (1823-1882) on natural selection.⁴⁷⁶ Wallace has been characterized by historians of biology as a “hyperselectionist,”⁴⁷⁷ “dogmatic selectionist,”⁴⁷⁸ or “group selectionist.”⁴⁷⁹ The main reason for this is that Wallace severely restricted the activity of the organism in the selection process. For example, one of these distinctions was claimed to be “the level of entity at which natural selection acts.”⁴⁸⁰ It is argued that, contrary to Darwin, whose entities were individuals on which natural selection acts, Wallace prioritized group/populations or varieties as the main units whose variations are significant for natural selection. For Darwin, the

⁴⁷⁵ While neo-Darwinians were strongly rejecting any external-environmental effect on the evolution of life forms, the term ‘external force’ should not come as surprise. The point here is, although the force behind the inheritance, what will be known as the gene in the following century, buried deep into the organism thus quite innate and internal for these group, it is externalized through natural selection as a causal force to the relations that unfolds among all the constitutive elements of the whole and beyond the organism. Therefore, genes were understood as physically innate, causally external to the organism and its development process. Lenny Moss, *What Genes Can't Do* (MIT Press, 2003), 6.

⁴⁷⁶ Wallace is known as the co-discoverer of natural selection with Darwin since their work, reaching the same conclusion, was published in the same issue of the Journal of Proceedings of the Linnean Society of London in 1858. However, as Wallace acknowledges, Darwin began his work well before Wallace but was in no hurry to publish it. Jakub Novák, “Alfred Russel Wallace’s and August Weismann’s Evolution: A Story Written on Butterfly Wings” (PhD diss., Princeton University, 2008), 10.

⁴⁷⁷ Michael Shermer, *In Darwin's Shadow: The Life and Science of Alfred Russel Wallace: A Biographical Study on the Psychology of History* (Oxford University Press, 2002).

⁴⁷⁸ Peter J. Bowler, *The Eclipse of Darwinism: Anti-Darwinian Evolution Theories in the Decades Around 1900* (Johns Hopkins University Press, 1992).

⁴⁷⁹ Jean Gayon, *Darwinism's Struggle for Survival: Heredity and the Hypothesis of Natural Selection* (Cambridge University Press, 1998), 17; Michael Ruse, “Myth 11: That Wallace’s and Darwin’s Theories Were the Same, and That Darwin Did Not Reveal Wallace’s 1858 Letter and Theory Until He Ensured His Own Priority,” in *Darwin Mythology: Debunking Myths, Correcting Falsehoods*, ed. Kostas Kampourakis (Cambridge: Cambridge University Press, 2024), 127–36; Richard Dawkins, “The Reading of the Darwin-Wallace Papers Commemorated—in the Royal Academy of Arts,” *Linnean* 18 (2002): 17–24; Jonathan Hodge, “On Revisiting Wallace’s 1858 Theory of Natural Selection,” in *Philosophy, History and Biology: Essays in Honour of Jean Gayon*, ed. Pierre-Olivier Méthot (Cham: Springer International Publishing, 2023), 177–97.

⁴⁸⁰ Dawkins, “Reading of the Darwin-Wallace Papers,” 20.

selection “operates on individual heritable variations, due to the chances of survival and reproduction that these confer on individual organisms, thus modifying races or varieties.” However, for Wallace, population wide variation is more significant for natural selection to do its job.⁴⁸¹

Darwin softened the determinism of blind natural selection by emphasizing sexual selection and mate choice with the *Descent of Man and Selection in Relation to Sex*, published in 1871.⁴⁸² Wallace, on the other hand, opposed sexual selection and especially female choice and aesthetic-based preferences and considered Darwin's approach anthropomorphic. According to Wallace, natural selection alone is sufficient to explain evolution, and the concept of sexual selection diminishes the strength of Darwin's argument. In the following decades, epistemic culture removed Darwinian sexual selection.⁴⁸³ Noble argues that its omission from the evolutionary process was later institutionalized with the Modern Synthesis which prioritizes atomistic units as agents. Wallace's separation of sexual selection and natural selection was an attempt to sanitize natural selection by excluding the agency of the organism in its totality. Its acceptance and the consolidation of a blind, unconscious selection served as normalizing and neutralizing the selection process which portrays agency of organism as powerless.⁴⁸⁴

Among neo-Darwinians, one of the pioneers was Francis Galton, Darwin's cousin, who argued for the separation of internal and external, innate and acquired, heredity and environmental factors and discursively constructed their mutual exclusivity through a dichotomy of nature and nurture.⁴⁸⁵ For Galton, nature, that is “all that a man brings with himself into the world” and nurture, “every influence that affects him

⁴⁸¹ Gayon, *Darwinism's Struggle for Survival*, 17.

⁴⁸² Charles Darwin, *The Descent of Man, and Selection in Relation to Sex*, (London: John Murray, 1871).

⁴⁸³ Jean Gayon, “Sexual Selection: Another Darwinian Process,” *Comptes Rendus Biologies* 333, no. 2 (2010): 134–44.

⁴⁸⁴ Noble, “Illusions of the Modern Synthesis,” 6. In the later period Wallace moved away from a strict natural selection for a higher intelligence in the creation of mankind. See Stephen E. Glickman, “Charles Darwin, Alfred Russel Wallace, and the Evolution: Creation of the Human Brain and Mind,” *Gayana (Concepción)* 73 (2009): 32–41.

⁴⁸⁵ Francis Galton, *English Men of Science: Their Nature and Nurture* (London: 1874).

after his birth” were “two distinct heads” of “elements of which personality is composed.”⁴⁸⁶ This clear distinction was regarded as the birth of the particulate theory of inheritance in which hereditary elements pass through generations undisturbed, invariantly.⁴⁸⁷

In Darwin’s pangenesis, these particules (gemmules) are taken as invisible units that are responsible for what is inscribed into an organism. However, contrary to Galton’s more atomic, independent and clearly invariant particules, Darwin left a considerable, yet untheorized, space for their interaction with the environment to some degree. For Galton, on the other hand, “the best environment will not free mankind from weaklings, they can only be ‘bred out’.”⁴⁸⁸

August Weismann was one of the well-known neo-Darwinians in the fight against soft inheritance through his unyielding emphasis on natural selection rather than adaptive change. His theory of the heredity was later named Weismannism or ultra-Darwinism. He was a strict separationist regarding the inheritance and development, with his “ironclad separation of tissue destined to be germ cells from that destined to give rise to the remainder of the body, or soma”, which became widely accepted by proponents of hard inheritance.⁴⁸⁹ Weismann was the first who called the term germplasm, as the reproductive substance within germ-cells, and argued that it is transmitted “in uninterrupted succession from one generation to the next”, while the “body (soma) which bears and nourishes the germ-cells, is, only an outgrowth from one of them”. This separation of the innate (germ-cells) and their visual representation (body-soma) was clearly following Galton, but in a more strict sense.⁴⁹⁰ Weismann, as a cytologist, was much more empirically oriented than Galton, and this is why he is credited for “given the inheritance of acquired characters its final coup de grace by cutting off the

⁴⁸⁶ Evelyn Fox Keller, *The Mirage of a Space Between Nature and Nurture* (Durham: Duke University Press, 2020), 23.

⁴⁸⁷ Michael Bulmer, “The Development of Francis Galton's Ideas on the Mechanism of Heredity,” *Journal of the History of Biology* 32, no. 2 (Autumn 1999): 288.

⁴⁸⁸ Keller, *The Mirage of a Space*, 28. For the effect of this separation for the racism debate Angela Saini, *Superior: The Return of Race Science* (Boston: Beacon Press, 2019).

⁴⁸⁹ Moss, *What Genes Can't Do*, 21.

⁴⁹⁰ Bulmer, “Development of Francis Galton’s Ideas,” 291.

tails of newborn laboratory mice and observing their offspring for several generations without once finding a newborn tail-less mouse”.⁴⁹¹ This was conceptualized as the Weismann Barrier, which “...makes impossible the inheritance of characters acquired by somatic cells, since they are a dead end, making no contribution to the next genera.”⁴⁹² Based on this, his experiment with mice, cutting off their tails to see whether they would give birth to tailless offspring, came to be accepted as the single most important proof of how wrong Lamarckism was.⁴⁹³

5.3. Mendel's experiment

Mendel's experiment came before the rise of genetics or the century of genes. The term gene and the distinction between phenotype and genotype were coined for the first time by Wilhelm Johannsen in the early 1900s. Genetics, as discipline for this new group of studies, was named by William Bateson around the same time. Mendel, on the other hand, began his experiment in mid 1850s, and published it in 1866. What Mendel thought he found, and what early Mendelians thought of them changed tremendously in the following years. Briefly, Mendel did not discover the whole story behind inheritance, but gave the basics, over a specific experimental design, for further development. However, Mendel's experiment and its interpretation had a lasting effect as it had been generalized so widely that it led further development in a particular direction.

Before Mendel, it was generally believed that parental traits, such as color or height, are blended/diluted⁴⁹⁴ during the reproduction in the progeny.⁴⁹⁵ Mendel's aim was to

⁴⁹¹ Ruth Schwartz Cowan, “Commentary: Before Weismann and Germplasm There Was Galton and Eugenics: The Biological and Political Meaning of the Inheritance of Acquired Characteristics in the Late 19th Century,” *International Journal of Epidemiology* 45, no. 1 (2016): 19.

⁴⁹² Bulmer, “Development of Francis Galton's Ideas,” 291.

⁴⁹³ However, Noble rightly pointed out that Lamarck argues that it is not any change that can be transmitted but the development that provides a functional advantage. Since mice need a tail, its disappearance is of no benefit. Noble, “Illusions of the Modern Synthesis,” 9.

⁴⁹⁴ Blending inheritance or gene blending theory of inheritance: “Inheritance in which the characters of the parents appear to blend into an intermediate level in the offspring with no apparent segregation in later generations.” Schlegel, *Dictionary of Plant Breeding*, 68.

⁴⁹⁵ Noel Kingsbury, *Hybrid: The History and Science of Plant Breeding* (University of Chicago Press, 2009), 425.

understand how traits were transferred from one generation to another. For this, he chose the garden pea as his model organism. It was a deliberate choice that would enable Mendel to control the fertilization process since pea plants were autogamous⁴⁹⁶ in the sense that the pollen of the same flower would fertilize the egg in the same flower. That means no other plant would interfere. The first step was the purification of various pea plants, through self-fertilization in which the plants had developed consistent characteristics that are easily measurable. As a result, he obtained homozygous⁴⁹⁷ plants for the traits he observed (i.e. pure breeding). Moreover, he focused on seven characteristics that can be easily observed and classified into two distinct forms. In short, Mendel had several pure-breds⁴⁹⁸ at hand as source of parental traits.

Mendel carefully designed his experiment in a way that would allow him to clearly observe the transmission of particular traits clearly. For this, he selected pea varieties with clearly contrasting traits. This way, he ensured that each individual plant has a stable phenotype that would not be altered with the environmental conditions. Then, he made sure that each trait remained constant in the following generations of self-pollination through true breeding.⁴⁹⁹ In other words, in terms of genotype, through inbreeding, he managed to obtain, rather unknowingly, pure lines which contain identical alleles at a particular loci of gene. This way, it prevented inferences of multiple genes (polygenic variation), thus managing to select those plants in which a single gene controls a particular trait.⁵⁰⁰

After crossing two distinct varieties, Mendel noticed that while some traits were passed into the hybrid plant entirely unchanged, some others disappeared, only to re-appear

⁴⁹⁶ Obligatory self-fertilization. Schlegel, *Dictionary of Plant Breeding*, 47.

⁴⁹⁷ “Having identical rather than different alleles in the corresponding loci of a pair of chromosomes and therefore breeding true gene.” Schlegel, *Dictionary of Plant Breeding*, 238.

⁴⁹⁸ “Derived from a line subjected to inbreeding; offspring that are the result of mating between genetically similar kinds of parents.” Schlegel, *Dictionary of Plant Breeding*, 368.

⁴⁹⁹ Rolf H. J. Schlegel, *History of Plant Breeding* (CRC Press, 2018), 47.

⁵⁰⁰ Kingsbury, Hybrid, 142.

in the second generation of crossing in a fixed proportion.⁵⁰¹ As a result of his experiment,⁵⁰² he argued that traits do not blend, rather carried over undisturbed through heritable substances in the form of particulate matters, which he called ‘elementen’ or factors. Thus, he argued that hereditary elements within plant cells determine the visible characters of plants. These elements as units of heredity are later called Mendelian factors, and finally genes, and are assumed to be governed by the rules of inheritance.⁵⁰³

These elements, later known as genes, had two alternative forms, now known as alleles,⁵⁰⁴ for the traits they represent. With Mendel’s Law on Segregation, it is argued that a hybrid plant receives two alleles from its parents, one from each parent. The hybrid may display both parental traits since it inherited both of them. During reproduction, pairs of alleles are separated and randomly passed into the offspring. For example, the plant with the dominant trait purple has ‘AA’ allele formation, while the plant with the recessive trait white has ‘aa’ allele formation. In self-fertilization of a purple plant (AA x AA), the offspring obtains A from each parental organism, resulting in an AA formation; similarly, the self-fertilization of a white plant (aa x aa), results in an offspring with ‘aa’ formation. However, when the purple parent (AA) crossed with the white parent (aa), since the offspring inherited one allele from each parent, and the resulted allele pair formed as (Aa), which refers to a genotypically

⁵⁰¹ Hans-Jörg Rheinberger and Staffan Müller-Wille, *The Gene: From Genetics to Postgenomics*, trans. Adam Bostanci (University of Chicago Press, 2017), 25.

⁵⁰² When Mendel crossed two pure-bred plants that differed in a single trait- white flower plant (P1) and purple flower plant (P2)- the first generation (F1) offspring had no white, but all purple flowers. Similarly, crossing two almost identical plants with different seed shapes (again a single trait)- a plant with wrinkled seeds and a plant with round seeds- resulted in an offspring (F1) that has uniformly round seeds. Based on a visual evaluation, i.e. phenotypically, the whiteness or wrinkledness did not make it to the next generation. However, in the second stage of crossing, when the F1 plants had self-fertilized, the resulted second generation (F2) offspring showed both parental traits. Moreover, the distribution of traits followed a 3:1 ratio: three for the dominant trait and one for the recessive trait. In other words, those traits that had gone missing in the first generation had somehow managed to transmit themselves but masked or hidden within the plant.

⁵⁰³ Helen Anne Curry, *Evolution Made to Order: Plant Breeding and Technological Innovation in Twentieth-Century America* (University of Chicago Press, 2016), 18.

⁵⁰⁴ “One of two or more alternate forms of a gene occupying the same locus on a particular chromosome.” Schlegel, *Dictionary of Plant Breeding*, 24.

heterozygous⁵⁰⁵ plant. In heterozygous individuals, phenotypical expression is determined by the dominant form of the gene (recessive-dominant).

Mendel had, in fact, developed an explanation for an observable yet unexplained phenomenon. Of course, these explanations were highly reductionist; in the following years, with the understanding of DNA structure and the rise of molecular biology, it had been shown that traits are actually blended at the genomic scale and that transmission is more relational than mechanistic. Most importantly, any trait (such as color or nutritional levels) is not determined by a single gene as several genes and their complex interaction affect it. However, Mendel's experiment was very well designed, conducted, observed and recorded as it left less room for scientifically oriented minds to reject it.⁵⁰⁶ In particular, the selection of contrasting traits and the pure-line characterization of the selected individuals made it possible to exclude the influence of other factors from the observation. In other words, Mendel had left only one path for the result of the cross as the process of purification eliminated the possibility of blended transmission. Moreover, prolonged and repeated practice had produced a convincing statistical finding.⁵⁰⁷ Mendel was not wrong, but his followers' generalization of Mendel's findings led to the birth of genetic science with a false start.⁵⁰⁸

5.3.1 Neo-Mendelians and their epistemic victory

Although Mendel's "Experiments in Plant Hybridization" had been read at the meetings of the Natural History Society of Brünn in 1865 and published in 1866, it remained buried for almost 40 years. It had been cited thrice until three scholars "resurrected [him] simultaneously" in 1900.⁵⁰⁹ Dutch botanist Hugo de Vries, German

⁵⁰⁵ "The condition of having unlike alleles at corresponding loci." Schlegel, *Dictionary of Plant Breeding*, 234.

⁵⁰⁶ In fact, this was one reason behind Weldon's criticism of Mendel's experiments.

⁵⁰⁷ Jonathan Harwood, "Did Mendelism Transform Plant Breeding? Genetic Theory and Breeding Practice, 1900–1945," in *New Perspectives on the History of Life Sciences and Agriculture*, ed. Denise Phillips and Sharon Kingsland (Springer, 2015), 345–70.

⁵⁰⁸ Gregory Radick, *Disputed Inheritance: The Battle over Mendel and the Future of Biology* (University of Chicago Press, 2023).

⁵⁰⁹ Schlegel, *History of Plant Breeding*, 51.

botanist Carl Correns and Austrian agronomist Erich von Tschermak, who were working independently, were about to publish their findings when they “discovered” Mendel’s work.⁵¹⁰

The rediscovery of Mendel and the epistemic controversies that followed did not immediately resolve the debate on evolutionary theory, but it added new perspectives, new concepts, new orientations and new openings to the debate. Most importantly, Mendel's discovery fuelled the ongoing debate among two groups of Darwinists, who advocate the continuity and gradual progression of evolution, and those who argue that evolution proceeds by leaps and bounds and is, therefore, discontinuous. It was a fight between two epistemic cultures. The debate between the discontinuous evolution advocated by Mendelians, armed with the newly found Mendelian experimental culture and the continuous evolution advocated by biometricians who relied on statistical models demanding highly complex mathematical skills, became the most important academic controversy of the era, especially within the British academic circles.⁵¹¹ Mendel's experiment showed, or had been interpreted, that two different traits were transmitted without mixing; thus, variation occurred in one generation and that this could be controlled.

In Britain, William Bateson from Cambridge was the pioneer of Mendelism. In 1901, he published ‘Problems of Heredity as a subject for Horticultural Investigation’, which introduced Mendel to the English-speaking scientific community. For Bateson, Mendel provided a simple and convincing answer to the decades-old debate on heredity by “sweep[ing] away all of the hitherto distorting complexity surrounding inheritance, exposing its underlying simplicity”.⁵¹² However, Bateson's attempts were not recognized by the institutionally strong biometricians, who interpreted Mendel's findings in opposition to Darwinism's slow and continuous hereditary variation. They pointed out that Mendel's work was designed to allow him to say what he wanted to say. In a way, it was too perfect an experiment to be true. Academic controversy turned

⁵¹⁰ Kingsbury, *Hybrid*, 143.

⁵¹¹ William B. Provine, *The Origins of Theoretical Population Genetics: With a New Afterword* (University of Chicago Press, 2001), 89.

⁵¹² Radick, *Disputed Inheritance*, 2.

into personal dispute; Bateson was soon forced to publish his books at his own expense under intense pressure from biometricians.⁵¹³

Among Bateson's critics, an Oxford scholar was taking the lead, Walter F. R. Weldon. As noted, before, neo-Darwinians who took over his legacy focused more on variation and inheritance in contrast to Darwin's emphasis on selection. At this point, they decontextualized variation, especially through a strong anti-Lamarckism, by sterilizing the organism from external factors. But not all Darwinists were on this page. Weldon had been in search of a way to capture and demonstrate Darwin's mechanism of natural selection in action. In his view, the question of inheritance was misapprehended from a Mendelian perspective. According to Weldon, hereditary variation results from a complex interaction of various factors rather than through atomistic units that transmit directly and unchanged. His understanding of variation emphasized context-dependency and multi-sourced causality. Since Mendel's experiment was based on an experimental case, it would be wrong to generalize such findings.

“In Weldon's view, Mendel had shown not how heredity at its most basic works, but what it looks like in lineages from which almost all ordinary sources of variability, internal and external, have been eliminated. To generalize from Mendelian experiments, in which context had been made to look ignorable and hereditary characters made to look well described by x-or-y (yellow-or-green, round-or-wrinkled, purple-flowered-or-white-flowered) categories, was thus to mistake the exception for the rule.”⁵¹⁴

The debate between Bateson and Weldon was quite intense. Bateson thought that Weldon was about to win the debate until the spring of 1906. Then, Weldon died. Before his death, Weldon was about to finish an alternative mechanism of inheritance to the Mendelian view. However, Weldonian ideas lost their visibility following his death, and Bateson emerged victorious. Some contemporary historians strongly argued that the defeat of the Weldonian inheritance approach against the Mendelians is the

⁵¹³ Kingsbury, *Hybrid*, 152-153.

⁵¹⁴ Radick, *Disputed Inheritance*, 2.

main reason for the current state of genetic science and the concept of the gene.⁵¹⁵ Until the post-genomic era, none of the Weldonian ideas became reputable once again. Now it was a time in which epistemic community were in doubt whether natural selection is the main mechanism of evolution. It was, as called by Julian Huxley, the eclipse of Darwinism until the rise of Modern Synthesis that combined Natural Selection, Mendelian Inheritance and Population Genetics.⁵¹⁶

In contrast to the theory-oriented Darwinians, Bateson emphasized the practical outcomes of Mendel's experiment for their utility in economic activities. He was a highly respected figure among scientific plant breeders. Attending the Second International Conference on Plant Breeding and Hybridisation in New York in 1902, Bateson wrote his observations on the train to his wife: "At the train yesterday, many of the party arrived with their 'Mendel's Principles' in their hands! It has been 'Mendel, Mendel all the way,' and I think a boom is beginning at last."⁵¹⁷

Bateson insisted that Mendel should be taken as a guide for plant breeders, who struggle to find their way in the dark. With his entrepreneurship, it was widely thought that "for the first time the plant breeder had a clear idea of how to proceed with crop improvement".⁵¹⁸ Bateson's words in his speech at the conference reflected the joy of someone who had finally seen the light:

⁵¹⁵ "Instead, our gene talk would be routinely hedged with talk of contexts, internal and external, because our concept of *the gene*... would be of an entity whose effects on bodies and minds can be variable depending on the mix of other causes in play. Change those other causes, and you potentially change a gene's effect, or even extinguish it: something you would hardly guess if you think of inheritance as Mendel's peas writ large." Radick, *Disputed Inheritance*, 3.

⁵¹⁶ Bowler, *Eclipse of Darwinism*.

⁵¹⁷ William Bateson to Beatrice Bateson, 3 October 1902, William Bateson Papers, University of Cambridge Library, letter G-3D-05, quoted in Diane B. Paul and Barbara A. Kimmelman, "Mendel in America: Theory and Practice, 1900–1919," in *The American Development of Biology*, ed. Ronald Rainger, Keith R. Benson, and Jane Maienschein (Philadelphia: University of Pennsylvania Press, 1988), 283.

⁵¹⁸ Garrison Wilkes and J. Trevor Williams, "Current Status of Crop Plant Germplasm," *Critical Reviews in Plant Sciences* 1, no. 2 (1983): 141.

[Breeder] will be able to do what he wants to do, instead of merely what happens to turn up... The period of confusion is passing away, and we have at length a basis from which to attack that mystery [...]⁵¹⁹

The term genetics was first used by William Bateson during the third international conference on plant breeding and hybridization in London in 1906. In his speech, he called Genetics the young science that transformed the study of plant breeding and hybridization “from being a speculative pastime to be pursued without apparatus or technical equipment in the hope that something would turn up...” to a “developed science”.⁵²⁰

As will be discussed later in detail, Bateson's enthusiasm was not quickly adopted by breeders. For this, a series of further studies had to be undertaken in the following three decades. In a sense, science, the abstract, had to be applied to technical systems. Nevertheless, Bateson did not hesitate to label Mendelian genetics as a revolution. One reason for Bateson's enthusiasm was the lack of funding and strong institutional support for his non-Darwinian ideas.⁵²¹ Promoting Mendelism as a revolution was an attempt not only to harness support but also to protect new science from opposition of the existing epistemic culture. Bateson was in need of alliances that would prove his usefulness and soon a network would be formed.

Foucault argues that Mendel's heredity units were new biological objects which were “calling for new conceptual tools, and for fresh theoretical foundations”. However, it remained buried until 1900. It was because of the discipline that “constitute a system of control in the production of discourse.”

Mendel spoke the truth, but he was not *dans le vrai* (within the true) of contemporary biological discourse: it simply was not along such lines that objects and biological concepts were formed. A whole change in scale, the deployment of a totally new range of objects in biology was required before Mendel could enter into the true and his propositions appear, for the most part,

⁵¹⁹ William Bateson, “Practical Aspects of the New Discoveries in Heredity,” in *Proceedings of the International Conference on Plant Breeding and Hybridization, Memoirs of the Horticultural Society of New York*, Volume I (New York, 1902), 3-8.

⁵²⁰ William Bateson quoted in Kingsbury, *Hybrid*, 157-58.

⁵²¹ Harwood, “Did Mendelism Transform Plant Breeding,” 363.

exact. Mendel was a true monster, so much so that science could not even properly speak of him.⁵²²

Although the discipline, that is the epistemic culture, was against Mendel, some others were in search of a path for systematizing plant improvement and transforming their agricultural systems. The results of the Mendelian experiment provided that path.

5.4. Mendelians at work

5.4.1 Svalöf Plant Breeding Station

Around the same time as the famous rediscovery, the modernization of agriculture and the plant breeding were emerging as priority areas. Mendelism fueled the process. In the early days, Mendelism's impact on plant breeding was most visible in the work undertaken at the Svalöf plant breeding station in Sweden.⁵²³ Sweden, the home of Linnaeus, had a significant influence in mainstreaming Mendelism within the plant breeding world as it "combined fundamental work in genetics with the solution of practical problems".⁵²⁴ One significant advantage of Svalöf over its contemporaries was its orientation towards practically useful end results and methodology driven research and development process that included highly ordered record-keeping, and sophisticated, for its time, measurement of the breeding process.⁵²⁵ The first director of the center, Thomas Bruun von Neergaard, a German agricultural engineer, had been influenced by the German method of selection (i.e. mass selection)⁵²⁶ that was

⁵²² Michel Foucault, *The Archaeology of Knowledge and the Discourse on Language*, trans. A. M. Sheridan Smith (Pantheon Books, 1972), 224.

⁵²³ In 1886, Birger Welinder, a Swedish large estate owner at Svälöf founded the '*Southern Swedish Association for the Cultivation and Improvement of Seed*' as a breeding centre. Later, in 1891, the association founded the General Swedish Seed Company with the task of production and marketing. Until it came under heavy state influence in 1913, the Svälöf center remained a private institution. Roll-Hansen, "Plant Breeding,"; Kingsbury, *Hybrid*, 160.

⁵²⁴ Kingsbury, *Hybrid*, 160.

⁵²⁵ Ibid., 161.

⁵²⁶ German method, that is mass selection, had been elaborated by Kurt von Rümker (1859-1940), a German scholar from Göttingen University, who is known for being the first scholar who offered a structured lecture for scientific plant breeding and his book, *Instructions for Cereal Breeding on a Scientific and Practical Basis* (1888). Rümker, following Darwin, argued for the mass selection of plants to find useful variations as "the heredity was constantly changing and intensely varied." Kingsbury, *Hybrid*, 178.

prominent in Europe under the Darwinian idea of the continuous and gradual change of characters. It was assumed that the best types, which evolved in nature, would be collected through continual mass selection and could be further improved through continuous selection.⁵²⁷ Neergaard, as a keen systematist, played a crucial role in making the Svalöf a center of method-driven research, through his insistence on “measure, number and weight”, which later made Svalöf “Mecca of plant breeding”.⁵²⁸ Neergaard had also developed a system for classifying cereal varieties with different characters collected by mass selection. This system offered a more flexible classification than Linnaeus' point of species fixity, as observation in the field did not fit into existing classification schemes.

The second director (1890-1924), Hjalmar Nilsson (1873-1949), further developed Neergaard's classification system, based on ‘botanical characters’ that had no immediate commercial value themselves but might be useful for identifying types that are more homogenous and with certain heritability advantage. However, Nilsson was somewhat frustrated with the lack of uniformity and commercially desired traits in his tested varieties as the plants that are mass selected and assumed to be purified failed to maintain their botanical characters in successive reproductions. On the other hand, he was amazed by the existence of good and uniform types that are reproduced by farmers who select particularly promising individuals from their fields. These were, in Darwinian language, individual chance mutations. He began selecting promising plants, carefully mixing them, and testing their progenies on their homogeneity. He found out that a small group of plants maintained their uniformity, that is, bred true to their parents. Upon checking their records, Nilsson found out that those plants that remained stable are offsprings of a single parent. This led him to start selecting individual plants rather than mass selection.⁵²⁹ This was one of the moments in which purification as a plant improvement strategy began rising, which would later inform conservation strategies. As a result of this breeding strategy, he was able to achieve

⁵²⁷ Erik Åkerberg, “Nilsson□Ehle and the Development of Plant Breeding at Svalöf during the Period 1900–1915,” *Hereditas* 105, no. 1 (1986): 1; Schlegel, *History of Plant Breeding*, 253.

⁵²⁸ Roll-Hansen, “Plant Breeding,” 2.

⁵²⁹ Deborah K. Fitzgerald, *The Business of Breeding: Hybrid Corn in Illinois, 1890–1940* (Ithaca: Cornell University Press, 1990), 25; Kingsbury, *Hybrid*, 162; Roll-Hansen, “Plant Breeding,” 2.

397 completely constant oat plants out of 422 pedigrees.⁵³⁰ Moreover, he put forth a theory of biotypes, which suggested that

[...] individual plants were composed of numerous elemental factors, or biotypes, that roughly corresponded with observable characteristics. Different wheat plants, for instance, were composed of different biotypes within the range of possible variation. By paying careful attention to observable variation among such plants, the breeder could select and isolate favorable biotypes.⁵³¹

It is here in this point, we began seeing the effects of Mendelians, or more broadly genetics, on plant breeding practices. Hjalmar Nilsson was heavily influenced by the Hugo De Vries' work on mutations and interpreted them "as the major source of genetic variation", thus focused on individual selection "as the main method of picking them up".⁵³² Hugo De Vries (1848-1935) was one of the rediscoverers of the Mendel's experiment. In line with the eclipse of Darwinism era, or rather being one of its initiators, he was skeptical that Darwin's mechanism of Natural Selection alone had brought about evolution; he therefore sought to revise Darwin's theory of pangenesis, which had been omitted by neo-Darwinians as previously noted. De Vries discovered that plant species could go through radical changes in a few generations, which he called mutations. He laid out the foundations of his theory, in which mutations occur through the transfer of the traits contained in the 'particles' that he called pangenesis. Nilsson, following de Vries, argued that the modification of existing races and the production of new races are governed by two different systems. Modification relies on the continuous transformation of races, which can be achieved artificially through mass selection. Producing new races, on the other hand, is based on discontinuous or even spontaneous events and can only be described as mutations, as De Vries called them.

De Vries was more of a pure scientist, while Nilsson was procurer of it. However, the influence had been mutual. De Vries had communicated with Nilsson extensively and described the work at Svalöf in his 1907 publication by praising their systematic efforts

⁵³⁰ Roll-Hansen, "Plant Breeding," 2.

⁵³¹ Fitzgerald, *The Business of Breeding*, 25.

⁵³² Nils Roll-Hansen, "Theory and Practice: The Impact of Mendelism on Agriculture," *Comptes Rendus de l'Académie des Sciences – Series III – Sciences de la Vie* 323, no. 12 (2000): 1110.

as “almost incredible.” De Vries interpreted the findings at Svalöf as proof of his theory, argued that neither mass selection nor hybridization has much practical value for breeding, and the only way to obtain them is an individual selection of those naturally occurring mutations.⁵³³ Nilsson was proud to declare that the breeding work at Svalöf “achieved what Hugo de Vries sets as the ideal and future hope of all breeding, the problem of exploiting the mutations in the service of practical life”.⁵³⁴ However, De Vries was not a mainstream Mendelian as he later distanced himself from other Mendelians who came to be the core of classical Mendelian genetics, with his work on instability of genetic component contrary to proponents of invariant Mendelian factors. For Nilsson, de Vries was a representative of this new science; therefore, under his rule, Svalöf adopted the science of genetics. But it was only one of its many faces.⁵³⁵

Another face of genetics made its way in plant breeding through Erich von Tschermak. During Nilsson’s directorship, a young botanist H. Nilsson-Ehle (1873-1949), was employed at Svalöf and put in charge of a hybridization program on wheat and oats (1900-1915) based on Mendelian genetics. Hybridization was gaining momentum before the Nilsson-Ehle, not just as a way of creating variation but also as a way of combining useful traits from different plants. Against his director, Nilsson-Ehle was in favor of recombinational strategy, that is, the hybridization of pure lines, in which it is assumed that individual genes would be summed up, unblended, within progeny through crossing.⁵³⁶ For him, in line with Tschermak, the hybridization was the main source of genetic variation, rather than individual mutations that are naturally occurring as offered by De Vries. This was a more consistent interpretation of Mendelism, one that suggests “the existence of underlying hereditary factors that determine the properties of the organism and will recombine according to simple stochastic rules in hybridization”.⁵³⁷ The different plant breeding strategies prioritized

⁵³³ Roll-Hansen, “Plant Breeding,” 3.

⁵³⁴ Ibid.

⁵³⁵ Roll-Hansen, “Impact of Mendelism on Agriculture,” 1114.

⁵³⁶ Roll-Hansen, “Plant Breeding,” 3.

⁵³⁷ Roll-Hansen, “Impact of Mendelism on Agriculture,” 1110.

by Nilsson and Nilsson-Ehle resulted in the latter's departure from the center, only to return as the director in 1925, to serve until 1939.

Beyond his early efforts in hybridization, Nilsson-Ehle's another significant contribution to the systematization of plant breeding was recognizing that multiple genes, not just single ones, can influence plant trait expression. He observed that commercially important quantitative traits⁵³⁸ are generally governed by several gene pairs. This phenomenon is now called polygenic⁵³⁹ variation or multi-factor variation and is understood to be quite common; therefore, since certain traits cannot be simply categorized, they require careful observation of subtle differences, not just color, but shades of them.⁵⁴⁰ This variation results from the cumulative action of multiple genes, producing continuous variation independent of environmental factors. Consequently, in many cases, parental traits may indeed blend into progeny.⁵⁴¹ His findings were crucial for integrating Mendelian inheritance with Darwinian statistics in modern population genetics.⁵⁴² Nilsson-Ehle and his contemporaries demonstrated that the mechanistic application of Mendelian laws in plant breeding was more complex than initially assumed, explaining the delayed acceptance of Mendelian genetics in plant breeding, particularly in France and, to some extent, Germany. This finding would be later used by critics of the dominant plant breeding strategy on the ground that isolating genes, despite generating predictable results, would not unleash the full power of crop variation.⁵⁴³

Svalöf case shows that newly established scientific doctrines, based on Mendel and its various interpretations, made their way relatively easy into the plant breeding researchers. They, with the help of their entrepreneurs, disturbed previously stable

⁵³⁸ Quantitative Traits: "a character in which variation is continuous so that classification into discrete categories is arbitrary." Schlegel, *Dictionary of Plant Breeding*, 371.

⁵³⁹ "Traits determined by many genes, each having only a slight effect on the expression of the trait." Schlegel, *Dictionary of Plant Breeding*, 355.

⁵⁴⁰ Roll-Hansen, "Impact of Mendelism on Agriculture," 1111; Harwood, "Did Mendelism Transform Plant Breeding," 362.

⁵⁴¹ Kingsbury, *Hybrid*, 425.

⁵⁴² *Ibid.*, 164.

⁵⁴³ See Chapter 6 for the debate between Erna Bennett and Otto Frankel.

ways of doing things. Kurt von Rümker's mass selection is adopted by the first director of Svalöf, then replaced by its second director, Nilsson, who realigned the center's strategy in line with De Vries' mutation theory and individual selection for purification. However, it was soon replaced by another version of Mendel, under the third director, Nilsson-Ehle and his beloved Mendelian, Tschermak, and his suggestion, hybridization. That is first purify, then recombine.

5.4.2 Johannsen and Pureline Theory - Hereditary Stability

Another Mendelian, this time from Denmark, was quite significant for the adaptation of Mendelism in plant breeding techniques, particularly in the USA. Wilhelm Johannsen (1857–1927) is known for coining the terms gene, genotype and phenotype and for his role in the diffusing pure-line breeding strategy throughout Europe.⁵⁴⁴ Johannsen agreed with the idea that Darwinian evolution based on natural selection requires a distinct theory of heredity to fulfil its promise. As the mass selection failed to show Darwinian continuous evolution, and individual selection based on De Vries' mutations become much more significant, it became clear that natural selection "did not by itself produce variation but only selected from variation produced by other causes". Now it was time to understand the causes of heritable variation and to distinguish it from non-hereditary variation.⁵⁴⁵

Johannsen invested his efforts in pure line breeding strategies and argued that two forms of variability exist. One is the fluctuating variability that resulted from environmental factors, and second is the type variability that is inherited by distinct pure lines and remains constant despite numerous selections. He later named these two types as phenotypic and genotypic variations. Johannsen argued that basically two distinct experimental strategies exist in Mendelian genetics: hybridization and pure line breeding. The selection of pure lines with the aim of further purification has a limit and leads to a dead end in terms of generating genetic variation. Continuous individual selection paired with self-fertilization would end up with genetically homogenous, or as Bateson calls it, Homozygous, types. Therefore, it does not produce

⁵⁴⁴ Frederick B. Churchill, "William Johannsen and the Genotype Concept," *Journal of the History of Biology* 7, no. 1 (1974): 5-30.

⁵⁴⁵ Roll-Hansen, "Wilhelm Johannsen's Genotype Theory," 465.

genetic variations and does not lead to modification. Self-pollinating plants, after several selections, remain constant in terms of their genotype. Although they develop better than their parents, if cultivated under optimal conditions (i.e. environmental-external factors), these changes in phenotype are not inherited in next generations. This is the basis of Johannsen's claim on hereditary stability. Therefore, something inside these identical life-forms, the Mendelian element or as Johannsen called them 'genes', should dictate their representation. Therefore, the only permanent variation could be achieved by crossing two distinct plants with distinct genotypes into one, that is hybridization.⁵⁴⁶

Johannsen's findings had been interpreted as confirmation of the previously debated separation of nature and nurture, or innate and external. Later, it had a tremendous impact, especially when it was successfully combined with the Gene-Chromosome theory pioneered by, among others, Thomas Morgan.⁵⁴⁷ Contrary to evolutionary and historical views, this understanding produced an ahistorical image of genotype and rendered the effect of myriad relations within and among organisms obsolete.⁵⁴⁸

Johannsen's work on pure lines produced an understanding of genes, units of heredity, as stored in a closed environment, deeply buried in the organism in which it has no interaction either with the rest of its home, nor with the outer world. In a way, this "sanctuarisation" of genes made the heredity "... a matter of inwardness rather than of interactivity" in which "... the presence or absence of identical genes in ancestors and their descendants" determine inherited characters.⁵⁴⁹ This made gene as an epistemic object that is isolated enough to be "investigated in its own right", thus initiated a "radical separation" of inward and outward, heredity and development, thus for some

⁵⁴⁶ Roll-Hansen, "Plant Breeding," 4.

⁵⁴⁷ Laureate of the Nobel Prize in Physiology or Medicine in 1933.

⁵⁴⁸ Rheinberger and Müller-Wille, *From Genetics to Postgenomics*, 40.

⁵⁴⁹ Christophe Bonneuil, "Producing Identity, Industrializing Purity: Elements for a Cultural History of Genetics," in *A Cultural History of Heredity IV*, ed. Staffan Müller-Wille and Hans-Jörg Rheinberger, Preprint 343 (Berlin, 2008), 88.

critical historians “... leading straight to the wholesale, reductionist worldview of genetic determinism”.⁵⁵⁰

The resulting understanding that builds one-to-one relationships between genes and traits was more of an experimental requirement than what scientists actually think about the nature of it. Johannsen was aware of the shaky ground his followers rely on by equating genes-for-traits.⁵⁵¹ For him, the phenotype was the result of the reactions or responses of the whole genotype rather than single or multiple genes. He was against the strict gene-centric assumptions of heredity.⁵⁵²

Johannsen had spent years within an agricultural context at the Copenhagen Agricultural College. Crops that are useful in agriculture are bred to produce specific characteristics that are determined by a large number of genes and their complex relations rather than stand-alone individual genes. However, Johannsen, despite his acknowledgement of the fact, believed that statistical tools to account for such complex phenomena of multifactorial inheritance were not readily available at that time.⁵⁵³ Even Thomas Hunt Morgan was aware of the many-to-many relationship in determining characters, thus reductionism he employed, but took it as an experimental strategy in order to show that “the unit addressed as a gene ‘made a difference’ that there was a constant and reproducible relationship between changes in genes and changes in traits.”⁵⁵⁴

⁵⁵⁰ Rheinberger and Müller-Wille, *From Genetics to Postgenomics*, 45.

⁵⁵¹ Roll-Hansen rediscovers Johannsen’s holistic approach on genotypes and his skepticism towards Morgan’s chromosome theory. According to this interpretation, Johannsen, in his own words, insisted that the newly established genetic science “... was very far from the ideal of enthusiastic Mendelians, viz. the possibility of dissolving genotypes into relatively small units, be they called genes, allelomorphs, factors or something else. Personally I believe in a great central ‘something’ as yet not divisible into separate factors.” However, this holistic or integrationist approach on how genome works remained under the radar until post-genomic era. William Johannsen, “Some Remarks About Units in Heredity,” *Hereditas* 4 (1923): 133–41, quoted in Nils Roll-Hansen, “The Holist Tradition in Twentieth Century Genetics: Wilhelm Johannsen's Genotype Concept,” *The Journal of Physiology* 592, no. 11 (2014): 2435.

⁵⁵² Roll-Hansen, “Holist Tradition,”.

⁵⁵³ Rheinberger and Müller-Wille, *From Genetics to Postgenomics*, 43.

⁵⁵⁴ *Ibid.*, 45.

Regardless of what scientists think about the ‘true’ nature of genes, the popular representation of them dominated the basic and applied research. Genes as fixed trait carriers can be taken out of their buried place regardless of their myriad relations and recombined with others in a new host, leading to hybridization come to be seen as a technical tool that merges two distinct places into one effectively.⁵⁵⁵

5.5. Mendelism and the [Myth of] Revolution in Plant Breeding

It is generally argued that Mendel was appreciated not only by biologists but also by breeders as it provided them with a validation of what they were already doing, through explaining the patterns they observed. It also granted them a clearly described route for effectively predicting and possibly controlling the inheritance of traits in plants.⁵⁵⁶

As the popular narrative goes, Mendelism revolutionized plant breeding. Today, one can learn from introductory textbooks the importance of that particular moment in 1900 for the development of genetics and the revolutionary effect of the Mendelian theory on plant breeding, industrialization of agriculture, and relatedly conquering hunger. Among the contemporary historians of biology, the rediscovery of Mendel had been hailed as the ‘revolution’ that paved the way for genetics as an emerging field of science and application. Mendel’s scientific clarity is argued to have led practitioners to believe in the simplicity of applying the rules of inheritance in a way that “quality and yield in wheat would be inherited as simply as shape and color in peas.”

[...] that nineteenth-century breeders had crossed varieties largely at random merely in order to generate diversity [...] from which the breeder would then select. Mendelism, by contrast, would allow for a ‘planned’ approach to hybridization since the breeder would be able to design crosses which would combine desired traits from each of the parents.⁵⁵⁷

However, another historiography argues that this revolution, the scientification of plant breeding, was not directly related to Mendel, that except for a ‘rhetorical revolution’ before the First World War, Mendelian influence did not become

⁵⁵⁵ Bonneuil, “Producing Identity,” 88.

⁵⁵⁶ Curry, *Evolution Made to Order*, 18-19.

⁵⁵⁷ Harwood, “Did Mendelism Transform Plant Breeding,” 348.

widespread until the Second World War.⁵⁵⁸ Despite such heroic narratives, the Mendelian theory of heredity remained debated among scientists and breeders throughout the first half of the 20th century.⁵⁵⁹ Moreover, it took more than four decades until Mendelian entrepreneurs managed to consolidate the theory as the right path for the modern plant breeding strategy.

Mendelians argued that pre-Mendelian breeders were clueless about what they were doing. They criticized the German method of mass selection, which is applied before the distinction of phenotype and genotype, on the ground that such practices relied upon physical properties of plants (external appearance-phenotype), thus misleading and inefficient as a breeding strategy.⁵⁶⁰ In most of the mainstream historiographies of plant breeding, it has been suggested that with Nilsson-Ehle's pedigree selection and Johanssen's distinction between phenotype and genotype, mass selection has proven to be inefficient and is buried in the past.⁵⁶¹ However, the rise of Mendelian genetics did not lead to a sudden leaving of mass selection. "... public-sector breeders realized that mass selection was less efficient than individual selection... they continued to recommend it anyway simply because it was quick and cheap".⁵⁶² Some other non-scientific factors must have contributed to the rise of Mendelian principles in plant breeding.

⁵⁵⁸ Harwood, "Did Mendelism Transform Plant Breeding," 345–370.

⁵⁵⁹ Dominic Berry, "The Resisted Rise of Randomisation in Experimental Design: British Agricultural Science, c. 1910–1930," *History and Philosophy of the Life Sciences* 37 (2015): 242–60.

⁵⁶⁰ Harwood, "Did Mendelism Transform Plant Breeding," 345–370.

⁵⁶¹ "It was once assumed that hereditary variation was continuous both in the expression of characteristics and over time, from one generation to another, and the technique of mass selection was founded on this assumption. Mendel's breakthrough was to show that it was not, that inheritance followed a predictable pattern of segregation and recombination, with a mathematical ratio, Johanssen's breakthrough was that populations consisted of a number of pure lines—at least in the case of inbreeding species. Nilsson-Ehle showed how the technique of developing pure lines, followed by the controlled crossing of these lines, would give the breeder much more precise control over the outcome. Mass selection, such as Rimpau's much esteemed "German method," belonged to the past." Kingsbury, *Hybrid*, 181.

⁵⁶² Harwood, "Did Mendelism Transform Plant Breeding," 350.

5.6. Change in National Breeding Strategies: 1900-1945

In fact, there was more than one path that opened with the interpretation of Mendelian theory of heritage, but a particular one came to dominate practices which prioritized breeding uniform varieties.⁵⁶³ In the words of a recent contributor, “we came to talk of inheritance as genic... not because the invisible string-pullers are real but because, in the early years of the twentieth century, a debate over Mendel’s experiments and their interpretation went as it did”.⁵⁶⁴ The role of these Mendelian entrepreneurs, both in genetics and plant breeding, was crucial for the diffusion of this new epistemic culture. Roll-Hansen suggests that Mendelians, rather than Mendel, were significant in the transformation of plant breeding strategy. He argues that the work at Svalöf, influenced by Johansson, played an important role in Sweden's improvement of existing crops; that hybrid maize in the USA was developed under the direct influence of Mendelian experimental designs; that in the Soviet Union Vavilov was able to direct huge Soviet resources into plant breeding based on Mendelian principles.

In a way, along with the superiority of scientific arguments, it required intense patchwork, which includes discursive, political and institutional arrangements, for establishing the scientific validity of Mendelism as the sole epistemic doctrine for the modernization and systematization of plant breeding. Mendelism did not diffuse in a vacuum; rather, it was embedded incrementally into the scientific debates and plant breeding strategies. Even within Mendelians, an epistemic culture became dominant over alternatives by making itself as a key component of a specific production regime in agriculture as a suitable breeding strategy that would feed this regime.

In any case, Mendel’s and Mendelians’ arguments, such as the particle nature of heredity units and the stability of the genotype, contributed to the systematization of crop development, agriculture and valuing plants for their genes as resources to be utilized. In line with this scientific consensus, genes were conceptualized as units that can transfer desired traits into desired targets, and the science of genetics emerged as a revolutionary tool for the plant breeding system in support of the broader process of

⁵⁶³ Bonneuil, “Producing Identity,”.

⁵⁶⁴ Radick, *Disputed Inheritance*, 2.

agricultural modernization. The emerging scientific paradigm has led to the belief that plant breeding can be controlled, managed and improved further. Even before the war, plant breeding's contribution to agricultural production had become clear enough, and the spread of modern seeds began. Productivity increased in several European countries and the success of Hybrid Maize in the USA since the 1930s supported a strong belief that industrialization of agriculture can be achieved by modern plant breeding methods based on scientific and technical advancement.

The standardized pure lines coming out of the breeders' plots promised to accomplish the dream of converting agriculture into an industrialized activity by putting an end to the chaos of the farmers' fields cultivated with unreliable traditional crop varieties, the so-called landraces produced by mass selection and adapted to local conditions.⁵⁶⁵

This systematization and predictability were seen as a step towards rationalization and normalization of agricultural practices, which had remained outside the capitalist relations of production. The public reform programs for redesigning agricultural systems in line with industrial principles, i.e. to establish the division of labor and increase productivity by eliminating variations in the production process, were crucial political and economic factors in the consolidation of the gene-centric inheritance concept.

5.6.1 The USA and Hybrid Corn

For the supporters of the Mendelian revolution in plant breeding, the most cited example is the often-told success of the hybrid maize (corn) and its transformation of US agriculture. According to this narrative, the hybrid maize not only transformed the practice of plant breeding but also paved the way for the industrialization of agricultural practices. In a way, Mendel indirectly triggered the transformation of the agricultural system from a primitive to an industrial practice.⁵⁶⁶

However, linking the rise of hybrid maize with the spectacular experimental design of Mendel as a proof of science-led transformation is misleading. It is a reductionist

⁵⁶⁵ Tiago Saraiva, "Breeding Europe: Crop Diversity, Gene Banks, and Commoners," in *Cosmopolitan Commons: Sharing Resources and Risks across Borders*, ed. Nil Disco and Eda Kranakis (MIT Press, 2013), 199.

⁵⁶⁶ Fitzgerald, *Business of Breeding*; Kloppenburg, *First the Seed*.

approach to place Mendel as the main causal force behind all these developments, as there are decades between Mendel's rediscovery and the introduction of hybrid maize into American fields. As noted by Kloppenburg, despite the euphoria that was generated by the rediscovery of Mendelian theory, it "... was less a Rosetta Stone, providing the key to the mysteries of heredity, than an agenda for further research."⁵⁶⁷ This is why Harwood asks whether Mendelian rediscovery was necessary, or even sufficient to the development of the hybrid corn in the USA, and answers neither is necessary nor sufficient to singlehandedly pave the way for it.⁵⁶⁸

Today, it became clear that the rise of hybrid corn in the USA was a cumulative result of science, economy, state policy and individual and collective entrepreneurship. Sophisticated knowledge of plant heredity at the turn of century created a belief in the superiority of combinational breeding programs. This belief shifted the focus from introduction of foreign varieties or development of existing ones to production of brand-new varieties by crossing existing landraces. The fastest method for this, hybridization, enabled the private sector to produce profitable seeds. At the same time, the federal government was in search of a rapid breakthrough in food production and export markets, rather than slow and gradual development; thus, it devoted its resources in this direction in a way to strengthen its hand in economic and social problems. Similarly, a network of entrepreneurs led to the popularization of a specific Mendelian interpretation and plant breeding method.

Of course, within this complex institutional setting, a specific and highly reductionist interpretation of the plant inheritance, based on the concept of genes, was well received. This interpretation led to the prioritization of specific traits of plants that were beneficial, either socially or commercially, rather than the whole organism and its socio-material relations. Moreover, in line with Latourian mechanisms mentioned in the earlier chapter, the idea that these traits could easily be transferred to other organisms through genes and be combined with other desired traits was instrumental in fueling the hybrid hype in the USA. Therefore, in the USA, the method of selection and gradual improvement was abandoned in the first half of the 20th century. This

⁵⁶⁷ Kloppenburg, *First the Seed*, 100.

⁵⁶⁸ Harwood, "Did Mendelism Transform Plant Breeding," 345-70.

change in plant breeding strategies paved the way for the reification of plants as genetic resources and for valuing them for their hidden richness. Moreover, the belief in the superiority of the hybrid method and its internationalization through the Green Revolution reinforced the belief that plants are highly valuable objects for their genetic resources. Therefore, they should be utilized and conserved by collecting, which necessarily requires their separation from their habitat and the context within which they evolve.

Mendel had significant influence in the USA. Observing Bateson's frequent visits, following the work of Johannsen and those at the Svalöf, two American scientists, Edward East, and George Shull began applying Mendelian interpretations into plant breeding experiments. Shull began selection experiments in 1904, and similar to Nilsson's frustration, observed that even with the repeated selection, the population of an open-pollinated corn variety consists of various random crosses.⁵⁶⁹ The individual plants within this population are not identical despite being almost the same in appearance (phenotype). In a way, there were several "independent life types." Therefore, he, like Johannsen, further isolated these individuals through self-pollination (hand pollination), and the resulting inbred produced distinct and homozygous genotypes. However, this method of inbreeding resulted in diminishing yields and vigor. This phenomenon is now known as inbreeding depression.⁵⁷⁰ On the other hand, when two of these true pure-lines cross-pollinated -that is, hybridized-, the resulting offspring, which has a heterozygous genotype, is much more promising than both parents in terms of overall yield and vigor. This is the effect of the hybridization of pure lines, which is called heterosis by Shull, or more generally, the hybrid vigor.⁵⁷¹ This was in line with the original Mendelian recipe, in which purification followed by crossing leads to predictable and effective results.

⁵⁶⁹ Roll-Hansen, "Plant Breeding," 6.

⁵⁷⁰ James F. Crow, "90 Years Ago: The Beginning of Hybrid Maize," *Genetics* 148, no. 3 (1998): 923. Paul and Kimmelman, "Mendel in America," 297; Helen Anne Curry, *Endangered Maize: Industrial Agriculture and the Crisis of Extinction* (University of California Press, 2022), 34.

⁵⁷¹ Crow, "Beginning of Hybrid Maize," 923.

However, it did not catch up with the expectations of breeders as his contemporaries found this method either dangerous or unproductive.⁵⁷² For one thing, the effect of heterosis would deteriorate after the first generation, which would prevent farmers from re-using their seeds. Secondly, the amount of the seed produced through hybridization would be too small to become economically feasible as the increasing yields would not compensate for the cost of the seed. This is because the inbred plants used in the cross to produce the hybrid seed are so depressed in vigor, due to inbreeding depression, that they are inefficient seed producers.⁵⁷³ More importantly, as discovered before, the commercially significant traits were shaped by a more complex genetic interaction, contrary to Mendelian simplicity, thus requiring many resources to fully develop hybrid varieties. The problem with the depressed vigor of single crosses and their unproductivity for mass production was solved by a technical fix, which made the process more complex. Shull's method was further sophisticated by Donald Jones, a student of East, with his double-cross method. The method was more complicated than Shull's single cross as it involved crossing two hybrids, each of which was a cross of two inbred pure lines. Despite being labor intense and resource demanding, it offered a way to make seed production profitable. The resulting hybrid contained four pure inbred lines, but since these inbreds were hybridized first, their vigor was higher, and therefore, they produced more seeds. According to Fitzgerald, "the big difference in 1919 was that a way had been found to make crosses commercially viable."⁵⁷⁴

The hybrid corn quickly dominated US fields, spread over the Corn Belt in one decade, and reached a 95% adaptation rate by 1965.⁵⁷⁵ Before hybrids, American farmers had been using varieties that were improved from local (Native American) landraces, which were basically open-pollinated. Despite its setbacks, one advantage was the dynamic genetic variation. Hybridization signaled a shift from selection to recombination, from open pollination to controlled pollination, and from locally oriented slow adaptation to rapid and manufactured variation. This process made crop

⁵⁷² Kloppenburg, *First the Seed*, 98.

⁵⁷³ Crow, "Beginning of Hybrid Maize," 923. Fitzgerald, *Business of Breeding*, 57.

⁵⁷⁴ Fitzgerald, *Business of Breeding*, 56.

⁵⁷⁵ Kloppenburg, *First the Seed*, 94.

development a scientific and highly sophisticated technical task, which ‘deskilled farmers’ in the long run by replacing their practices.⁵⁷⁶ Nevertheless, it is, for some scholars, interesting that hybrid maize dominated US agriculture in a relatively short time. Neither hybrid varieties nor hybridization method had clear advantage over the selection method in open-pollinated varieties; their production process was resource-demanding: costly, time-consuming and complex; and it would also lead to the exclusion of farmers from seed production and plant improvement, which was against the overall policy of US Department of Agriculture (USDA)⁵⁷⁷. Then how did hybrid maize dominate US fields?

The relatively early impact of Mendelian genetics in the USA and the rise of scientific breeding is not the making of scientists alone. By the time Mendel's rediscovery reached America, there was an extensive institutional infrastructure, an epistemic community, and economic interests to capitalize on this discovery for both scientific and practical outcomes. The rediscovery was timely in the sense that hybridization emerged as an “... unprecedented importance in American agricultural research”.⁵⁷⁸ Mendelian heredity was sold as a miracle that would directly match with the specific demands of the US. It will boost the production, increase the income of American farmers and breeders.

The hybrid method and hybrid maize were, first of all, better suited to the federal government's program and the agricultural modernization infrastructure it had built. The ability to predict and control heredity matched perfectly with the attempts for the industrialization and scientification of agriculture in the USA at the beginning of the 20th century. Several considerations, both domestic and foreign, made the science of breeding particularly welcomed in the USA and placed the crop developments high on the agenda as a matter of national interest, thus public funds for such endeavors.⁵⁷⁹

⁵⁷⁶ Deborah K. Fitzgerald, “Farmers Deskilled: Hybrid Corn and Farmers' Work,” *Technology and Culture* 34, no. 2 (1993): 324–43.

⁵⁷⁷ Paul and Kimmelman, “Mendel in America,” 299; Jean-Pierre Berlan and Richard C. Lewontin, “The Political Economy of Hybrid Corn,” *Monthly Review* 38 (1986): 35–48.

⁵⁷⁸ Paul and Kimmelman, “Mendel in America,” 293.

⁵⁷⁹ Robin Pistorius and Jeroen van Wijk, *The Exploitation of Plant Genetic Information: Political Strategies in Crop Development* (CABI Publishing, 1999), 32–33.

Before Mendel's arrival in the US, the federal government was quite active in crop introduction and seed distribution. Through its patent office, the government developed a quite extensive mechanism for the introduction of novel varieties that had been transferred from abroad and their distribution into farmers' fields. Since the 1850s, the government had already been spending much more on crop development programs. Farmers were the main allies of the government, along with state-funded agricultural colleges and experiment stations. Mass selection was the widely practiced method of improving crops, which prioritized selecting promising populations with desired traits. The selected seeds would be let openly pollinate, which increases variability and the frequency of desired traits.⁵⁸⁰

The increase in international trade during the Civil War brought direct government intervention in both industrial and agricultural production processes. Following the footsteps of industrialization, the idea that agricultural modernization could be driven by science-based prescriptions became prominent. The aim was to achieve agricultural modernization by extending the knowledge produced in federally funded central institutions to farmers. In 1862, the USDA was established, and the Morrill Land-Grant Act was enacted, establishing agricultural colleges. The federal government's budget for agricultural research increased, especially after the 1870s. In 1887, the Hatch Act provided funding for the establishment of experiment stations in close cooperation with land-grant universities and agricultural colleges. In the 1890s, the USDA's budget and personnel increased significantly, and with the Morrill Act of 1890, land-grant universities extended to former confederate states. With the Smith-Lever Act of 1914, a cooperative extension service system was established, which placed federal research institutions in close collaboration with farmers. The research stations established with this infrastructure were mainly focused on open-pollinated varieties, but an important breakthrough would direct this huge mechanism towards hybridization.

An important argument for Mendel's rapid rise in the United States is that the federal government at the time was not only aiming to increase the total amount of crops produced, but rather a more targeted agricultural transformation. By the 1880s, wheat

⁵⁸⁰ Curry, *Endangered Maize*, 34.

production in the US had increased significantly compared to 1830. This surplus was achieved without hybrids; the opening of new lands to agriculture, the increased connectivity between farms and markets by railroads, and the increase in demand following the successive crop failure in Europe caused this surplus production. By the 1880s, however, wheat prices had declined in parallel with the increase in European production. Therefore, there was little incentive to further increase levels of wheat production. Therefore, efforts are directed to find paths to reorient production to reduce the area under wheat cultivation, to substitute imported products and to produce for the international market. In other words, it was necessary to shift the productivity in wheat into another product, a product that others could not compete with easily. The search for “diversification, quality improvement, and increased self-sufficiency” led to new plants and institutional openings.⁵⁸¹ One promising candidate was corn (maize), which, contrary to wheat, could serve dual purposes: food for urbanites and feed for livestock.

The key point that emerged from the extension of Mendelian experiments into the US context is the extended applicability of the theory to new plants. In the USA, the plant that was desired to be improved was corn, unlike wheat, which was crucial for European nations. For scientific reasons, corn had a clear advantage as a model organism, particularly in hybridization research, compared to wheat and other improvement methods. The difference between these plants is based on their reproductive biology, that is, the process of fertilization (self or cross) and mechanism of pollination (open, self or controlled), which determines the appropriate breeding strategy. Shull, East and his student Jones focused on hybrid corn precisely because it was useful for this task. As an open-pollinated plant, corn has several kernels, each of which can be fertilized with pollen from different plants, which results in several variations in a single fertilization. Wheat, on the other hand, is notoriously difficult for hybridization as a self-fertilizing plant. Moreover, corn offers easily measurable traits regarding the size, shape, number and color of various kernels. More importantly, its significance as an economically importance crop was rising, in line with the diversification strategy of the federal government. “Thus, theoretical and practical

⁵⁸¹ Paul and Kimmelman, “Mendel in America,” 288.

interests combined, in the early years of American genetics, to focus attention on corn.”⁵⁸²

From the 1880s to the 1890s, under the influence of these searches, hybridization and varietal crossing became prominent in order to produce new and superior varieties through increasing genetic diversity rather than improving existing ones. Collecting varieties from various parts of the world, crossing them in experiment stations and encouraging farmers to produce inbred plants and then crossing them became the main plant development strategy. As a result of this process, thousands of crossings were carried out, and hundreds of varieties were produced, but it was not possible to test their quality.⁵⁸³

The federal government was quite active in redirecting existing research infrastructure towards adapting Mendelian principles and hybridization, with the USDA's periodicals widely publicizing Bateson's translations and writings on Mendel and spreading Mendelian studies throughout the American continent. Steps were taken to establish and consolidate federal control over regional experiment stations to prevent them from carrying out independent programmes, such as non-hybridization research. For instance, the Hatch Act facilitated the transfer of federal funding for experiment stations through the Office of Experiment Stations, with the objective of transforming them from mere extension centers that educate farmers and provide practical outputs to active scientific institutions that conduct original research, based on the Mendelian genetics, through hybridization, with the aim of varietal development. The federal government and the USDA re-defined a 'strong station' as one that engaged in 'original investigation', while a station that solely provided training to farmers was regarded as a 'weak station'. Consequently, the number of stations implementing imposed scientific orientation and breeding practices increased.⁵⁸⁴

The government's rapid interest in the hybrid crops as a solution to its economic needs, of course, is not spontaneous. The growing visibility of Bateson and other Mendelians

⁵⁸² Ibid., 297.

⁵⁸³ Ibid., 290.

⁵⁸⁴ Ibid., 291.

at American universities and meetings of plant breeders had created a rapidly growing Mendelian community. The number of plant breeders following this new trend was increasing. Among these, the most significant one was Henry A. Wallace, a maize breeder himself. Wallace engaged in correspondence with Dr. Donald Jones, the inventor of the double-cross method, and shared his inbred lines. Wallace had become a pioneer of hybrid corn and popularized the double-cross method through his influential *Wallace's Farmers* magazine.

Wallace also led an initiative that served as evidence for the superiority of hybrids, thus contributing to the rapid popularization of the hybrid method. In the early days, it was accepted that hybrids were superior in terms of yield and vigor compared to their highly depressed inbred parents. However, there was no clear proof that shows the same result against open-pollinated varieties improved through selection. In the early 20th century, corn shows were big events in rural USA and involved a contest over the best corn to encourage farmers to choose better varieties. As such, they were useful as an agricultural extension activity. Wallace wanted to shake the dominance of traditional breeders at corn shows with his hybrids, and he proposed a yield competition in 1919. Wallace's hybrid, Copper Cross variety, won against the show's previous winner in 1924. It was highly cited evidence for the supporters of hybrids. However, Wallace's variety did not, in fact, win against the best farmers' variety in terms of yield. This is because the evaluation criteria of these shows were based more on aesthetics and visual qualities and less on commercially desired qualities. The champion that Wallace competed with, therefore, was not the best variety that a farmer can develop regarding the yield criteria. Nonetheless, the results led to a quick conclusion that the breeders' hybrid was superior to the farmers' best open-pollinated. Only around the 1950s was it understood that, in the long run, selection alone, without crossing, would create plants with vigor and yield as much as the inbred-hybrid method.⁵⁸⁵

Wallace's involvement in the story is more than this. His father, Henry C. Wallace, became secretary of agriculture under President Warren Harding in 1920. Wallace

⁵⁸⁵ Paul and Kimmelman, "Mendel in America," 299; Harwood, "Did Mendelism Transform Plant Breeding," 359.

advised another Mendelian corn breeder and inbred-hybrid supporter, F. D Richey, as the USDA's Principal Agronomist in Charge of Corn Investigation, who replaced the anti-hybridist C. P. Hartley. This was one of the key moments in which the route was changed. Richey, in one of his early addresses, declared that "All experimental evidence indicated that the older methods of open-fertilized breeding of corn varieties are of little value... the fundamental problems of corn improvement can be solved only through investigations based on self-fertilized lines".⁵⁸⁶ The Purnell Act of 1925 created a massive public corn development program and enabled Richey to be both institutionally and financially able to direct scientific efforts into a particular direction, that is, through hybrid development. In line with the concerted effort on hybridization, the Maize Genetic Cooperative Group was established in 1928. Existing stations were pushed for collaborative research, including the exchange of ideas and germplasm. Richey selectively supported research stations based on their attitudes towards hybridization.⁵⁸⁷

Similar to combined genes within hybrids, Wallace, Jones, and Richey formed an alliance that combined distinct capabilities from different spheres of influence. This was a clear form of network that worked perfectly for achieving common goals.

[...] together the three formed a potent lobby for the new method, for each commanded considerable authority within his own context. Jones could speak, to some degree, for both the geneticists and the station workers; Wallace had the support of farmers and private seed houses; and Richey brought the sheer weight and prestige of the USDA to bear on corn questions.⁵⁸⁸

As a result of these developments, federal policy on crop development focused its research and development institutions on hybridization practices. Thus, the infrastructure of this huge plant breeding system adjusted in line with the combinational strategy. Since it was getting more technical and costly, farmers slowly lost their ability to develop new varieties and their seed exchange networks. In the following years, the private plant breeding sector emerged as a capable actor, mostly because of their close cooperation with the public breeding programs. However, since

⁵⁸⁶ Kloppenburg, *First the Seed*, 103.

⁵⁸⁷ Kloppenburg, *First the Seed*, 107.

⁵⁸⁸ Fitzgerald, *Business of Breeding*, 61.

they were unable to compete with the public sector, it managed to delimit public crop development programs into basic science, out of variety development. As a result, farmers are forced to buy hybrid seeds from the private sector.

5.6.2 Effect of Mendel in Europe

The case of Hybrid corn in the USA shows the role of political and economic factors, along with institutional strategies in directing the translation of scientific knowledge into a specific socio-technical system, rather than a purely technical one. The sociality of technical systems not only emerges from the effect of social processes during their design processes but also as a result of the consequences they have on society. As a socio-technical system, modern plant breeding conditioned not only how people develop plants and produce food but also how they participate in social life.

From a technical point of view, this breeding system is designed for producing standard and uniform varieties. It could have prioritized selection method for improving local varieties, not strictly uniform but well adapted, in which farmers would have remained crucial social actors in not only improving crop quality but also maintaining crop diversity. Unlike the Mendelian scientific community, practitioners at the experiment stations did not suddenly adopt the hybrid method, as uniformity and broad adaptability were not their primary objectives. However, through a combination of legislative acts and keen entrepreneurs, centralized control over the existing public research and crop improvement infrastructure was established, directing its activities towards a specific method of plant breeding.

In Europe, the spread of gene-centric breeding practices took place under diverse political, social and economic conditions. It aligned well with the ideologies of National Socialists in Germany who had been in search of nutritional freedom and autarky, Fascists in Italy and their quest for breed freedom and Stalin's desire for a jump towards industrial agriculture. Although such choices during the 20th century

ultimately transformed plants into genetic resources, the rise of “de-historicized gene” had to wait in some other national contexts.⁵⁸⁹

France is an example where Mendelian genetics, particularly its gene as a unit experimental culture, arrived late in the second half of the century.⁵⁹⁰ One reason for this was that small-scale farmers had been seen as crucial for the stability of the regime and as a balance against the urban working classes; therefore, agricultural modernization was not a priority for the Third Republic. Moreover, unlike the land-grant university system in the USA, the universities and agricultural education institutes were not directly linked, which limited the impact of scientists over practitioners. Therefore, there was considerable skepticism towards a purely scientific plant breeding system and methods of single trait transfer among breeders in France. Breeding was still an art which relied on breeders’ subjective evaluations.

The gene was a unit in a Mendelian experimental culture, an “epistemic thing” as Rheinberger put it, that could be grasped utilizing statistical regularities, but it remained of secondary importance for French plant breeders, for whom the strain or the variety – not the gene – was the fundamental unit of analysis and manipulation.⁵⁹¹

During the Vichy regime, the increasing need for food and the necessity to supply Germany initiated the creation of a state-controlled agricultural system and the pioneering genetic modernization. Plant breeding, seed testing and seed distribution systems were directly targeted by this state-controlled modernization process. In the following period, the production of genetically homogeneous varieties through purification became the primary objective. At the same time, steps were taken to prevent the spread of farmers’ varieties. Thus, a fixist understanding dominated the modernization process, in which seeds were disconnected from the environment, farmers and local adaptation, becoming both means of productivity and control. It was

⁵⁸⁹ Dominic Berry, “The Plant Breeding Industry after Pure Line Theory: Lessons from the National Institute of Agricultural Botany,” *Studies in History and Philosophy of Biological and Biomedical Sciences* 46 (2014): 28.

⁵⁹⁰ Christophe Bonneuil, “Mendelism, Plant Breeding and Experimental Cultures: Agriculture and the Development of Genetics in France,” *Journal of the History of Biology* 39 (2006): 281–308; Christophe Bonneuil and Frédéric Thomas, “Purifying Landscapes: The Vichy Regime and the Genetic Modernization of France,” *Historical Studies in the Natural Sciences* 40, no. 4 (2010): 532–68.

⁵⁹¹ Bonneuil, “Development of Genetics in France,” 281.

in line with the “genetic modernism” that considered living beings as having an intrinsic genetic identity.⁵⁹²

The Soviet Union was among the early adapters of the Mendelian genetics into plant breeding system. Under Tsarist Russia, the Bureau of Applied Botany (1896), renamed as the Department of Applied Botany and Breeding in 1916, began systematically collecting and evaluating the plants grown in the vast Russian empire. During this pre-Soviet period, plant exchange networks were established with the scientific circles in Europe and America. Nicolai Ivanovich Vavilov, who spent several years for education in Germany, England and France and established close relations with the scientists and plant breeders such as W. Bateson and J. Vilmorin, was the entrepreneur who brought Mendelian genetics to the Soviet Union. In 1921, he was appointed as Director of the All-Union Institute of Applied Botany and New Crops (later renamed the All-Union Institute of Plant Industry, VIR).⁵⁹³

This new science became an integral part of Stalin’s Great Break, the policy of rapid development and modernization of the Soviet Union.⁵⁹⁴ Rising in popularity quickly, Vavilov became the director of the newly established ‘Lenin Academy of Agricultural Science’ governing 1300 institutes and 26000 scientists directly. It seems no better candidate would have filled this spot, considering the Soviet motto of “mobilizing science in the service of socialist construction”. Vavilov was one of the first who embedded a resourcist vision into plants by considering the world as a “universal store of genes” and genes as resources.

Breeding had now to be associated with the mass production of pedigree seed and livestock. Factories were set up with the labor and equipment requisite for extensive serial output... From an art, breeding has, to a large extent, become an industry or a trade.⁵⁹⁵

⁵⁹² Bonneuil and Thomas, “Purifying Landscapes,” 532-68.

⁵⁹³ Igor G. Loskutov, “Vavilov Institute (VIR): Historical Aspects of International Cooperation for Plant Genetic Resources,” *Genetic Resources and Crop Evolution* 67, no. 8 (2020): 2237–53.

⁵⁹⁴ Olga Elina, Susanne Heim, and Nils Roll-Hansen, “Plant Breeding on the Front: Imperialism, War, and Exploitation,” *Osiris* 20 (2005): 161–79.

⁵⁹⁵ Christophe Bonneuil, “Seeing Nature as a ‘Universal Store of Genes’: How Biological Diversity Became ‘Genetic Resources’, 1890–1940,” *Studies in History and Philosophy of Biological and Biomedical Sciences* 75 (2019): 5.

He was also the entrepreneur of the idea for directly state-sponsored collecting activities. As the diversity of crops was great both in terms of taxonomy and geography, existing networks among individual breeders would not be able to complete surveys. This call found its perfect match in Stalin, who was in search of replacing “small, backward, and fragmented peasant farms” with “consolidated, big, public farms”.⁵⁹⁶ This was a victory to be shared with Churchill: “We have improved the quality of the grain beyond measure. All kinds of grain used to be grown. Now, no one is allowed to grow any sort but the standard Soviet grain from one end of the country to the other.”⁵⁹⁷

Initially, Stalin did not force scientists in following his rapid development policy, rather scientists paved the way for it.⁵⁹⁸ It was Vavilov who called for preventing farmers from planting their farm-saved seeds and mandating a forced shift to modern seeds. These standard varieties were key to the great break into industrialized, mechanized, high-productivity agriculture that Stalin aimed to achieve quickly. Under his tenure, more than 180 collecting missions were organized, and a total of 250.000 samples were collected at the VIR. Beyond the Soviet context, Vavilov had a lasting impact on the scientific community with his theory of “centers of origin of the cultivated plants”, in which he argued that some regions were the hot spots where mankind started agriculture and cultivated plants spread around the world. This theory initiated more comprehensive collecting missions towards “Vavilov Centres” of origin or diversity. Moreover, it led to an epistemic consensus for collecting not just landraces (farmer varieties) but also their wild relatives.⁵⁹⁹

The transformation of the breeding system in Germany reflects the role of political, economic and security concerns over the interpretation of science in remarkably designing technical tools. At the beginning of the 20th century, a fierce debate began

⁵⁹⁶ Saraiva, “Breeding Europe,” 191.

⁵⁹⁷ Donald L. Plucknett and Nigel J. H. Smith, *Gene Banks and the World's Food* (Princeton, New Jersey: Princeton University Press, 2014), 16.

⁵⁹⁸ Elina, Heim and Roll-Hansen, “Plant Breeding on the Front,” 161-79.

⁵⁹⁹ Stephen B. Brush, *Farmers' Bounty: Locating Crop Diversity in the Contemporary World* (Yale University Press, 2004), 24-25.

in Germany between supporters of two different breeding strategies: local and cosmopolitan. It was also a debate between peasant-friendly public breeding institutions and commercial-oriented private breeders. The first group insisted on the need for breeding diverse varieties that are well adapted to local conditions. This breeding strategy begins with already adapted varieties, then attempts to increase its yield and, in turn, demands less from the farmers. The second group believed in the possibility and superiority of breeding universal varieties that are well adapted and high yielding in any field. This second strategy starts with a high-yielding variety regardless of its geographical distribution and then crosses it with locally adapted varieties to ensure its adaptability. This view prioritizes yields before adaptation but requires intensive cultivation practices such as fertilizers, soil preparation, and pest and weed control. From a productivist approach, the second strategy was in search of a highly efficient product that can be applied in any situation regardless of the capabilities of farmers, in a one-size-fit all fashion. The first strategy was in line with a more ecological perspective, considering not only the diverse cultivation conditions but also the capabilities of farmers.⁶⁰⁰

This debate also extended to conservation strategy. Two scientists had greatly diverged on the issue: Erwin Baur and Tschermak, a rediscoverer of Mendel. Both were considering landraces as genetic resources to be extracted and collected before removed from the field. Baur proposed a state-controlled centralized institute for collecting landraces. Tschermak, on the other hand, argued in favor of provincial stations on the ground that “some typical traits of these varieties would be considerably altered due to change of soil and climate”. This debate at the beginning of the 20th century was a representation of divergent views on the role of the environment on plant development. More than that, it was an extension of the division between the locally oriented breeding system and the cosmopolitan strategy.⁶⁰¹

However, this was not just a scientific debate. In Germany, agriculture began adopting scientific ideas and systematization in the mid-19th century. Agricultural productivity

⁶⁰⁰ Jonathan Harwood, *Europe's Green Revolution and Others Since: The Rise and Fall of Peasant-Friendly Plant Breeding* (Routledge, 2012), 46.

⁶⁰¹ Bonneuil, “Universal Store of Genes,” 4.

increased significantly between 1840 and 1870 in order to feed the rising number of urbanites and supply the emerging food industries.⁶⁰² However, they needed more than this. The most important reason for the modernization of agriculture through public support was the decreasing prices in the international markets. Countries with vast and fertile lands, such as the USA and Russia, were able to fill the European market with cheaper cereals thanks to their enabling technologies of transportation, such as steamships and trains, and earlier reforms for modernization of agriculture. As the prices fell, rural unrest began. In response, authorities began designing agricultural extension programs to make modernization spread among German farmers. First, however, they had to make an important decision: Which farming system should be prioritized?

In Germany, there were two farmer groups with diverse farming practices due to ecological and economic factors. In terms of economy, the southern lands of Germany and Austria were mostly inhabited by small-scale farmers, whose lands were generally smaller compared to their northern colleagues with large estates. In terms of ecology, the climate has significantly varied between these regions. Large estate owners were farming under a relatively temperate climate, while Southerners had to deal with harsher winters. Moreover, the quality of soil, thus its cultivation method, varied within the southern parts. These differences made it easier for farmers in the north to adapt to capital-intensive industrialized agriculture based on standardized varieties and practices, while those in the south had to rely on traditional methods and diversification of their production.⁶⁰³ Agriculture and rural politics were highly contested in 19th century Germany. Large landowners (estate owners) had a disproportionate influence in policymaking process, despite they comprised no more than %1 of farmers. On the other hand, small-scale farmers numbered around 5 million by 1900 had a limited representation.⁶⁰⁴

⁶⁰² Thomas Wieland, "Scientific Theory and Agricultural Practice: Plant Breeding in Germany from the Late 19th to the Early 20th Century," *Journal of the History of Biology* 39, (2006): 314.

⁶⁰³ Harwood, *Europe's Green Revolution*, 40.

⁶⁰⁴ *Ibid.*, 26.

Another problem for the government to consider was the private plant breeders. The commercial plant breeding sector grew to considerable size in the second half of 19th century, thus, the volume of commercial, high-yielding varieties increased. The main demand for their commercial varieties came from large-scale estate owners whose high-input farming practices needed standardized and highly responsive varieties as they were applying industrial modes of production.⁶⁰⁵ However, these varieties were not suitable for the small farmers in the southern lands. More than that, the government had to appease small-scale farmers so as not to cause a rural uprising. At the beginning of the 20th century, several public breeding stations were established in southern Germany. They initially began testing varieties for local conditions to assist farmers in their choices. Then, they began assisting farmers to breed their own varieties. This caused a backlash among commercial breeders who called for “unfair competition and reduced market”. Along with private breeders, some Mendelian academics criticized these public breeding activities for their unscientific methods and inefficient varieties.⁶⁰⁶ For example, Baur, a supporter of cosmopolitan strategy designed to supply industrial agriculture with standard varieties, argued that the public sector should remain within the conservation work and basic science whose outputs to be used by private breeders.”⁶⁰⁷

Therefore, at least until the 1920s, peasant-friendly plant breeding was quite significant. However, both the wartime blockades and the post-war food shortages made food self-sufficiency an important political and strategic goal. Around this time, scientists and breeders began pushing for a narrative that emphasized the importance of plant breeding for national interests. Collecting genes with useful traits around the world that can be combined into new varieties for self-sufficiency was the main frame.⁶⁰⁸

⁶⁰⁵ Jonathan Harwood, “The Reception of Genetic Theory among Academic Plant-Breeders in Germany, 1900–1930,” *Sveriges Utsädesförenings Tidskrift* 107, no. 4 (1997): 192.

⁶⁰⁶ *Ibid.*, 192-193.

⁶⁰⁷ Bonneuil, “Universal Store of Genes,” 4.

⁶⁰⁸ *Ibid.*

With the Nazi regime, this frame found a new sponsor as plant breeding based on genetic modernization was linked with the agricultural autarky and the concept of *Lebensraum*. Baur's suggestions for establishing a plant breeding institute within the Kaiser Wilhelm Society for the Advancement of Science were realized within this process, and Kaiser Wilhelm Institute for Breeding Research was established in 1928 with Baur as its first director. Backed by his new institutional power, he began collecting widely and storing deeply. Plant breeders in Germany tasked with "creating and improving crops that allow for a denser population of the whole [northeastern and eastern territories] as well as other border regions..." as declared by the head of the institute, Wilhelm Rudorf.⁶⁰⁹ Germany's quest for 'nutritional freedom' led to state control of the agricultural, food and plant breeding system, and several institutional mechanisms were put in place that led to the rapid erosion of non-standard, traditional farmer varieties.⁶¹⁰

5.7. Conclusion

This chapter explained how scientific ideas and political considerations led to the emergence and quick adoption of a gene-centric plant breeding paradigm in the United States and Europe. In the early 20th century, a series of scientific discoveries and their translation into technical applications led to the emergence of an epistemic community over the ways of utilizing crop diversity in plant breeding. This technical intervention made it possible to bypass the 'chaotic' and 'unpredictable' ecological adaptation of the plant. The belief that genes could be isolated, and plants can be purified was hailed as the victory of science over nature. As a result, genes replaced plants as their representations. Collecting and storing them became more 'rational' and thus important than the plants themselves. Plant breeding modernized in the footsteps of this victory. The process clearly involved scientists and their discoveries. However, victory required more than scientists and their ideas. Mendel's experiment dictated neither a single interpretation of the inheritance nor a single plant breeding method, but it has been interpreted as such. The transfer of science into concrete socio-technical systems, such as the modern breeding system, that redefined plants as genes and

⁶⁰⁹ Thomas Wieland, "Autarky and *Lebensraum*: The Political Agenda of Academic Plant Breeding in Nazi Germany," *Journal of History of Science and Technology* 3 (2009): 14–34.

⁶¹⁰ Saraiva, "Breeding Europe," 195.

breeding as science was made possible by the intervention of the state and private breeding sector. The knowledge provided them with rapid solutions to their political, economic, and social problems. Therefore, the 20th century is known as the century of genetic reductionism, not because scientists reduced it into genes but because social forces led their efforts into this. Mendel's experiment dictated neither a single interpretation of the inheritance nor a single plant breeding method, but it has been interpreted as such.



CHAPTER 6

TURNING CROP DIVERSITY INTO GENETIC RESOURCES THROUGH SCIENCE, TECHNOLOGY AND NETWORKS

6.1. Introduction

This chapter traces two interlinked developments, globalization of modern plant breeding practices through Green Revolution and the international efforts on plant genetic resources conservation. These two developments together institutionalized the gene-centric plant breeding system at the international level. The first part of the chapter begins with the diffusion of the productivist agricultural paradigm into the developing world through miracle seeds of Green Revolution and modern plant breeding system. It highlights the role of public-philanthropy alliance in mainstreaming the modernist agricultural vision. The second part examines the emergence of genetic resource conservation agenda at the international level. It provides detailed analysis on the scientific and institutional conflicts over the appropriate methods for conserving plant genetic diversity. This chapter demonstrates how two sources of power, epistemic culture, and actor-alliances, shaped the ideas and institutions in designing the genetic resource conservation program in line with the productivist paradigm.

6.2. Green Revolution: Diffusion of Plant Breeding Technology

Throughout the previous chapters, emergence and development of the dominant agricultural paradigm, that is increasing yields and food quantity through industrial farming, has been elaborated extensively by following the history of plant breeding technology. It was a productionist paradigm of agriculture that relies on yield-increasing methods based on the intensive use of improved agricultural products. This farming model, and its component technologies began diffusing into the developing nations since mid-1950s. This process of technology diffusion was termed as the Green

Revolution. It took place through the adoption of modern seeds and the accompanying technology package by developing countries and followed by economic and institutional reforms for the agricultural modernization.

The process that globalized productivist paradigm of farming had been achieved through a partnership of scientists, philanthropy, politicians and public institutions. In particular, public and philanthropy partnerships played a key role in mainstreaming productivist paradigm through developing national programs and establishing agricultural research centers.

6.3. Before the Green Revolution: U.S Food Aid Policy

Friedmann calls the period between 1947 and 1973 the 'mercantile-industrial food regime'. In 1947, the United States and the United Kingdom rejected a proposal to establish the World Food Board that would serve as a multilateral mechanism for stabilizing grain prices in international markets, managing food surplus storage and disposal, and instead following a unilateral approach in managing surplus and disposal.⁶¹¹ In 1973, the first 'World Food Crisis' broke out, and the way the United States managed its food surplus ended. Contrary to the liberalizing spirit of the time, the mercantilist tendency of US Agricultural policy was rooted in the incompatibility between its domestic agricultural policy and foreign policy. In other words, the United States, while promoting trade liberalization as part of its post-World War design, subjected the agricultural sector to national regulation due to domestic policy imperatives. US agricultural production, particularly wheat, increased due to interwar and postwar scientific and technological developments and subsidies to the agricultural sector. Increased production has put pressure on farmers' incomes by depressing prices. In order to please influential agricultural sector representatives, the US subjected agriculture to national regulations through production and export subsidies and import barriers. Production subsidies and the public procurement policy above-the-market prices further increased the surplus food the government had to stock and distribute, creating a heavy financial burden. A creative institution, Food

⁶¹¹ Shaw, *World Food Security*; McKeon, *Food Security Governance*.

Aid, has formed and solved the mutual aim of disposing of surplus food without depressing domestic prices.

The food aid, starting with the Marshall Plan, was institutionalized as the 'Food for Peace' program with Public Law 480 in 1954, authorizing the US government to dispose of surplus food through aid or concessional sales.⁶¹² This move allowed the US to arrive in foreign markets while maintaining import barriers during a time when international food trade was out of the agenda. With food aid, the US was able to "turn the problem of surplus stocks into an opportunity to pursue strategic, welfare, and economic policies."⁶¹³ Food Aid policy was more than just an economic solution. It is speculated that the program attempted to achieve several political and strategic goals, such as containing communism and securing allied loyalty, assisting developing nations, disposing of surplus wheat, and creating markets for future export and investment.⁶¹⁴ The earnings from PL-480 sales were designed by law to fund activities including "development of new markets, administration of American-run schools and community centers, funding of the Fullbright exchange program, and the disbursement of loans to American components."⁶¹⁵

Aligning with US Foreign Policy priorities, the program also served as a tool to contain communism by supporting allies.⁶¹⁶ For example, under US President Lyndon Johnson, the so-called "short tether" policy relied on short-term contracts for food aid to India and was conditional to the "willingness of the Indian Government to implement and perfect American-style economic and agricultural reforms."⁶¹⁷ Similarly, Gamal Abdel Nasser's search for autonomy during the Suez Crisis in 1957-1958 met with the suspension of food aid under the Food for Peace program to be

⁶¹² McMichael, *Food Regimes*,

⁶¹³ Friedmann, "International Political Economy of Food," 516.

⁶¹⁴ Sophia Murphy and Kathy McAfee, "U.S. Food Aid: Time to Get It Right," *The Institute for Agriculture and Trade Policy-Trade and Global Governance Program* (2005): 3.

⁶¹⁵ Kristin L. Ahlberg, "Machiavelli with a Heart: The Johnson Administration's Food for Peace Program in India," 1965–1966," *Diplomatic History* 31, no. 4 (2007): 606.

⁶¹⁶ Araghi, "Invisible Hand," 128.

⁶¹⁷ Ahlberg, "Food for Peace Program in India," 666.

continued under Kennedy's presidency. By 1962, 99% of Egypt's wheat imports and 53% of its total supply were covered under PL-480. Food aid was interrupted once again as a response to Egypt's intervention in North Yemen. The disposal of US surplus wheat terminated between 1967 and 1973, only to be resumed after Kissinger's visit.⁶¹⁸ In another case, this time during the peak of the world food crisis, Bangladesh's refusal to prosecute Pakistani war criminals resulted in the suspension of food aid.⁶¹⁹ Such instances generated significant debate on whether the food aid was for peace or defense and profit.⁶²⁰

6.3.1 The First Green Revolution: Miracle Seed from Mexico

The Mexican Agricultural Program (MAP), launched in 1943 out of the partnership of the Rockefeller Foundation and the Mexican government and promoted by the US government, aimed to conduct agricultural research and modernize the Mexican agricultural sector. Specifically, it aimed to develop improved varieties adaptable to Mexican conditions.⁶²¹ Norman Borlaug was hired in 1944 to work for the wheat variety development leg of the program. He successfully produced high-yielding wheat varieties with 'wide adaptation' by employing a technical innovation in plant breeding methods called shuttle breeding. In addition to wide adaptability, Borlaug's wheat varieties were highly responsive and resistant to fertilizers. The effects of fertilizer for increasing yield had been already acknowledged in earlier periods. Moreover, the repurpose of war equipment production technologies after the First World War and the Second World War increased synthetic fertilizer production capacity. Newly emerging fertilizer industries were eager to expand their operations into broader markets. However, one problem delayed their integration into the agricultural system. Traditional varieties of cereal crops were susceptible to falling

⁶¹⁸ William Joseph Burns, *Economic Aid and American Policy Toward Egypt, 1955-1981* (Sunny Press, 1985); Jean-Jacques Dethier and Kathy Funk, "The Language of Food," *Middle East Report* 17 (1987): 22-27.

⁶¹⁹ Araghi, "Invisible Hand," 132.

⁶²⁰ David S. Sorenson, "Food for Peace-or Defense and Profit? The Role of PL 480, 1963-73," *Social Science Quarterly* 60, no. 1 (1979): 62-71.

⁶²¹ Marci R. Baranski, *The Globalization of Wheat: A Critical History of the Green Revolution* (University of Pittsburgh Press, 2022), 18.

over, known as lodging, under high yields achieved through intensive fertilizer application.⁶²² The solution to this problem, which would maintain plant health under heavy yields, was again solved through a science-led idea. Borlaug cross-bred high-yielding Mexican variety and the semi-draft Japanese Norin-10 variety which has a shorter stature and thicker stem and had been obtained by post-war field officers from Japan and sent to the USA.⁶²³ The resulted new variety combined both the wide adaptability and responsiveness and resistance to intensive fertilizer use.

During the first World Food Congress (1974), miracle seeds with wide adaptability and high yield traits were promoted as the most effective tools to achieve the 'normative' ideal of ending hunger. Since then, the belief in science and technology for supplying humanity with enough food had been the essential strategy against the Malthusian catastrophe. It is agreed that the global effort in fighting against hunger should include the development of high-yielding plant varieties, production of their high-quality seeds, their distribution by effective channels and their adaptation by the farmers. Now the plant was ready to be applied with higher than usual rates of fertilizer, diffused into non-Mexican context, and solve rural problems with its newly acquired ability of carrying increased yields.

Thus, seeds and fertilizers became indispensable inputs for agricultural production. On the other hand, this technology package also necessitated irrigation, which further necessitated increasing public spending on agricultural infrastructure programs. As a result, high-quality seeds of improved varieties, high levels of fertilizer, and modern irrigation systems became the appropriate means to produce more. This technology package expanded the financial burden of the agrifood system by increasing farmers' input costs and national economies' infrastructural expenditures such as irrigation, education, research, and subsidies. Conditions were ready for the transformation of the agrifood system.

⁶²² Paul B. Thompson, "Food System Transformation and the Role of Gene Technology: An Ethical Analysis," *Ethics & International Affairs* 35, no. 1 (2021): 40.

⁶²³ Baranski, *Globalization of Wheat*, 32. For a more detailed account: Perkins, *Geopolitics and the Green Revolution*, 230.

6.3.2 The Green Revolution and its Expansion into the Global South

MAP was considered to be a successful example of the public-philanthropy partnership in agricultural modernization in its time, and its impact grew rapidly. MAP's 'success' in Mexico attracted interest from Latin America, Asia, and the Middle East. Although MAP was initially created with a country-specific approach, the widespread adaptability of Borlaug's miracle seeds with irrigation and fertilizer set the stage for the diffusion of this technological package. MAP's preliminary findings reinforced the perception of the Green Revolution as a "scale-neutral technology"⁶²⁴ that can be applied in diverse settings, both in small-scale and industrial farming, and increased confidence in one-size-fits-all solutions.

The first expansion of Rockefeller-funded agricultural research and development programs reached Colombia in 1951 and Chile in 1955.⁶²⁵ In the 1950s and 1960s, countries such as India, the Philippines, Türkiye, and Indonesia asked the foundation to help them develop their national agricultural programs.⁶²⁶ These requests were the first step in the internationalization of the US and philanthropy-funded agricultural research and development processes. Rockefeller Foundation was not the first foreign aid actor in India. In 1951, the Ford Foundation dispatched \$1.2 million for the Indian agriculture program, and in 1952, the US Technical Cooperation Administration, reformed in 1961 as the US Agency for International Development (USAID), launched a \$50 million program. After preliminary research, internal discussions, and negotiations with the Indian government, the Rockefeller's Indian Agricultural Program was launched in 1956. In line with India's request, the foundation supported the establishment of the Indian Agricultural Research Institute and created the institutional fora for graduate education while at the same time playing a key role in

⁶²⁴ Only a decade later, it is recognized that the heterogeneity of national agricultural systems operating under different socio-economic conditions is significant for designing agricultural programs. This ignorance of diversity would later make it necessary to take into account location-specific social and political factors in assessing the efficiency of agricultural modernization programs and allocated funds. At that time, however, Borlaug's belief that public investment would improve agricultural infrastructure and make fertilizers more accessible to all farmers sidestepped such concerns. See Patel, "The Long Green Revolution," 1-63.

⁶²⁵ Rockefeller Foundation, "The Rockefeller Foundation Annual Report of 1961," (1961), 111-112. <https://www.rockefellerfoundation.org/document/1961-annual-report/>

⁶²⁶ Baranski, *Globalization of Wheat*.

the development of maize (corn) varieties.⁶²⁷ However, the success was only realized with the introduction of wheat through the Mexican seeds in 1967.⁶²⁸ In 1972, India announced that it would no longer import wheat from the United States and is self-sufficient.

Another country that requested the foundation's support was Türkiye. Initially, there was a brief internal debate on the introduction of Mexican wheat. The first trials were conducted in 1963, and the first mass planting of improved varieties took place in 1967 with 70 tons of seed imported from Mexico. Under the impact of the promising preliminary results, the initiatives of Bahri Dağdaş, Minister of Agriculture and Food, and the technical and financial support of USAID, 22,000 tons of improved Mexican varieties were imported and planted in coastal areas in 1967.⁶²⁹ Between 1967 and 1971, the planting area increased from 170,000 hectares to 1 million.

A protocol signed between Türkiye and the Rockefeller Foundation in 1969 to initiated cooperation to achieve wheat self-sufficiency and develop a national agricultural research program. With the initiative of the foundation, the program was supported by the (International Maize and Wheat Improvement Center) CIMMYT and Oregon State University. Several researchers enrolled in advanced programs in the USA and completed a 9-month field internship at CIMMYT in Mexico. The enduring impact of this partnership in terms of Türkiye's agricultural policies has been made possible through training and education researchers.⁶³⁰

Regional and international research centers were the next stage in the diffusion of the model. Upon the request of Central American countries, the Central American Corn Improvement Program was initiated in 1954 and enabled the Rockefeller Foundation

⁶²⁷ John H. Perkins, "The Rockefeller Foundation and the Green Revolution, 1941–1956," *Agriculture and Human Values* 7, (1990): 6-18.

⁶²⁸ Perkins, *Geopolitics and the Green Revolution*, 245.

⁶²⁹ S. A. Breth, "Turkey's Wheat Research and Training Projects," *CIMMYT Today*, no. 6 (1977).

⁶³⁰ Breth, "Turkey's Wheat Research and Training Projects,". Through Rockefeller grants, CIMMYT sent a plant pathologist and a plant breeder, and OSU tasked three scientists to support work in Türkiye. Similarly, through USAID grants, four more agronomists were recruited. The program re-designed the activities of national experiment stations, which had been 11 in total, and deployed scientists to work in stations.

to conduct maize tests in a wider geographical area. These pioneering efforts evolved into the ‘Inter-American Food Crop Improvement Program’ in 1958.⁶³¹ Towards the end of the 1950s, the Ford Foundation and the Rockefeller Foundation, previously operating separately, decided to collaborate and establish an international research center, noting the financial constraints and lack of human resources that made it challenging to replicate national programs in other regions. In other words, “necessity again was the mother of invention.”⁶³²

One of these necessities was the U.S. government's aim of diffusing the Mexican model to Asia to address social unrest in the region.⁶³³ In 1959, at the request of the Philippine government, with the encouragement of the American administration and in cooperation with the Rockefeller-Ford Foundation, the International Rice Research Institute (IRRI), "intended to be the world's most complete center for training and research on rice, its production, distribution, and utilization" was established.⁶³⁴ IRRI developed a rice variety called IR-8, which was quite successful in yield. IR-8, as a simple seed, created great interest in international agricultural programs, accelerated the regional diffusion of the Green Revolution technology, and intensified the lust for obtaining it in places even as far away as Türkiye. When Kasım Gülek almost begged Dağtaş to bring IR-8 to Türkiye, Dağtaş replied briefly: “We are in talks with the Rockefeller Foundation for bringing it.”⁶³⁵

By 1961, the MAP had already trained a considerable number of Mexican researchers and fulfilled its function. The Rockefeller Foundation ended its financial support to this program, dispersed researchers to other programs, and began playing an advisory

⁶³¹ Rockefeller Foundation, “The Rockefeller Foundation Annual Report of 1961,” 113.

⁶³² Rockefeller Foundation, “The Rockefeller Foundation Annual Report of 1971,” (1971), 20. <https://www.rockefellerfoundation.org/wp-content/uploads/Annual-Report-1971-1.pdf>.

⁶³³ Nick Cullather, “Miracles of Modernization: The Green Revolution and the Apotheosis of Technology,” *Diplomatic History* 28, no. 2 (2004): 232.

⁶³⁴ Rockefeller Foundation, “The Rockefeller Foundation Annual Report of 1961,” 214. The Philippines government allocated the land and prepared legal ground, the Ford Foundation provided \$7 million for construction costs, and the Rockefeller Foundation covered IRRI's operational expenditures and personnel costs. Ibid., 24-25.

⁶³⁵ Türkiye Büyük Millet Meclisi, *Millet Meclisi Tutanak Dergisi*, Dönem 2, Toplantı 3, Birleşim 83 (July 1, 1968), 505-506.

role to Mexico.⁶³⁶ Later, in 1963, Rockefeller Foundation, Ford Foundation, and Mexican Government formed another partnership and established the International Center for Corn and Wheat Improvement (CIMMYT), headquartered in Mexico. CIMMYT subsequently served as an umbrella organization for the Rockefeller Foundation, supporting technical and training operations for national and international programs. In 1967, two more International Research Centers emerged out of another Rockefeller-Ford cooperation, the International Institute of Tropical Agriculture (IITA) in Nigeria and the International Center of Tropical Agriculture (CIAT) in Colombia.

As a result of such initiatives, the practice of using high-yielding seeds, large amount of fertilizer and pesticides, and a reliance on large-scale irrigation systems was quickly adopted in the developing world, leading to a rapid increase in agricultural production, particularly in wheat and rice. The seeds of the Green Revolution enabled developing countries to achieve production levels that once unimaginable.⁶³⁷ At the very early stage of the program in 1968, India's Minister of Agriculture and Food, C. Subramaniam, stated that they had increased their cereal production by 3% annually between 1950 and 1964, and that this achievement “as a feat of human engineering” was unique and “has scarcely an equal in history.”⁶³⁸ The success of the Mexican wheat was so impressive that Kasım Gülek, an opposition member of the Grand National Assembly of Türkiye, described the increasing yields as a “revolution,”⁶³⁹ barely three months after the term 'Green Revolution' had been used for the first time

⁶³⁶ Rockefeller Foundation, “The Rockefeller Foundation Annual Report of 1961,” 109.

⁶³⁷ Ashok Kumbamu “The Philanthropic-Corporate-State Complex: Imperial Strategies of Dispossession from the ‘Green Revolution’ to the ‘Gene Revolution’,” *Globalizations* 17, no. 8 (2020): 1367-1385.

⁶³⁸ Rockefeller Foundation, “The Rockefeller Foundation Annual Report of 1971,” (1971), 19.

⁶³⁹ Türkiye Büyük Millet Meclisi, *Millet Meclisi Tutanak Dergisi*, Dönem 2, Toplantı 3, Birleşim 83 (July 1, 1968), 505-506. Upon this yield revolution, Gülek shared his dreams on the possibility of becoming a wheat exporting country: “It is possible to increase the yield of wheat at least one-fold... It is possible to export 15 million of it... It means 10 billion foreign currency will arrive in Türkiye annually. This bears significant implications for the country. In a country where 70% of the inhabitants are peasants, the domestic, foreign and social implications are great. My dear friends, this success was achieved with the new seed.”

by USAID head William S. Gaud.⁶⁴⁰ There seems to be a consensus among developmentalists on describing this techno-political change as a revolution. The miracle seeds provided the South not just with the food but with a passage to modernity. For Benigno Aquino, a Philippine senator, miracle seeds were “the jumbo jet! The twentieth century” in contrast to traditional seeds which were “the bullock cart...the nineteenth century.”⁶⁴¹

6.3.3 After the Green Revolution

American food aid, the spread of the Green Revolution, and state subsidies have changed social relations throughout the developing world with political, cultural, and economic implications. Whether the Food Aid was intentionally deployed to create markets or the Green Revolution was designed to achieve that remains to be answered, yet that was one of their consequences.⁶⁴² The Green Revolution integrated peasants into “the global markets of fertilizers, pesticides, and seeds, and disintegrated their organic links with their soils and communities” by turning them into urbanites or entrepreneur farmers.⁶⁴³ Input sector -seed, fertilizer, and pesticide companies- have grown in the US, looking for future markets to expand their operations. The problem was not market access but the lack of a market. The Green Revolution has turned the third-world countries into a market for agricultural input producers. Countries that trained their farmers with the Green Revolution and designed their agricultural sector according to this prescription were emerging as a new market for corporate actors. Therefore, the Green Revolution and US domestic politics created transnational agribusiness searching for new markets and offered them a vast market to expand into.⁶⁴⁴

⁶⁴⁰ Patel, “Long Green Revolution,” 1-63.

⁶⁴¹ Cullather, “Miracles of Modernization,” 227.

⁶⁴² Jonathan Harwood “Was the Green Revolution Intended to Maximise Food Production?,” *International Journal of Agricultural Sustainability* 17, no. 4 (2019): 312-25.

⁶⁴³ Shiva, *The Violence of the Green Revolution*, 191.

⁶⁴⁴ Kloppenburg, *First the Seed*, 169.

Although the Green Revolution was promoted as applicable across all regions and scales, it “selected winners” at the national and international levels.⁶⁴⁵ While countries with access to irrigation opportunities and easy credit were able to modernize their agriculture through the Green Revolution, the revolution did not come to those countries that predominantly farm in arid or rain-fed farming regions. Overall, the Third World became more productive in agricultural production, yet the gap between the productivity of new adapters and developed farmers continued to widen. In 1950, Western farmers were seven times more labor-efficient than those in the third world, and by 1985, they were 36 times more productive. Nor did productivity growth make developing countries self-sufficient or net exporters of food. On the contrary, by the 1980s, many former net exporters of food had become dependent on imports.⁶⁴⁶ Between 1955 and 1980, the import-export balance in the Third World increased from 50% to 80%.⁶⁴⁷

The diffusion of market forces into rural areas changed traditional social and economic relations. The practices of the Green Revolution offered an integrated use of agricultural inputs, as a package, that both raised farmers' input costs and initiated the integration of previously distinct agribusiness sectors such as chemical corporations, seed breeders, and biotechnological innovators.⁶⁴⁸ The arrival of Green Revolution technology in the countryside and the necessary state subsidies expanded the “monetized and commodity relations into the countryside and increasingly exposed the emerging small farms to market forces.”⁶⁴⁹ At the national level, it improved the welfare of a small number of farmers who had access to technology packages, information, and credit. The spreading Green Revolution eliminated the competitive power of small farmers and empowered commercial and large-scale farmers practicing

⁶⁴⁵ John Robert McNeill, *Something New Under the Sun: An Environmental History of the Twentieth-Century World* (WW Norton & Company, 2001), 225.

⁶⁴⁶ Ibid.

⁶⁴⁷ Araghi, “Invisible Hand,” 129.

⁶⁴⁸ Philip McMichael, “A Food Regime Analysis of the ‘World Food Crisis’,” *Agriculture and Human Values* 26, (2009): 287.

⁶⁴⁹ Araghi, “Invisible Hand,” 128.

industrial agriculture.⁶⁵⁰ Already unable to compete with market prices that were intentionally kept stable by US Food Aid, the Green Revolution brought more trouble for small farmers and triggered the process of urbanization and deruralization. The remaining larger farms were unable to compete with the farmers from the developed world and could only survive through price regulation policies. The new design that transformed agricultural practices towards input-intensive techniques exposed farmers to a risk that is waiting to be triggered with the retreat of the state.

Risk became a reality in the second half of the 1970s when the US-led regime collapsed. State subsidies were necessary for the spread of the Green Revolution, and they fulfilled their function. The new technology package was accepted, and farmers were able to access inputs and increase production and their income. However, increased expenditure within national budgets led states into an unmanageable balance of payments preventing them from opposing the prescriptions offered for restructuring their economies. Systemic changes in the global economy throughout the 1970s and 1980s made national governments vulnerable to “debt-enforced structural adjustment” programmes.⁶⁵¹

6.4. Genetic Erosion and Gene Banks: Science and Politics of Crop Diversity Conservation

The Green Revolution and the spread of improved plant varieties resulted in the decline of crop diversity. This section analyses the process in which crop diversity conservation policies designed and institutionalized. The scientists played a critical role in persuading the decision-makers that genetic erosion was a global threat to be dealt with. In this process, however, there have been scientific disputes regarding the causes of genetic erosion, and the methods by which it should be solved. These disputes can be seen as a debate between two different epistemic cultures of genetics and plant breeding. At the end, however, not only scientific arguments, but also institutional competition and political considerations played their part in finalizing the institutional structure.

⁶⁵⁰ McMichael, “Food Regime Analysis,” 287.

⁶⁵¹ Araghi, “Invisible Hand,” 133.

6.4.1 Two Epistemic Cultures of the Science behind Plant Breeding

This sub-section briefly introduces two epistemic cultures regarding the scientific orientations on evolution, genetics and plant improvement. In line with Marianna Fenzi's recent conceptualization, these epistemic cultures were Plant Breeders' Epistemic Culture and Evolutionary Epistemic Culture and represented by two figures: Otto Frankel (1900-1998) and Erna Bennett (1925-2012).⁶⁵² The division between these knowledge systems was not limited to the plant breeding activities. Rather, it was an extension of the broader debate taking place among genetics since the beginning of 20th century.⁶⁵³

Frankel was a genetic modernist who saw the genes as the main unit of inheritance and understood evolution as intrinsic to genetic content of organisms. As a follower of the synthesis between Mendelism and a hardened interpretation of Darwin, Frankel believed in stability and targeted mobility of genes into new combinations to improve life forms. Bennett, on the other hand, was a representative of another epistemic culture that remained at the back seat of the discipline since the early dismissal of the continuous evolution. It was based on an understanding of evolution as a dynamic and gradually unfolding phenomenon.

For Frankel, plant breeding was a scientific practice that relies on breeders' technical knowledge, and it should replace farmers' practice of crop improvement which relies on traditional knowledge. This approach prioritized the collection and mobilization of genes that contain useful traits to develop plants with desired qualities, such as high-yielding varieties. For Frankel's epistemic orientation, plants were useful if only their genes could be used as raw materials for producing improved organisms. Therefore, for Frankel, the path drawn by science and technology in plant breeding is quite clear, and the conservation of plants can only be done by collecting the genes and making them accessible to the professionals. On the other hand, the technical solution proposed by Bennett was beyond conservation of stand-alone genes. It was a holistic agenda for the preservation of relations emerging from the totality of human and non-

⁶⁵² Fenzi, "Crop Genetic Diversity,".

⁶⁵³ See Chapter 5.

human interactions. This was what enabled the continuous variation. In her view, plants should be allowed to adapt local conditions through developing responses to their environments. In this view, crop improvement is a core and ongoing element of the traditional agricultural practices.

These two figures, Frankel and Bennett, had different views of the Green Revolution. For Bennett, the division of labor between breeders and farmers and the separation of plants from fields into experimental gardens or labs was wrong. For Frankel, on the other hand, this process of division was not only inevitable but also desirable. They had starkly different visions for the future of food. Considering the current divisions over the future of food and its global governance,⁶⁵⁴ Frankel appears to be a reformist or neoliberal, supporting his practice with the discourse of Food Security. For him, science and technology-led progress is the only solution to feed the world. Therefore, collecting plants in order to utilize them was necessary as the extinction of some crop varieties was inevitable. Bennett, on the other hand, was not a passive reformist who would remain within the system silently, and this is why she was forced to resign from the FAO in early 1980. Her ideas were similar to proponents of Food Sovereignty: interacting with and knowing nature through local paths.

Frankel was committed to the productivist paradigm, a man of the Green Revolution who tasked himself with feeding the millions. For this paradigm, plants that are adapted to local conditions and lacks wide adaptability would be of no use. Bennett, having aware of the Green Revolution's unfulfilled promises, prioritized feeding the local first: "If the millions were being fed, then the most critical among us would be fully prepared to accept many compromises not only with the seed corporations, but also with breeding techniques. But the millions were not fed, and are not being fed."⁶⁵⁵

6.4.2 FAO Technical Meeting on Plant Introduction and Exploration of 1961

The first FAO Technical Meeting on Plant Introduction and Exploration was held in 1961 with experts from 28 countries. Although the meeting agenda centered around discussions on exploration, exchange and collection practices and global

⁶⁵⁴ Holt-Giménez and Shattuck, "Food Crises, Food Regimes and Food Movements,".

⁶⁵⁵ Pistorius, *Scientists, Plants and Politics*, 26.

collaboration, the threat that is induced by the “agricultural development and general progress” on the crop variability was emphasized as a recurring theme. Participants pointed out that landraces and crop wild relatives and their habitats are under imminent threat of overgrazing, agricultural intensification and industrialization in general. They were calling for financial resources to establish “conservation areas” and “exploration stations” at the gene-rich regions or Vavilov centers to facilitate evaluation and exchange of local varieties. However, as Curry rightly pointed out, these arguments were not a result of field observations in the gene-rich developing world; rather, they were based on the past experiences of breeders from Europe and the USA. Curry argued that this view was rooted in a “postcolonial oversight” stemming from the perceived inability of newly independent governments for initiating and enforcing conservation programmes. In line with this logic of linear progress of modernization, destruction was an expected outcome of the development. Moreover, the decolonization trend in progress meant the retreat of colonial-era restrictions that had limited locals' interaction with nature. In a way, participants were questioning locals' ability to manage their natural resources.⁶⁵⁶

However, there was a concern, particularly among breeders' associations, about the proposed exploration centers. Initially, exploration centers were designed to explore and develop locally useful plants in line with national priorities, rather than supplying international breeding stations and the private sector with genes that are useful for them.⁶⁵⁷ In order to overcome breeders' concern, it was decided that FAO Introduction Centers, along with exploration centers, would be established in these genetically rich regions to supply other international centers and private plant breeders. By this dual structure, it was hoped that these activities would serve both national and international interests.⁶⁵⁸

One of the most significant outcomes of the meeting was to establish a pilot Exploration Centre in Türkiye. It was jointly funded by the government of Türkiye,

⁶⁵⁶ Curry, *Endangered Maize*, 100-102.

⁶⁵⁷ This concern echoes the debate in Germany between local and cosmopolitan strategy at the beginning of the 20th century. See Chapter 5.

⁶⁵⁸ Pistorius, *Scientists, Plants and Politics*, 18.

United Nations Development Programme (UNDP), and FAO and began its activities in 1964. However, this early initiative would leave an unpleasant memory, and it would have a considerable impact on the future technical debates regarding what kind of conservation strategy should be designed. The problems faced in Türkiye spanned from technical/practical to financial and political, thus raised questions about the practicality of regional gene banks and In Situ methods. Even Erna Bennett, who would be the major supporter of this strategy in the following years, was straightforward in expressing her discontent: “too many people playing for prestige, and too few were genuinely concerned with creating a Centre of excellence. The Turks wanted it to be theirs, and the UNDP and FAO administrators wanted it to be theirs.”⁶⁵⁹

6.4.3 FAO’s Network Synthesis: Panel of Experts

A new agenda was emerging, and FAO was looking for ways to extend its mandate into this area. Until the 1960s, FAO had no specific unit for addressing crop diversity issues, rather it was active in plant introduction processes. Throughout the 1950s, FAO published World Catalogues of Genetic Stocks. In 1947, FAO Plant Industry Branch was established and renamed in 1957 to the Plant Production and Protection Division. Within this new division, the Crop Production and Improvement Branch was established. At the same time, FAO Plant Introduction Newsletter started to be published, and FAO World Seed Campaign was launched. This campaign was supported by various breeders' associations, including the International Seed Congress, the European Association for Research on Plant Breeding, and the American Seed Trade Association.⁶⁶⁰ In 1959, the FAO Conference called for efforts on plant collection and exchange. Therefore, following the first technical meeting in 1961, FAO had the mandate, but lacked the expertise to deal with plant genetic resources.

Then, suddenly, someone from another institution with such expertise appeared. The International Biological Programme (IBP) was established in 1964 at the time of increasing environmental concerns. Its work oriented towards humans’ adaptation to changing conditions under ecological crisis. Otto Frankel managed to bring IBP and

⁶⁵⁹ Ibid.

⁶⁶⁰ Fenzi and Bonneuil, “Global Policies for Crop Diversity Conservation,” 75.

FAO together. They agreed on a division of labor, with FAO dealing with agriculture and IBP with genetic stocks and conservation efforts. The FAO Panel of Experts on Plant Exploration and Introduction was established in 1965 to support FAO's activities on plant exchange and conservation. This panel included 6 experts from the IBP and 7 from various FAO departments. In addition to Otto Frankel, reputable scientists such as Jack Harlan, and Jack Hawkes were also involved. In 1967, Erna Bennett, who was the first to draw attention to the issue of genetic erosion and conservation in her 1964 and 1965 articles joined FAO.

6.4.4 FAO/IBP Technical Conference on the Exploration, Utilization and Conservation of Plant Genetic Resources of 1967

This epistemic community formed around the FAO organized the 1967 Technical Conference on the Exploration, Utilization and Conservation of Plant Genetic Resources. It was called the “watershed” moment for collective conservation efforts as the technical path designed during this conference later served as the established model for the way of conserving plants. The participants aligned the issue of genetic erosion with the development, but this time pointed out the global scale and urgency of the problem. Moreover, it established the link between the spread of Green Revolution and the loss of genetic diversity by marking the “irony” that practices intended to increase agricultural production were “depriving plant breeders of the very materials upon which they depend.”⁶⁶¹ Upon these observations, it was understood that existing seed banks are no more than working collections, without any long-term conservation strategy, standard and technical means. As such, they are unable to conserve plants from genetic erosion. Despite the emerging consensus over genetic erosion and the need for conserving and collecting, the debate centered over the methods of conservation, Ex Situ or In Situ, and of collecting, Mission oriented or Generalist. At the end of the Conference, it was broadly agreed that:

Seed banks, wherever applies and to whatever material they are applied are inexpensive and, technically relatively well explored, and so must be taken seriously... Preservation in seed banks, probably the most secure way of preservation where it can be used, has been discussed extensively and opinions

⁶⁶¹ Curry, *Endangered Maize*, 108.

have been expressed on this and other methods, but it is generally agreed that on economic grounds [...] seed banks have the advantage.⁶⁶²

Participants agreed on the appropriateness of conserving plants in Seed Banks, i.e. *ex situ*, because it is financially feasible and technically superior. Moreover, it makes collected material easily exchangeable for use by plant breeders. Therefore, the decision was mainly driven by economic, technical and operational considerations, with a strong focus on utilization. Then the question remains to be answered: What were these other methods and why were they rejected?

6.4.5 A Fight between Epistemic Cultures

During the conference, participants put forward scientific and technical arguments on how to conserve plant genetic resources. In the broadest sense, there was a debate among two groups over the mechanisms of variation and inheritance, which illustrated the emerging instability of the epistemic community of genetics. The first group was the established community around the Modern Synthesis that combines Mendelian and neo-Darwinian ideas on the stability of germplasm and the Central Dogma. In other words, environmental effects are not passed on to the next generation. The emerging community, the dissenting one, emphasized the locally induced variations that plants undergo as a result of their interaction with the environment and asserted the continuity of evolution. In other words, to ensure that plants adapt to changes around them, they should be conserved in fields. However, these views were not scientific enough for the proponents of mainstream genetics.

Bennett, as a supporter of the idea of continuous evolution and adaptive changes, argued that the *Ex Situ* method differed not much from the museums, a container of static objects. Rather than conserving the steady state of plants, the main strategy should be providing them with conditions to enable their adaptation to their habitats under human influence.

I see no special advantage in conservation in the form of seed apart from the very eminent one of convenience, and I think that attempts to find other merits in the 'steady state' which seed storage represents seem to come dangerously near to adopting museum concepts. The purpose of conservation is not to

⁶⁶² Pistorius, *Scientists, Plants and Politics*, 28.

capture the present moment of evolutionary time, in which there is no special virtue, but to conserve material so that it will continue to evolve. Such 'continued evolution' could only be possible in situ collections.⁶⁶³

While pointing out the importance of In Situ approaches for maintaining continuous evolution, Bennett discursively empowered her point by mentioning established ideas and practices. She pointed out Vavilov's ideas on the importance of landraces and crop wild relatives and the Exploration Centre in İzmir:

Institutes of this type represent an essential stage in the development of a coordinated world genetic conservation programme based upon the genecological concept stressed by Vavilov and later workers that the potentialities of species are determined by the potentialities of the local populations of which the species are composed.⁶⁶⁴

Frankel, on the other hand, questioned the practicality of her idea based on the inevitable transformation, the Green Revolution, that was taking place: "What is the purpose of keeping landraces in a 'dynamic state' in their original site, if the site itself is changing beyond recognition?"⁶⁶⁵ Frankel, in other words, were pointing out the impossibility of conserving fields. However, Kuckuck argued that the design of the strategy can also accommodate changes in the agricultural practices:

My proposal is that the local varieties, landraces, should be grown under the improved environmental conditions in regions where agricultural conditions are being improved. Natural selection will act on these local varieties; the frequency of genotypes will be changed by the new environmental conditions.⁶⁶⁶

However, Frankel's criticism of In Situ methods was not only about his pessimism regarding the inevitable doom or ecological concerns. According to Frankel, dynamism was not always desirable:

⁶⁶³ Ibid., 27.

⁶⁶⁴ Pistorius, *Scientists, Plants and Politics*, 105. Bennett was not the only one defending this position, as similar points were made by Kuckuck: "The gene pools of local varieties should be considered from the dynamic rather than the static point of view. They are permanently evolving. The influence of wild and weed relatives, and of mixed genotypes in a population should be seen as continually producing new forms"

⁶⁶⁵ Ibid., 25.

⁶⁶⁶ Ibid., 105.

[...] Material maintained other than as seed, it must be remembered, is subject to adaptive changes in environments as they change under the influence very largely of man and less of major climatic changes. [...] Biological freezing of material has its distinct advantages.⁶⁶⁷

Frankel's concern, in fact, was a concern of breeders. Making plants stable, fixed and discrete in their composition of genes was their technical invention specifically to make their work easier, predictable, and successful. Steady state means ready-to-use raw material, and dynamism, on the other hand, means instability. For Frankel, methods other than freezing seeds disconnect the conversation from utilization.

Bennett also reiterated Nilsson-Ehle's findings on polygenic traits.⁶⁶⁸ Multiple genes and their complex interactions develop traits, and the variation occurs on a more integrated level, that is, polygenic variation: "... experience indicated that not single gene characters but whole groups of character affecting the phenotype at many levels and in many ways are responsible for adaptive fitness."⁶⁶⁹

However, the polygenic variation was a chaotic mess for the breeders, who, at that time, were unable to manipulate genetic composition in a targeted manner. A plant with polygenic traits was already difficult for breeders, but it becomes much more difficult to detect and pick out desired traits if it is adapted to local conditions. Since the beginning of the 20th century, the breeding system had been designed based on single gene transfer, one gene-one trait, as it provided predictability and precision, two of the most important qualities for industrial agriculture. Moreover, knowledge of single gene traits was easy to obtain and store. This is why breeders usually start their breeding program with plants that carry known traits obtained through other breeders. In other words, they were not ready to deal with this complexity. Moreover, the Green Revolution was not just a modern tool or technique, but a technology package which required its users to adapt all the components at the same time. Therefore, single-gene resistant improved seeds should be used with their accompanying fertilizers, pesticides

⁶⁶⁷ Ibid., 29.

⁶⁶⁸ See Chapter 5.

⁶⁶⁹ Pistorius, *Scientists, Plants and Politics*, 24.

and other inputs. For this reason, polygenic resistance was simply undesirable for the market.

In line with the genecological premise, Bennett offered that collecting missions should include ecogeographical survey, rather than just sample collecting: "... an extended survey of climate and its local variations, soil types, topography, distribution of crops, detailed knowledge of local crop varieties... more knowledge on agricultural structure and practices, social structure, customs and history."⁶⁷⁰ For some others, all these extra information would make it impossible to select plants to be conserved. Frankel was skeptical of this method's feasibility and practicality, but more than that, he questioned the science behind genecology:

I think genecology, being a part of ecology and a part of genetics, is a very interesting field, but it is just not possible nor even necessary to repeat parallel studies in very many places on very many organisms. [...] As in all scientific endeavor one has to have a good idea, and test an intelligent hypothesis, but genecological studies should not be regarded as necessarily a routine thing.⁶⁷¹

It was no surprise that Frankel dismissed alternative methods by questioning their scientific validity, since at that time genetic reductionism was in its prime time, with a focus on genes that act, barriers, dogmas and the limited role of environment.⁶⁷² However, Frankel's opposition was not totally fair as genecology was emerging as a promising way of studying organism-environment relations with convincing evidence for their co-evolution. He could have praised recent findings with a stronger word than 'interesting' if only he were not "a geneticist by training, a plant breeder by occupation."⁶⁷³ Compared to genetics as a pure science, its application in breeding followed a more specific epistemic culture, where starting from the genes that are isolated was the established way of applying the science of genetics. Moreover, it was institutionally and financially secure, embedded into the broader consensus for ending

⁶⁷⁰ Ibid., 25.

⁶⁷¹ Frankel cited in Pist 25.

⁶⁷² Kathleen McAfee, "Neoliberalism on the Molecular Scale: Economic and Genetic Reductionism in Biotechnology Battles," *Geoforum* 34, no. 2 (2003): 203-19.

⁶⁷³ Lloyd T. Evans, "Sir Otto Herzberg Frankel: 4 November 1900-21 November 1998," *Biographical Memoirs of Fellows of the Royal Society* 45, (1999): 165.

hunger, which exclusively begins with producing more, that is, yield. Therefore, an alternative technique which rejects the dominant ways of improving crops was subjected to established ways of evaluating success that include, among others, yield, wide adaptability and uniformity. They simply failed to “outyield the successes of high-yielding varieties [...] and] release ready-made, commercial crops.” Bennet was straightforward in her later remarks: “[alternative method] was less profitable, even though it pointed the way to a better solution of breeding problems.”⁶⁷⁴

After deciding how to conserve, it was time to decide what to conserve. In other words, whether generalist or mission-oriented approach should guide the collection activities. Ignoring Bennet’s insistence on the social and ecological components of the plants, some others were solely concerned about the material itself since the plants were targeted for their genes, not their relations and context. The first option goes after economically significant crops, and the second one is more in line with a biological diversity perspective.

Mr. Creech, from New Crops Research Branch of USDA, made clear how they decide what to collect in United States:

[...] chosen strictly for the purpose of solving specific economic problems. [...] Breeders require sources of genetic traits that are readily incorporated into existing varieties. [...] Plant breeders prefer it this way, and we [...] operate by servicing the needs of specific groups of plant breeders.”⁶⁷⁵

Krull and “the father of Green Revolution” Borlaug supported a mission-oriented strategy, while Frankel opposed this, arguing that it is “highly selective and hence contributes relatively little towards countering the threat...” Frankel's support for the generalist approach was not directly related to his concern for ecological diversity but rather a byproduct of his epistemic culture. Following the ideas of his doctoral supervisor Erwin Baur and idol Nikolai Vavilov, collecting a vast number of plants into a systemically ordered collection would provide breeders with much more genetic

⁶⁷⁴ Pistorius, *Scientists, Plants and Politics*, 43.

⁶⁷⁵ Ibid., 31.

diversity. In fact, this divergence was largely related to the technical design that is used by the breeders.

Following the Mendelian experiment, which had been based on genotypically uniform plants, the breeding strategy followed a similar path of purification and, if desired, hybridization. This helped breeders to detect desired traits that are determined by single genes, such as susceptibility to pathogens, and then isolate it. Then, it became a common practice to look for genes that make plants resistant to specific pathogens. This resulted in a gene-for-gene understanding regarding the host (plant)-pathogen relationship. However, there is a missing part in this relationship. Breeders and farmers can stabilize the gene in the host, and prevent the evolution of it, yet they are unable to do so with the genes of pathogen. In other words, one "... can't deny a species the ability to reproduce. Life will find a way."⁶⁷⁶ Since the plant had been bred to contain a single-gene resistance against a pathogen, a mutation in the pathogen would break down this resistance mechanism as the established gene-to-gene link is no longer exists. Moreover, the spread of these plants into new lands via industrial agriculture speeds up the mutation of pathogens as they spread within host population and results in a rather quick removal of plant resistance.⁶⁷⁷ This results in a situation in which while breeders should keep on finding new genes to breed new plants, farmers should keep on buying new and updated seeds. Moreover, plants that are bred to be resistant against particular pathogens may easily lose this quality. Single-gene-based plant breeding methods that produce uniform varieties also produce a huge vulnerability. Since the susceptibility of plants to pathogens was built on single genes, then a mutation in the pathogen will directly and indiscriminately affect the whole population. It was a less popular topic at the time of the 1967 Conference. However, it generated significant debates in early 1970 after an epidemic hit hybrid maize in the USA.

⁶⁷⁶ H. Arnold Bruns, "Southern Corn Leaf Blight: A Story Worth Retelling," *Agronomy Journal* 109, no. 4 (2017): 1.

⁶⁷⁷ This is known as boom-and-bust cycle where "varieties possessing effective resistance are grown on an expanding acreage (boom) until matching virulence evolves and spreads within the pathogen population (bust)." See David Pink and Ian Puddephat, "Deployment of Disease Resistance Genes by Plant Transformation: a 'mix and match'," *Trends in Plant Science* 4, no. 2 (1999): 71-75.

In contrast to Breeders' uniform varieties, Farmers' varieties develop gradually by a combination of natural and artificial selection. Farmers, based on their preferences and observations, select promising lines within the population, i.e. mass selection. Nature too selects those that are unable to cope with abiotic and biotic stresses. This process results in genotypically non-uniform varieties that respond well to the local conditions with "... a fairly effective defense against serious epiphytotics."⁶⁷⁸ In other words, the population contains various lines, rather than a pure line, which offers a wider, population-wide protection against pathogens. Even if some of these lines are affected by the pathogen, the overall population remains healthy.

As previously noted, it is usually agreed that the 1967 Conference ended with the victory of Ex Situ approach and since then it became the "standard practice" for conserving plant genetic resources. However, the Conference remained divided over the method of collection. In addition to this unresolved debate, another one started: Who should govern these precious collections.

6.4.6 A Fight between Institutions over the control of Genetic Resources: CGIAR and FAO

The 1967 Conference had agreed that such a global network should be under the roof of FAO to provide legitimacy for its operations. In Frankel's words, "whatever national storage is used it will be restricted in some way or another. This seems to be inevitable, and this is the very reason why in all the discussion we have had here in FAO..."⁶⁷⁹ Following the conference, the FAO Panel of Experts began working on the idea of the global ex situ network. It held various meetings with the aim of operationalizing the grandiose project. At the 1969 meeting, the Panel developed a list that included 7 regions as the sites of seed banks and some priority plants to be collected. Although the list identified several plants as priority targets, this decision was not driven purely by economic considerations or a crop-specific approach. In 1971, the Panel revised the list of plants that should be collected urgently. In line with the Panel's earlier efforts, the list included subsistence crops that are locally significant

⁶⁷⁸ Jack R. Harlan, "Our Vanishing Genetic Resources," *Science* 188, no. 4188 (1975): 618.

⁶⁷⁹ Pistorius, *Scientists, Plants and Politics*, 30.

for small-scale farmers, indicating Panel's consideration of the needs of peasant communities.⁶⁸⁰

Around this time international community began recognizing the problem of genetic erosion. In 1970, the corn leaf blight epidemic led to significant losses of crop harvest in the USA. It is estimated that the epidemic affected 15% of crops and resulted in a total economic loss of \$1 billion. It directly targeted the hybrid corn simply because a pathogen managed to evolve. Most of the corn varieties planted that year were resistant at the gene level to a known pathogen, however a simple variation removed that defense all together.⁶⁸¹ The importance of genetic diversity in producing new plant varieties which are resistant to rapidly evolving diseases was understood once again. The U.S. National Research Council prepared a report on the threat imposed by the uniformity and pointed out its social and economic origins:

Crops become genetically vulnerable because of the uniformity society demands of the plant breeder. The market demands inexpensive food—the farmer who can produce it most cheaply captures the market. The market demands a uniform product—the farmer must produce it, and the plant breeder must produce the variety uniform in size, shape, maturity date, and the like. Uniformity of produce means uniformity in the genetics of the crop. This, in turn, means that a genetically uniform crop is highly likely to pick up any mutant strain of organism that chances to have the capacity to attack it.⁶⁸²

Genetic erosion emerged as a concerning issue at the United Nations Conference on the Human Environment held in Stockholm in 1972 and was included in 7 of the 109 recommendations of the Conference. It is agreed that “both static (seed banks, culture collection etc.) and dynamic (conservation of populations in evolving natural environments) ways are needed”⁶⁸³ to conserve plant genetic resources including

⁶⁸⁰ Curry, *Endangered Maize*, 113.

⁶⁸¹ Bruns, “Southern Corn Leaf Blight,”.

⁶⁸² National Research Council, *Genetic Vulnerability of Major Crops*, (The National Academies Press, 1972), 15.

⁶⁸³ Report of the United Nations Conference on the Human Environment (5-16 June 1972), Recommendation 39, 13.

“high-producing varieties and primitive varieties of traditional pre-scientific agriculture (recognized as genetic treasures of plant improvement).”⁶⁸⁴

The agenda was rapidly emerging at the global platform, while the FAO and its Panel of Experts were working to claim it. However, there was one significant problem. FAO was out of resources:

At this particular time we were very short of funds and our genetic conservation program was constantly being pruned and paired to the point where it did little but pay our salaries and pay for a very minimum takeover of a program which worried a lot of us because we realized that the program needed much more impetus than we could give it and so a lot of talk began about how to fund and finance an adequate global program.⁶⁸⁵

Otto Frankel was aware of the FAO’s budget problems. He contacted the Rockefeller Foundation to harness their support in early 1967, only to be politely declined. However, the epidemic had rapidly changed foundation’s plans. Some scientists within CIMMYT were also actively pushing the foundation into establishing systematic efforts of collection and conservation. Norman Borlaug, with its newly consolidated international fame thanks to the Nobel Peace Prize of 1970, was calling for the systematization of collecting activities. Sterling Wortman, an expert at the foundation, formulated a plan for the ‘World Germplasm Project’. However, Wortman’s plan was radically different from the generalist orientation that the FAO Panel had agreed to in 1967. The plan was directing collection efforts towards five crops (wheat, maize-corn, rice, sorghum and the millets) which was considered as the most important ones for the conquest of hunger by the foundation. The plan proposed that all samples for these five crops be collected and stored in gene banks within 5 years. The foundation approved the plan and established committees for each of the 5 crops. The revolving door strategy was highly visible. For example, the vice chairmanship of Pioneer Hi-

⁶⁸⁴ Report of the United Nations Conference on the Human Environment (5-16 June 1972), Recommendation 43, 14.

⁶⁸⁵ *Erna Bennett interviewed by Gregg Borschmann*, Environmental Awareness in Australia Oral History Project. <https://www.youtube.com/watch?v=0Y3GrRaS8RQ&list=PLvPtCF4i-UZl8qEepMmXuVgHs9gGVK-VK&index=2&t=307s>.

Bred breeding company was selected as the vice chairmanship of the Maize Committee of World Germplasm Project.⁶⁸⁶

With this newly established program, the Rockefeller Foundation had developed an alternative conservation effort that is independent of the FAO's initiative. However, this was only the beginning. As the regional and international research centers (IARC) began to earn a reputation for their role in agricultural modernization and emerged as new forms of development assistance, the foundation began searching for additional funds for their activities. At the time, it became clear that neither the United States nor philanthropy had been willing to provide for such extended activities unilaterally.⁶⁸⁷ A series of conferences sponsored by the Rockefeller and Ford, called the Bellagio Group, laid the foundations for this search.⁶⁸⁸

Upon this initiative, Robert McNamara, then the president of the World Bank Group, invited international partners for a meeting on the "Long-Term Support for International Agricultural Research" in January 1971. This process led to the "Consultative Group on International Agricultural Research" (CGIAR). Network synthesis emerged out of non-contradictory objectives made the gathering of international research centers under a single institution. For the United States, it was sharing the burden of assisting agricultural modernization and diffusing technological package; for other developed nations, it was searching for markets and plant genetic resources; and for the philanthropy, it was further diversity in terms of available varieties and accessible geographies.⁶⁸⁹ At the first meeting of CGIAR, 9 governments (Canada, Denmark, France, Germany, Netherlands, Norway, Sweden, United Kingdom, United States), five IOs (African Development Bank, FAO, Inter-American Development Bank, IBRD, UNDP) and four other actors (Ford Foundation, Rockefeller Foundation, Kellogg Foundation, IDRC) joined CGIAR.

⁶⁸⁶ Curry, *Endangered Maize*, 112-113.

⁶⁸⁷ Curry, "Breeding Uniformity," 5.

⁶⁸⁸ *Report of the First Meeting of Bellagio Group*, Agricultural Development: Proceedings of a Conference Sponsored by the Rockefeller Foundation, Bellagio, Italy April 23-25, 1969.

⁶⁸⁹ Baranski, *Globalization of Wheat*, 126-27.

Soon after its establishment, CGIAR gathered the existing international research centers (IRRI, CIMMYT, IITA, CIAT) under one coordination mechanism. This provided the CGIAR with the most active program of conservation, evaluation and exchange of germplasm. Moreover, CGIAR's newly established Technical Advisory Committee (TAC) have come to dominate the decision-making process regarding plant genetic resources.⁶⁹⁰ TAC's influence was highly visible over CGIAR as they managed to convince them to support a coordinated system of conservation "as a pressing need for international agricultural research."⁶⁹¹ TAC members were distributed equally among developing and developed nations, however, members had to be nominated by donors and appointed by CGIAR.⁶⁹² In other words, despite its seemingly balanced geographical distribution, the TAC was under heavy influence of CGIAR's largest donors.

At its first meeting, TAC considered a proposal from Otto Frankel regarding the global network of genetic conservation which "were supported in principle but certain reservations were expressed about its priorities."⁶⁹³ In 1972, CGIAR's TAC invited FAO's Panel of Experts to join its Ad-Hoc Working Group and participate at a meeting in Beltsville. The Panel of Experts represented by Otto Frankel and Jorge Leon without the participation of Erna Bennett. The meeting reiterated the dominant idea among plant breeders that "no country can today support an advanced and competitive agriculture based on indigenous plants alone."⁶⁹⁴ CGIAR's TAC and the FAO's Panel of Experts were on the same page regarding the urgent need for a conservation strategy of genetic resources "against the needs of the future without retarding agricultural expansion."⁶⁹⁵ Scientists pointed out the dilemma that agricultural modernization imposes upon the developing countries "which have both the greatest need to adopt

⁶⁹⁰ Fenzi, "Crop Genetic Diversity," 259-85.

⁶⁹¹ Curry, "Breeding Uniformity," 5.

⁶⁹² Pistorius, *Scientists, Plants and Politics*, 56.

⁶⁹³ CGIAR TAC, Report of the First Meeting of the Technical Advisory Committee, (5 November 1971), 14.

⁶⁹⁴ CGIAR TAC, The Collection, Evaluation and Conservation of Plant Genetic Resources: Report of TAC Ad Hoc Working Group held in Beltsville, U.S.A (20-25 March 1972), 3.

⁶⁹⁵ Ibid., i.

improved varieties and contain the largest reservoir of genetic diversity threatened by their adoption.”⁶⁹⁶ It justified the involvement of CGIAR into the genetic conservation agenda by recalling the inability of the Crop Ecology and Genetic Resources Unit of FAO to fulfill its mandate due to the inadequacy of its resources.⁶⁹⁷

The Beltsville Meeting agreed on a plan to establish a global network of genetic resources centers. The proposed global network would include existing institutions, along with the establishment of 9 regional genetic centers located at the Vavilov centers of diversity. The collaboration with the existing international research centers, as strongly advised by the CGIAR, and particularly Rockefeller representatives, had been mentioned, but left to be operationalized in the later stages. The collecting method decided to be a mix of generalist and crop specific approaches. The CGIAR were insisting on crop specific collection and conservation approach, particularly a major crop-oriented schema. However, the report of the meeting noted that genetic erosion threatens all the regions and crops under cultivation, referring to the generalist orientation of the FAO’s Panel of Expert. Regardless, it established “some relative priorities” based on a consideration of urgency of the thread and human welfare. Therefore, along with a generalist focus, three regions and some crops had been prioritized.⁶⁹⁸

The plan proposed a coordinating committee consisting of 10 scientific members of which 6 would represent the global network, and 3 others would be appointed by the TAC as independent members. The coordinating committee tasked with reporting and making recommendations to TAC, and controlling a central fund for exploration, collection, and training which would be allocated to the network institutions. Moreover, a central staff consisting of three specialists would be formed and located at the FAO headquarters as an administrative unit whose activities would be funded under a Trust Fund in order to safeguard its independence.

⁶⁹⁶ Ibid.

⁶⁹⁷ Ibid., 10.

⁶⁹⁸ Ibid., 6.

The proposed governance mechanism deliberately limited FAO's institutional involvement in the network and attempted to portray decision-making process as a science-led one. For example, the coordinating committee would be directly reporting to TAC, thus to CGIAR. The members of the coordinating committee, even those representing the network members, would be appointed by the TAC. Since the members of the committee are scientists, its recommendations, and the following TAC policies, would be decorated with scientific validity and neutrality. Although the central staff at the FAO was declared to be "executive agent in implementing the policies of the coordinating committee", it was deprived of this authority. The real impact expected from the FAO-located staff would contribute the joint programmes among network institutions by dealing with political processes. Moreover, the central staff were separated from the FAO's Unit of Crop Ecology in order to limit FAO intervention. In other words, the involvement of the FAO as an intergovernmental organization was more of a legitimizing factor upon the global network.⁶⁹⁹

At its 3rd meeting, TAC evaluated the proposal of the Beltsville Meeting. Otto Frankel clarified the proposed global network plan to persuade TAC members, emphasizing TAC's oversight over the proposed coordinating committee and FAO's symbolic presence as a legitimizing.⁷⁰⁰ Some CGIAR members had doubts over the proposal. TAC Chairman, John Crawford, was quick to point out two issues that bothered him: if this issue was so important, why had it not been considered until now? Is the scientific validity of the plan and the phenomenon of genetic erosion sufficient or is it in need of further progress? On these issues, he sought the views of M. S. Swaminathan, a figure closer to the Green Revolution paradigm and the CGIAR. Swaminathan praised the working group's report and confirmed the urgency of the issue but argued that as the minimum requirement for its success "there must be an assurance that the material collected and conserved in these centers would be freely available to all the other users whoever they were irrespective of political and other considerations."⁷⁰¹ In order to guarantee this, he suggested that the coordinating

⁶⁹⁹ Ibid., 10.

⁷⁰⁰ CGIAR TAC, Report of the Third Meeting of the Technical Advisory Committee, (10-13 April 1972), 10.

⁷⁰¹ Ibid., 23.

committee should be established as an international institute and become the core center, and that memorandum of understanding should be signed between this core center and the regional and national centers of the global network. In this way, he argued that political conflicts could be avoided. Another member called the issue a matter of universal responsibility and beneficial for plant science and food problems. He recalled the previous work of the Rockefeller Foundation regarding plant conservation and criticized the FAO for not having worked on this issue before. Lastly, he suggested that the budget should be increased. Several members similarly drew attention to the technical and financial aspects of the proposed program, suggesting that the project may be inadequate and that existing research institutes should be included, and priority regions should be reviewed. Some members were against the involvement of FAO and suggested that special arrangements should be made with FAO to avoid bureaucratic difficulties. Otto Frankel reiterated that FAO, with its established links with state actors, is an important asset for the success of the plan.

Another issue that came to the fore at the meeting was the crop priority list. Some members found the generalist focus of the plan unwarranted and suggested that the list “be reviewed in the light of the real needs of developing countries and that first emphasis be given to food crops.”⁷⁰² Similarly, Crawford made it clear that the committee would not support “a proposal which involve conservation for its own sake.” Swaminathan replied that the program is not intended to build a museum, but the risk of erosion of genetic material should be assessed with a broader focus than the current needs since it is not possible to know in advance which genetic material will be needed, thus a prospective collection approach is required.⁷⁰³ The plan was not good enough for the CGIAR’s donors. In its evaluation, TAC endorsed the general lines of the plan but found it “too ambitious” and suggested funding 3 new regional centers, instead of 9. Moreover, the role of FAO and its contribution to the work of Central Staff, and the sidestepping of the existing international agricultural centers under CGIAR were problematic topics for the TAC. As a result, TAC requested that

⁷⁰² Ibid., 26.

⁷⁰³ Ibid.

Swaminathan revise the Beltsville plan and re-submit it to be evaluated in the following meetings.⁷⁰⁴

Swaminathan's revised plan was evaluated at the 4th meeting of TAC in 1972. Swaminathan tried to adopt some of the TAC's recommendations while softening others. For example, he remained loyal to the originally proposed 9 regional centers but phased out their establishment. However, Crawford was quick to notice this and recalled that "TAC had in fact made a more restrictive decision which was not to proceed beyond three centers without its undertaking a further review..."⁷⁰⁵ In the revised plan, the term Governing Body replaced coordinating committee and the independence of the central staff to be located at the FAO was emphasized once more. However, the Chairman required much more guarantee as he was "... most anxious to protect [central unit's] ability to recruit on merit without regard to geographical distribution, and to ensure that its funds were solely utilized for the purposes decided on by the Governing Board."⁷⁰⁶ Dr. Harrar suggested that the proposed centers should be linked to existing research centers of CGIAR. As a result, TAC decided to recommend the plan to the CGIAR but "taking into account its decision to establish only three new regional centers in a period of three years and emphasizing the need to ensure freedom of recruitment and operations of any central staff."⁷⁰⁷ At the end of 4th TAC meeting, the project was revised to \$2.2 million for 3 years and submitted to the CGIAR. Some members of the CGIAR questioned the reluctance to include existing CGIAR research centers into the network. They also criticized the lack of FAO's contribution and wanted to know whether it was possible for FAO to participate more actively in terms of monetary contributions. The CGIAR decided that the plan needed further work.⁷⁰⁸

⁷⁰⁴ Ibid., 27.

⁷⁰⁵ CGIAR TAC, Report of the Fourth Meeting of the Technical Advisory Committee, (2-4 August 1972), 28.

⁷⁰⁶ Ibid.

⁷⁰⁷ Ibid., 30.

⁷⁰⁸ CGIAR, Report of the Third Meeting, (1-2 November 1972).

FAO's interest in the agenda expanded rapidly following the Technical Conference on Crop Genetic Resources held in March 1973, which was a follow up to the 1967 Conference. FAO declared their commitment to allocate increased resources from its regular budget to enhance the proposed unit and make it enable to “undertake the coordinating function” in line with the original Beltsville plan.⁷⁰⁹ TAC evaluated yet another revised plan at its 6th meeting. Contrary to CGIAR’s expectations, this version moved further away from the priorities of the CGIAR members. The new plan, while praising the activities of existing research centers under CGIAR, argued that they alone would not meet future needs. It stated that “a wide spectrum of highly important crop species would remain neglected unless complementary action was taken with international support to reinforce the global network.” It therefore insisted that new centers be established outside the existing CGIAR centers.⁷¹⁰ In terms of action priorities, the views of the FAO Panel of Experts were strongly represented in the plan. Regional centers were selected based on urgency which is determined “to a large extent on the actual or expected erosion of genetic resource, but also on the need for making available fresh genetic material for immediate use.”⁷¹¹ In other words, while the actual needs of the plant breeding sector were considered, a future orientated view was adopted. At the same time, as the Panel of Experts strongly insisted, the development of national institutes for plant exploration and training was again identified as essential for the needs of developing countries. In other words, the Panel of Experts wished to see developing countries as actors capable of carrying out their own breeding activities, rather than as markets for modern seeds. Moreover, the governing body was envisaged to be located at FAO headquarters, and it was proposed that the Panel of Experts would provide guidance to this body. In other words, the Panel of Experts would serve as the advisory council with the budget allocated by FAO.⁷¹²

⁷⁰⁹ CGIAR TAC, “A Revised Proposal for the Collection, Evaluation and Conservation of Plant Genetic Resources,” submitted to Sixth Meeting of the TAC (25 July-3 August 1973), 3.

⁷¹⁰ Ibid., 7.

⁷¹¹ Ibid.

⁷¹² Ibid., 10.

The increased interest and newly enhanced role of FAO in the proposed project met with skepticism from some of the CGIAR donors. Chairman openly declared that "... TAC and the Consultative Group were concerned to discover why FAO was now attaching such importance to this work and why it had therefore not been given higher priority in FAO's own programme."⁷¹³ Moreover, the proposed advisory role for the FAO's Panel of Experts, headed by Otto Frankel, were questioned on the ground that it "was a technical rather than an administrative body and was not representative in any way of the Consultative Group."⁷¹⁴ Moreover, TAC once again insisted on the direct participation of the existing CGIAR centers and began questioning the necessity of new regional centers, even those previously agreed ones.⁷¹⁵

The distance between FAO and the CGIAR was widening, however FAO was in no position to fall out with the CGIAR donors or to carry out the programme through its already troubled regular budget. The CGIAR appointed a Sub-committee on Genetic Resources to negotiate with FAO to find a middle ground. The Sub-committee held its first meeting at FAO headquarters on 1-2 October 1973. The Chairman of the CGIAR attended the meeting personally, while the Assistant Director-General attended on behalf of FAO, indicating the importance of the agenda for the donors of CGIAR. The Sub-committee succeeded in shaping the agenda on its terms. The parties agreed to establish a network of genetic resources, IBPGR. The Board would be under the authority of the CGIAR, while physically located at FAO headquarters. FAO was expected to contribute no more than assisting and advising the Board. The Board was to consist of 14 members, 13 of whom were to be elected by the CGIAR. At least 6 of the members are decided to be scientists and 4 from developing countries. The remaining 1 seat was to be filled by a non-voting FAO elected member. CGIAR was able to transform the project into an initiative that is in line with the vision of the Green Revolution: "The program was designed to help conserve characteristics which might

⁷¹³ CGIAR TAC, Report of the Sixth Meeting of the Technical Advisory Committee, (25 July-2 August 1973), 18.

⁷¹⁴ Ibid.

⁷¹⁵ Ibid., 19.

be of value in breeding plants with higher yields, better food value or greater resistance to pests and diseases.”⁷¹⁶

During the negotiations, it was agreed that the FAO Panel of Experts would serve as an advisory body to the Board to provide scientific and technical advice. Although this role was neither exclusive to the Panel nor guaranteed, it was decided that Panel members should not join the Board as members. However, CGIAR's tendency to move the Panel away from routine Board activities soon became apparent as Frankel was not informed of its first meeting. Moreover, R. J. Pichel, head of the FAO Crop Ecology Unit, informed Frankel that there was a group within the CGIAR, led by de Bakker and Hugh Bunting, “critical not only of the role of FAO, but of the participation of the Panel in the Board's future activities.” When confronted by Frankel, Bunting confessed his idea that Panel was more of a pressure group that might hinder Board's ability to make decisions independently. In response, Frankel wrote to TAC Chairman Crawford, reminding him of the Panel's contribution to this agenda. Frankel argued that the Panel, with a strong global vision for the conservation agenda, could contribute vastly to the main objectives of the Board, whereas others such as Bunting with their emphasis on single plants, might misdirect coordinated efforts.⁷¹⁷ Although the CGIAR was open to Frankel's individual contribution, they remained committed to limit institutional agency of the Panel, and relatedly the influence of FAO.

The debate over the conservation programme was not limited to a debate among epistemic cultures for making their ideas prominent, but it was also a battle among institutions for controlling the plant genetic resources. Against the rise of CGIAR, FAO was still the foremost intergovernmental agency in terms of agricultural development, despite its declining role. Through its Panel of Expert, FAO tried to transplant its mandate into this new international effort. The plan offered by the Panel retained the independence of national and regional gene banks while offering a centralized monitoring and implementation mechanism, but not a centralized control.

⁷¹⁶ CGIAR, Proceedings of the CGIAR Meeting (1–2 November 1973), 3. <https://cgspace.cgiar.org/items/27dd9217-03ef-4a41-93c7-b43ebbc14c76>.

⁷¹⁷ “Letter from Sir Otto Frankel to Sir John Crawford on IBPGR and its Relationship to the FAO,” dated July 5, 1974. <https://dspace7test.ilri.org/items/ddb8f068-421d-411d-a237-0cc9998f4135>.

This was not in line with the CGIAR's priorities, whose donors were attempting to tighten their control over genetic resources, rather than giving it away.⁷¹⁸

Panel's proposed network maintained a generalist conservation approach which targets all types of food crops including those with local importance regardless of their commercial value.⁷¹⁹ This, too, was in stark contrast with the one desired by CGIAR as it was mostly preoccupied with the spread and continuity of the Green Revolution, which itself was based on monoculture farming based on genotypically uniform varieties. Therefore, the conservation strategy should be focused on region specific plants that are required by the Green Revolution breeders for "further development of Green Revolution."⁷²⁰

During the Beltsville meeting, CGIAR declared their readiness to cover the financial burden of the programme. FAO, on the other hand, were not able to compete with this move. CGIAR and its donors succeeded in excluding FAO's mandate from plant conservation issues. It was a time in which the Third World countries were pressing for the New International Economic Order (NIEO) with a particular emphasis on the governance of global commons. The decision-making process at the FAO as an intergovernmental agency was based on a one-country-one-vote system, which rendered it difficult to control. Moreover, while IARCs were useful tools for countering communist spread, FAO had no specific mandate in this regard.⁷²¹ FAO faced strong criticism from the Rockefeller Foundation, one of the most influential donors of the CGIAR, whose representative shared the foundation's concerns over highly bureaucratic procedures FAO dealt with and pointed out the foundations previous activities of coordinating IARCs. Compared to IARCs scientific authority in this area, a FAO leadership would "take control out of the hands of those with the most

⁷¹⁸ Pistorius and van Wijk, *Exploitation of Plant Genetic Information*, 97.

⁷¹⁹ Ibid., 93.

⁷²⁰ Ibid., 97; Curry, *Endangered Maize*, 120.

⁷²¹ Pistorius and van Wijk, *Exploitation of Plant Genetic Information*, 97.

relevant experience”. For this reason, this non-political and “scientific undertaking... must be controlled at all the times... by the very best scientific judgement.”⁷²²

As a result of this process, IBPGR was established as a CGIAR institution but located physically within FAO, which was described by CGIAR as an “historical anomaly.”⁷²³ The Rockefeller Foundation expressed one objective, among others, that they had planned to achieve with the Board: “[It] will complete the collection of crop germplasm which, despite the thirty-year interest of the Rockefeller Foundation in this work, is neither worldwide nor complete.”⁷²⁴ Therefore, existing international agricultural centers come to serve “as transfer points” for exchanging local landraces and their wild relatives.⁷²⁵ The U.S. and Rockefeller control over IARC enabled them to design conservation practices in line with their priorities, which regarded genetic resources as raw materials for improved varieties. FAO as an international organization provided much needed legitimacy for IBPGR, particularly in developing world. Moreover, FAO’s strong presence at the country and regional levels helped IBPGR for organizing field missions.⁷²⁶

6.5. Conclusion

This chapter explored the globalization of the modern plant breeding system, the birth of genetic diversity conservation agenda, and its co-optation by the productivist paradigm of agriculture. It focused on the scientific and institutional contestation over the appropriate method and governance of the genetic diversity conservation agenda. Beginning with 1960s, the cooperation between the United States and the Rockefeller Foundation succeeded in diffusing the productivist paradigm into the developing nations. This development was more than a technological diffusion. By extending the gene-centric modern breeding system, it also added new actors to the institutional network of productivist paradigm, thus diffusing the idea of genetic reductionism and

⁷²² Curry, “Breeding Uniformity,” 5.

⁷²³ Kloppenburg, *First the Seed*, 164.

⁷²⁴ Rockefeller Foundation, “The Rockefeller Foundation Annual Report of 1973,” (1973), 16.

⁷²⁵ Pistorius and van Wijk, *Exploitation of Plant Genetic Information*, 93.

⁷²⁶ Pistorius, *Scientists, Plants and Politics*, 67.

the appropriateness of valuing plants for their genetic content. Early results of the Green Revolution were promising enough to convince politicians and farmers alike to abandon their traditional seeds for the modern ones. Therefore, the Green Revolution managed to replace landraces with improved plant varieties, which led to a sudden reduction in the available genetic diversity. The term genetic erosion dominated the agenda and initiated early discussions on how to conserve genetic diversity. These discussions quickly turned into a scientific and institutional struggle over the right methods of the conservation program and its governance.

While some scientists were desperately pushing for conserving plants in their natural habitat by prioritizing their significance for the local population, others were arguing for conserving plants in gene banks as a part of universalist plant development strategy in line with productivist paradigm. The division was partly informed by the scientific dispute within genetics, but it was also a reflection of competing visions for feeding the world. Soon another struggle began, this time between institutions, FAO and CGIAR. Eventually CGIAR, the network with enormous resources, managed to co-opt the agenda, and established the International Board of Plant Genetic Resources. In short, the struggle resolved with the decision of Ex Situ method under CGIAR's control, instead of In Situ approach or a FAO-led hybrid method. The Ex Situ was the preferred method of plant breeder's epistemic culture, and its institutionalization required scientific arguments, technical designs, political and economic resources. With this decision, the idea of plant genetic conservation was institutionalized as a transfer point between nature and breeders. Therefore, its main task was to provide the modern breeding system with raw materials only to be improved in line with productivist paradigm of agriculture. In other words, it was designed to conserve the supply lines of the breeding sector, rather than the plants themselves.

CHAPTER 7

CONCLUSION

This thesis provides a historical analysis of the scientific developments in the emergence and institutionalization of the productivist paradigm in global good governance. It attempts to explain how scientific developments and technological changes contributed to its formation and further legitimize it as the dominant framework for global food policies. To this end, it focuses on the changes in plant improvement techniques and examines its 20th century integration into the productivist paradigm. To move beyond limitations of the existing accounts, most notably externalization of the technology, the thesis employs a practice-oriented approach to normativity informed by insights of the Science and Technology Studies (STS).

Following the recent contributions in critical norm studies, the thesis argues for a practice-oriented approach to normativity in order to extend the analysis into undetected sites where norm shaping practices routinely reinscribe the meaning of what is appropriate or not. In line with this premise, Chapter 3 opens a theoretical space for advancing a practice-oriented understanding of normativity and a critically informed approach to science and technology. The analysis of the case, global governance of the plant genetic resources, reveals a discursively or textually hidden, but institutionally enforced hierarchy between productivist and non-productivist plant breeding methods, which reinforces existing hierarchy between professional plant breeders and farmers. Although the text of ITPGRFA promotes both productivist and non-productivist plant improvement practices, the implementation practices end up sanctioning traditional plant improvement practices. Through a reinterpretation of the term ‘breeding’ at the implementation stage, the governing body of the treaty redefined what constitutes an appropriate breeding practice. This redefinition excluded farmers’ plant improvement methods on the ground that it involves a treaty sanctioned practice, direct use, which in fact a crucial technical stage in traditional plant improvement. The

analysis shows that, in addition to content or discourse-based analysis, a focus on implementation process reveals how seemingly technical practices have socially conditioned and significant consequences.

Instead of applying the analytical framework on contemporary dynamics of plant breeding, Chapter 4 takes it to the 18th century in order to demonstrate the interplay of botany, as science, and imperial politics. It follows an infamous journey, known as the original act of biopiracy, to reveal how an alliance of scientists and imperial institutions managed to transport plants, sterilize information overload, control knowledge production processes and determine the validity of knowledge claims. The analysis shows how the network synergy between scientific societies and imperial institutions provided each with novel capabilities in fostering their aims, securing their interests and controlling nature and the knowledge of it. This chapter particularly emphasized the justificatory narratives to render plant theft as an intervention for the plant, people and science, which can be seen as convention reorientation. Moreover, the discursive framing of plants as national or imperial interests contributed to transformation of previously scientific societies into public institutions. This chapter also pointed out the enhanced means of action through technological revision, by showing how science-led technological innovations provided necessary means to transport and improve plants, collect and systematize their knowledge.

Throughout Chapters 4-6, thesis examined the birth and spread of a gene-centric plant breeding system through following scientific developments in their politically conditioned environments. After following 200 years of plant improvement history and politics, this thesis confirms that the 20th century plant breeding methods co-evolved with the overall trend of industrial agriculture and was designed directly to supply it with raw materials. The thesis provides significant observations on the role of science and technology.

The first observation is related to the power of science in redefining objects. At the beginning of the 20th century, with the rediscovery of Mendel, genes were conceptualized as stable units of transmission and recognized as the atomistic particles of inheritance. This determinant gene concept proposed a one-to-one relationship between the biological functions of an organism and its building block, genes. In line

with this discourse of gene action, they were granted with the power to act and serve as ontologically causal factors. Then, plants had been evaluated whether they have the desired gene or not. In other words, plants were defined with a “hard genetic identity” which is formed by self-acting, isolated genes that are undisturbed by the environment. The idea that genes can be isolated led to their further decontextualization, and turned them into stable, mobile, tradable and patentable resources. With this scientific lead, it became possible to transfer desired traits from one organism to another, in order to combine them in a new host. This recombinational breeding strategy quickly led to the systematization and scientification of plant breeding, first in the USA and then in Europe. It paved the way for a long-desired transformation, that is industrialization of agriculture and initiated a resourcist cosmovision.

This resourcist cosmovision towards genes, the ability to utilize plants via genes as proxies, has shaped three systems simultaneously: breeding, agriculture, conservation. Genes, as units of inheritance and carriers of desired traits, came to represent the plants themselves. In a way, it made it possible to separate the genes from the broader organism in which it develops. This de-contextualized gene concept normalized the idea of storing the genes in containers, whether dried in a botanist’s herbarium, alive in a trail field, or frozen in a seed bank. Storing plants in containers represented the practice of conserving the plant itself, even if it would disappear in its natural habitat. More than this, today plants are considered conserved if their genetic sequence information has been recorded in databanks. While science declared the gene as the representation of life form, practice made it real. Through this gene-centrism in plant breeding that translate life forms into “immutable objects”, plants began to be collected, circulated, and combined without having the costly burden of keeping them in the field or alive.

The second observation debunks supposedly linear and undisturbed path from scientific knowledge to technology. As a result of this century-old process, genes replaced plants as their representations. The collecting and storing them became more ‘rational’, thus important than plants themselves. Plant breeding modernized in the footsteps of this scientific understanding. The process clearly involved scientific discoveries, their translation into technical systems and the invention of supporting tools. However, the transfer of science into concrete technical tools (material) was

highly susceptible to intervention of social actors. The 20th century is known as the century of genetic reductionism not because scientists reduced it into genes, but because social actors and their alliances led their efforts into this. These scientific discoveries were turned into particular technical tools in order to provide rapid solutions to the political, economic and social problems of various actors.

In each analyzed period, the thesis finds that, while scientific progress enabled more than one option to be turned into plant breeding methods, the process that led to the emergence of a particular method is highly context dependent. To reiterate the findings of Chapter 5:

Mendel's rediscovery did not offer a single plant breeding method. In the USA, plant breeding quickly adopted hybrid techniques and combinatory breeding as it was presented as a solution to political-economic concerns by a highly effective network of political actors, scientists and interests' groups. Nazi regime in Germany quickly adapted genetic modernization as a response to their nutritional freedom concerns, and as a way to make Lebensraum in occupied lands possible. Similarly, Mendelian plant breeding was supported by the Fascist regime in Italy as a solution for their self-sufficiency in wheat production.

The institutionalization of the hybrid breeding method, and dismantling the alternative, in the USA required public institutions, scientists and an entrepreneur farmer group who would be the pioneers of the emerging private breeding sector. For example, Henry Wallace, an early adopter of the hybrid method, F. D Richey, as the USDA's Principal Agronomist in Charge of Corn Investigation, and Donald Jones, a scientist who invented the double-cross method, formed an alliance that combined distinct capabilities from different spheres of influence, just as the combination of useful genes in hybrids. This was a clear form of network synthesis that worked perfectly for achieving common goals. However, it required more than a successful network, as the role of the larger collectivities, in this case US Federal Government, should not be underestimated. To cite from Chapter 5:

[Wallace's] father, Henry C. Wallace, became secretary of agriculture under President Warren Harding in 1920. Wallace advised another Mendelian corn breeder and inbred-hybrid supporter, F. D Richey, as the USDA's Principal Agronomist in Charge of Corn Investigation, who replaced the anti-hybridist C. P. Hartley. This was one of the key moments in which the route was changed

The United States and the Rockefeller Foundation formed a successful network from the 1950s onwards. The synthesis of these two actors combined their capabilities, thus introduced industrial agriculture, modern seeds and modern plant breeding systems to developing countries. The intervention of social actors in the design of technical systems was not limited to practice of breeding, it also covered the practice of conserving. Chapter 6 examined the institutionalization of plant genetic conservation agenda. In Situ method, conserving plants in their habitat failed to obtain institutional backing despite an emerging scientific paradigm behind it. The Ex-Situ method, conserving plant genes in gene banks, dominated the agenda. The main advantage of Ex Situ conservation for breeders is that the resources are accessible for breeders. On the other hand, In Situ is neither accessible nor feasible for breeders since the dynamism of genetic content would make it burdensome to collect knowledge about the plant. The push for the winner came from a strong lobby of the Green Revolutionaries. The decision confirmed the appropriateness of maintaining the direct supply line between plant breeders and industrial agriculture by extending it into the gene banks. Therefore, gene banks, as containers of raw materials, would supply plant breeders who then provide the productivist paradigm with standardized and uniform plant varieties.

This thesis contributes the existing literature in several ways. Firstly, adopting a practice-oriented approach to normativity and STS informed theoretical framework contributed to the analysis significantly. The framework provided ample space for conceptualizing the multilayered connections among science, technology and politics. As an entry point, taking the materiality and sociality of practices as entangled provided necessary tools for the simultaneous investigation of the technological innovations and their political context. Moreover, the emphasis on the process of knowledge production as a social, thus political, activity provided necessary ground for conceptualizing epistemic cultures or institutionalized ways of doing science. Therefore, this thesis confirms the necessity of this theoretical space in examining the role of science in international institutionalization as it enables the researcher to extend causality without relying on either technological or social determinism. Therefore, it contributes to recent calls for making technology endogenous to international politics. Moreover, the findings of this thesis suggest that supposedly linear link between pure

scientific knowledge and technical systems is in fact constructed in particular ways by social actors under political, cultural and economic considerations. This contradicts the tendency in the social sciences to separate science and technology into the realm of basic science and applied science or distinguishing science and technology from the realm of political and economic. These separationist tendencies are not only analytically misleading, but also socially consequential. These findings confirm and contribute to the existing STS scholarship.

Secondly, the thesis provides a novel entry point for critical norm studies by introducing multiple normativity claims and demonstrating the contested and power-laden dynamics of global agrifood politics. Alternative future imaginaries and reform proposals clearly involve more than scientific and technical debates. The sharp divisions among stakeholders are deeply embedded into distinct knowledge systems and worldviews. These debates offer empirically rich case studies, along with potential lines for theoretical contributions.

Third, it confirms the insights of the critical agrifood studies by revealing the legitimizing role of scientific discourse in maintaining the productivist paradigm in agriculture. Moreover, it extends this observation with a focus on practices as a space for maintaining social order and challenging it. Thesis showed in several cases how seemingly minor technical or scientific practices had significant impacts. For this reason, this thesis calls for more technically informed and detail-oriented investigation into the pathways of productivism in global governance.

This thesis concludes by arguing that, considering the swift institutionalization of novel practices based on biotechnology and digital technologies as contemporary science-led solutions of the neo-productivist paradigm, a critically informed, historically grounded and detail-oriented understanding of science and technology is not only necessary for resisting it, but also for producing alternatives.

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APPENDICES

A. CURRICULUM VITAE

Job

Research Assistant, Department of Political Science and Public Administration, Ondokuz Mayıs University, 2017- continuing

Education

Ph.D. in International Relations, Middle East Technical University, Department of International Relations, Ankara, Turkey, 2025

M.Sc. in International Relations, Eskişehir Osmangazi University, Department of International Relations, 2016

B.Sc. in International Relations, Eskişehir Osmangazi University, Department of International Relations, 2013

Publications

Ünal Gürhan. "State-building process in Uzbekistan: Many miles to go." Journal of Mehmet Akif Ersoy University Economics and Administrative Sciences Faculty 5.3 (2018): 519-537.

Ünal Gürhan and Yiğit Çolak, "Avrupa Birliği Ortak Tarım Politikası" in Avrupa Birliği: Kurumlar ve Politikalar (2020).

Projects

Arařtırmacı Türkiye'nin Normatif Dıř Politikası ve Kresel Norm Srelerine
Katılımı: ECOSOC zerinden bir inceleme, TUBİTAK 3005, 2022-2024.



B. TURKISH SUMMARY / TRKE ZET

20.yzyılın bařlarında gerekleřen bir dizi kurumsal reform ve teknolojik buluş retimci paradigmaya dayanan endstriyel tarım sistemini ortaya ıkarmıştır. Ziraî ilaç ve gbre gibi girdilerin yoğun biimde kullanımına dayanan, modern ıslah teknikleri sonucu elde edilmiř verimli bitki eřitlerinin geleneksel/yerel bitki eřitlerinin yerini aldıđı, makineleşme ve standartlaşma bařta olmak zere endstriyel retim biimlerinin tarıma uyarlandıđı bu sistem, tm řartların yerine getirildiđi durumlarda ve ona uygun cođrafî kořullar altında hızlı ve nemli lde tarımsal retimi arttırabilmektedir. Yzyılın bařlarında ABD’de ve Avrupa’da benimsenen bu yntem, 1950’li yılların ardından geliřmekte olan lkelere yayılmıştır. Bu tarım yntemi uluslararası toplum tarafından gıda gvencesi normatif vizyonuylay uyumlu olarak grlmüş ve alıđı sonlandırmaya dnk kresel zm olarak teřvik edilmiştir. Mevcut uluslararası kurumsal mimari, barındırdıđı kural, kurum ve normlar ile bugn hâkim olan retimci paradigmayı destekleyecek biimde tasarlanmıştır. Gıdanın ve tarımsal retim biimlerinin hızlıca sınırları aşması, gıda gvenliđi, kırsal kalkınma ve srdrlebilir tarım gibi normatif vizyonlar erevesinde teřvik edilerek meřrulaştırmıştır. Bylece, mevcut retimci paradigma gıdaya dair kresel sorunlara karřılık tek zm olarak n plana ıkmıştır. Yntemin bilimsel ilerlemeler sonucu sađlanan teknolojik buluşlara dayanıyor olması, onun sorun zc niteliđi zerinde uzlaşıyı kuvvetlendirmiştir. Bylece, yoğun girdi kullanımına dayalı, endstriyel tarım modelinin benimsendiđi retimci paradigma kresel gıda-tarım sisteminin temel paradigması haline gelmiştir.

Mevcut gıda-tarım sistemi vadettiđi zmleri retmediđi gibi yeni sorunlara yol amıştır. Yzyılın ortalarında kapitalist retim iliřkilerinin etkisi altına giren tarım-gıda sistemi, sonlarına dođru ise kamusal kontrol zel aktrler lehine ortadan kaldıran reformlar ile neoliberal iktisadi sistemin parasına dnřtrlmřtir. Tm bu geliřmeler, gıda politikalarını kresel politik srelerin ve ihtilafların konusu haline

getirmiştir. Küreselleşen tarım-gıda sistemi, küresel yönetim sisteminin en kapsamlı gündemlerinden birisine dönüşmüştür. Bu durum, sistemin dönüşümüne dair yoğun ve radikal itirazların artmasına neden olmuştur. Örneğin, Gıda Güvencesi konsepti ve söyleminin mevcut paradigmayı meşrulaştıran ve böylece toplumsal adaletsizlikleri muhafaza eden içeriği ve anlamının yenilenmesi önerilmiş ya da topyekûn alternatif paradigmalarla değiştirmesi için toplumsal bir mücadele başlatılmıştır. Üretimci paradigma tüm bu başarısızlığa ve itirazlara rağmen, halen küresel sorunların çözümünde ayrıcalıklı bir konuma sahiptir mevcut tarımsal üretim biçimleri ve gıda politikaları hakimiyetini korumaktadır.

Tez en geniş anlamıyla bugün mevcut olan tarım-gıda sisteminin nasıl yaygınlaştığını ve kurumsallaştığını sorgulamaktadır. Bu amaçla, bu sistemi mümkün kılan bilimsel ve teknolojik ilerlemeler üzerindeki politik ve iktisadi faktörlerin etkisine odaklanarak, eleştirel tarihsel bir teknoloji/politika analizi sunmaktadır. Bu odak tercihi, mevcut çalışmalar tarafından göz ardı edilen bazı teknik/mikro süreçlerin ve bilimsel argümanlar üzerinden gerçekleşen tartışmaların mevcut sistemin inşasına dair önemli açıklayıcı potansiyel taşımasından kaynaklanmaktadır. Mevcut sistemin ortaya çıkışı, yayılması, kurumsallaşması ve normatifleşmesine dair iki farklı çalışma grubunun açıklamaları mevcuttur. Uluslararası Politik Ekonomi odaklı çalışmalar, mevcut sistemin neden ve nasıl küreselleştiğine dair oldukça aydınlatıcı açıklamalar üretmiştir. Bu çalışmalar 20. yüzyıl boyunca yaşanan dönüşümü kapitalist üretim ilişkilerinin ulusöteleşmesi üzerinden okumaktadır. Bu çalışmalar üretim ilişkilerinin ulusal seviyede değişimden başlayarak, bunları küreselleştiren makro süreçlere odaklanarak daha yukarıdan bir bakış açısı sunmakta ve böylece bütüncül bir resim görmeyi sağlamaktadır. İkinci bir çalışma grubu ise gıda ve tarım politikalarının küreselleşmesine ve kural-bazlı hale gelmesine dair kurumsal perspektiften açıklamalar üreten uluslararası rejim ve küresel yönetim çalışmalarıdır. Bu çalışmalar gıda güvenliği, biyoçeşitlilik, tohum hakları başta olmak üzere çeşitli tarım-gıda gündemlerine dair uluslararası rejimlere ve artan kurumsal yoğunluğa dikkat çekmiştir.

Bu çalışmalar ulusal bağlamı bypass ederek, doğrudan uluslararası politika yapım süreçlerini incelemektedir. Bu grupla daha yakından ilişkili olan sosyal inşacı norm çalışmaları doğrudan tarım-gıdanın küresel yönetişimini inceleme konusu haline

getirmemekle birlikte, az sayıdaki çalışma tarım ve gıdaya dair küresel normların nasıl inşa edildiğini, ihtilafa uğradığını ve politikaları şekillendirdiğini göstermektedir.

Bu çalışmalar, teknoloji ve bilimi analize dahil etmemiştir. Bir başka deyişle bilim ve teknoloji analize dışsallaştırılmıştır. Bu durum aslında genel olarak Uluslararası İlişkilerinde yaygın rastlanan bir durumdur. Fakat, bu teze göre bu eksiklik oldukça önemli bir göz ardı edıştır. Zira, modern tarım sistemi ve bitki ıslah teknikleri teknik ilerleme ve teknolojik buluşlar ile mümkün olmuştur. Üstelik bilimsel gelişmeler ve teknik ilerleme daimî biçimde sürmektedir. Dolayısıyla tekniklerden ziyade normlara ve kurallara dayalı bir açıklama olguları geriden takip etme riskine düşmektedir. Bu çalışma ise, makro-yapısal süreçler, soyut normlar ve kurallardan ilk etapta uzaklaşarak, doğrudan sistemi sürdüren tarımsal pratiklerin, yani tekniğin, dönüşümüne odaklanmaktadır. Bu yaklaşımın benimsenmesinin birinci gerekçesi, pratik-odaklı bir sosyal ilişkiler analizinin getirdiği faydalardan yararlanma amacıdır. Pratik teorisi, son dönemdeki çalışmalar ile uluslararası ilişkiler disiplini tarafından önemli bir teorik çerçeve olarak benimsenmeye başlamıştır. Soyut toplumsal olgular olan normlar ile failliği çoğu zaman yapısal faktörlere delege eden makro süreçlerin aksine pratikler daha mikro ölçekte gerçekleşen, tekrarlanarak revize ve rafine edilen, böylece mevcut kuralları tasdik eden ya da onları esneterek yeniden tanımlayan anları yakalamaya imkân tanımaktadır.

İkincisi ise, teknoloji ve bilim üzerine eleştirel yaklaşımlardan faydalanarak, konuya dair az çalışılan bir kısma ışık tutmayı amaçlamaktadır. Sosyal bilimlerin ve Uluslararası İlişkiler disiplininin genelinde yaygın olan eğilim, teknoloji ve bilimi dışsal bir açıklayıcı faktör olarak ele almaktadır. Bu eğilim, Teknolojik Determinizm olarak adlandırılan ve teknolojiyi toplumsal ilişkiler üzerinde doğrudan belirleyici, tarafsız ve apolitik gören kavramsallaştırmaya işaret etmektedir. Fakat, bilimsel süreçlerin, teknolojik buluşların, teknik aygıtların toplumsal ilişkilere etkisini eleştirel biçimde inceleyen çalışmalar ise bilimsel argümanlar ve teknolojik tasarımların oluşumunda politik, iktisadi ve toplumsal süreçlerin etkisini ikna edici biçimde göstermeye başlamıştır. Bu çalışma bu açılımlardan faydalanarak, bilimsel argümanların ve teknik araçların nasıl toplumsal birer mücadele alanı haline geldiğini ve böylece toplumsal ilişkileri spesifik biçimde etkilediğini göstermeyi amaçlamaktadır.

Doğrudan uluslararası süreçlerden etkilenen ve pek çok faaliyet alanı küresel yönetim organlarınca regüle edilen bu alanın uluslararası ilişkiler çalışmaları tarafından nadiren konu edinilmiş olması oldukça şaşırtıcıdır. Üstelik halen süregiden açlığın, yetersiz beslenmenin, kırsal yoksulluğun, toprak gaspının ve çevresel sorunların doğrudan mevcut tarım-gıda sistemiyle olan ilişkisi göz önünde bulundurulduğunda, tarım-gıda politikaları uluslararası ilişkilerin eleştirel ve sorun çözücü yaklaşımlarının tümünün katkısına ihtiyaç duymaktadır. Bu çalışma, mevcut politikaların coğrafi olarak yayılması ve uluslararası yönetim sisteminde kurumsallaşmasına dair bir incelemeden oluşmaktadır. Böylece, ilk olarak, bugün tarım-gıda sisteminde mevcut olan sorunların tarihsel ve politik kökenlerine dair tekrarlanmış bir farkındalık sağlanarak, tarım-gıda sisteminin dönüşümüne dair inatçı fakat az görünür itirazlara bir görünürlük kazandırmak istenmektedir. İkinci olarak ise, uluslararası ilişkiler çalışmacılarını gerek ampirik gerek teorik bakımdan sayısız inceleme alanı sunan uluslararası politik bir süreç ve küresel yönetim sistemini tanıtmak amaçlanmaktadır. Bu iki amaç, çalışmanın literatür haricindeki genel katkılarını garanti etmektedir.

Bu tez yukarıda belirtilen soruyu, kısaca tanıtilen kavramsal çerçeveyi kullanarak, tarım-gıda sisteminin küreselleşmesindeki en önemli rolü oynayan ve teknolojik yeniliklerin doğrudan politik çıktılar üretmiş olduğu tohum sistemi ve bitki ıslah pratiklerindeki değişimler üzerinden yanıtlamaktadır. 20. yüzyılın başında Avrupa ve Amerika Birleşik Devletleri'nde, 1950 sonrası ise gelişmekte olan ülkelerde yaşanan tarımsal modernizasyon süreci ile gıda üretme pratikleri önemli biçimde değişmiştir. Tarımsal modernizasyon sürecinin en önemli parçalarından birisi modern ıslah pratikleriyle elde edilmiş olan modern bitki çeşitleri ve bunları taşıyan tohumlar olmuştur. 20. yüzyıl boyunca genetik biliminde sağlanan bilimsel ilerlemeler, bitki ıslahında yeni tekniklerin ortaya çıkmasını ve bilimsel yöntemlerin yaygınlaşmasını sağlamıştır. Modern ıslah pratikleri, bitki kalıtım mekanizmasına ve genetiğine dair yeni bulguları kullanarak, ıslah sürecini daha kontrol edilebilir hale getirmiştir. Böylece, farklı niteliklerin tek bir bitki çeşidinde toplanmasını sağlayarak, örneğin verimlilik ve kuraklığa dayanıklılık, tarımsal üretimin daha verimli hale gelmesine imkân tanımıştır. Bilim ve tekniğin sağladığı bu imkanlar, insanların bitkilerdeki genetik yapıyı değiştirme; ona yeni parçalar ekleme yeteneği kazandırmıştır.

Bu şekilde elde edilen bitki çeşitleri ve tohumlar, modern tarımın standartlaşmaya dayalı üretim moduna uygun girdiler üretirken; yine onun keskin iş bölümüne dayanan işleyişine uygun biçimde çiftçiler ile ıslahçıları ayırmıştır. Modern tarım, bitki geliştirme ve tohum üretim aşamalarını çiftçilerden alarak, yeni aktörlere devretmiştir. Modern tohumların ve bitki ıslah teknikleri sağladıkları hızlı verim artışı nedeniyle ilgiyle karşılanmıştır. Modern tohumların gelişmekte olan ülkelere benimsenmesi, Yeşil Devrim süreci ile endüstriyel tarım pratiklerinin de yayılmasına izin vermiştir. Böylece tarıma dair üretimi paradigma, modern ıslah sistemi aracılığıyla küresel hale gelmiştir.

Bitki ıslahı üzerindeki bu dönüşüm toplumsal, iktisadi ve politik anlamda önemli değişimleri tetiklemiş ve tartışmalara yol açmıştır. Özellikle yeni bitkilerin ıslah edilebilmesi için gereken genetik kaynakların toplanması, korunması ve kullanılmasına dönük uluslararası kurumsallaşma yoğun mücadeleler sonucunda inşa edilmiş, fakat eleştiriler ve reform taleplerinden muaf kalmamıştır. Tohumların ve bitki genetik kaynaklarının piyasa dinamiklerine indirgenmesi, tohum hakları ve bitki genetik kaynaklarının sahipliğine dair tartışmaları tetiklemiştir. Bitkiler ve onların genetik parçaları üzerinde inşa edilen fikri mülkiyet rejimleri, sivil toplum tarafından yoğun eleştirilere maruz kalırken, tohum ve ıslah endüstrisinin gelişerek küresel birer aktör olmasını sağlamıştır. Bugün mevcut tohum ve bitki ıslah sistemi küresel düzenlemeler ile güvence altına alınmıştır.

Mevcut çalışmalar tarım-gıda sisteminin bütününe dönük açıklamaların aksine, modern tohumların ve tohum sisteminin nasıl yayıldığına, pratiklerin nasıl kurumsallaştığına dair az sayıda açıklama üretmiştir. Politik iktisadi süreçlere dayanan açıklamalar, dönüşümü daha yapısal bir perspektifle metalaşma süreci üzerinden okumakla birlikte, tohumlara dair hakların kısıtlanmasının legal, kurumsal ve teknolojik boyutlar üzerinden ele almışlardır. Bu tez politik iktisadi açıklamaların sunduğu bu üç mekanizmanın etkileşimini daha geniş bir tarihsel süreci inceleyerek ve bağlantılarını daha mikro boyutta yeniden kurarak anlatmaktadır. Öte yandan, uluslararası rejim ve küresel yönetim çalışmaları, tohumlar ve bitki genetik kaynakları üzerindeki kurumsal mimariyi detaylı biçimde tanımlayarak, çok sayıda kural ve normun nasıl bir kompleksler yarattığını göstermiştir. Fakat bu açıklamalar, mevcut rejimlerin güvence altına aldığı hâkim pratiklerin nasıl inşa edildiğini

sorgulamamaları sebebiyle, yalnızca bugünkü politik mücadeleleri mercek altına almaktadırlar. Bu tez, bugünkü kurumsal yönetim mimarisinin nasıl spesifik bir bitki ıslah sistemine uyumlu biçimde inşa edildiğini göstererek, mevcut çalışmaların eksik bıraktığı bir noktayı aydınlatmayı amaçlamaktadır. Bir başka deyişle, kurallar ve normlardan davranışlara, yani pratiklere dönük bir açıklama yerine, pratiklerden yola çıkarak onlara uygun biçimde inşa edilen bir küresel kurumsal yapı anlatılmaktadır. Üretimci paradigma, mevcut itirazları içerisinde eritecek ve muhalifleri ehlileştirecek biçimde yeni aktör ittifakları, söylemsel araçlar, teknik aygıtlar ve kurumsal mekanizmalar üretmektedir. Gıda halen insanların en temel ihtiyaçtır ve buna rağmen gıdaya, tohumlara, topraklara dair haklar güvence altına alınmamıştır. Bu nedenle, temel bir insan hakkı olan gıdanın ve dolayısıyla tarımın politikasını ve onu çevreleyen küresel kurumsal yapıyı eleştirel bir incelemeye tabi tutmak bu nedenle önemli ve gereklidir.

Tezin ikinci bölümü küresel tarım ve gıda politikalarına dair tarihsel bir arka plan sunarak, siyasi, iktisadi ve bilimsel gelişmelerin, tarım ve gıda pratiklerinin küreselleşmesinde, sonrasında ise ona dair küresel yönetim sisteminin inşasında nasıl etkili olduğunu göstermeyi amaçlamıştır. Başlangıçta iki ayrı faaliyet alanı olan tarım ve gıdanın, yaşanan gelişmeler sonucunda bütünleşmiş hale gelerek bir pratikler bütünü oluşturduğu, dolayısıyla artık bir tarımgıda sistemi olarak adlandırılması gerektiği vurgulanmıştır. 20.yüzyıl boyunca gerçekleşen bilimsel ilerlemeler ve teknolojik yenilikler, üretimci paradigmaya ihtiyaç duyduğu araçları sağlamıştır, fakat güçlü bir siyasi ve iktisadi irade bu paradigmanın kurumsallaşarak yayılmasını mümkün kılmıştır. Yüzyılın başlarında yerel ilişkilere dayanan tarım ve gıda pratikleri, izleyen ulusal kalkınmacı devlet modelinin ürettiği kamu politikaları aracılığıyla ulusal ilişkilere dahil edilmiştir. 1980’li yıllardan sonraki neoliberal iktisadi reformları takip eden süreçte ise küresel ölçekteki piyasa hareketlerinin etkisine girmiştir. Üretimci paradigmaya dayanan endüstriyel tarım sisteminin savunucuları, uluslararası toplumun gıda güvenliği söylemini hızlıca sahiplenmiş ve dünyayı besleyebileceklerini ileri sürmüşlerdir.

2000’li yıllara doğru, açlığı sonlandırma ve kırsal yoksulluğu azaltma hedeflerindeki başarısızlığın yanı sıra çevresel sorunlara yol açmış olmalarına rağmen sürdürülebilir kalkınma gündemini uhdelerine alarak, kaynak kullanım verimliliğini artırma yoluyla

dünyayı besleyebileceklerini iddia etmişlerdir. Tüm bu iddialarda, bilime dayalı teknolojik ilerleme yoluyla sorunların çözümünü vadeden Teknik-Bilimsel söylem ön plana çıkmıştır. Bugün dahi bu söyleme dayanarak, örneğin biyoteknoloji buluşları aracılığıyla, iklim değişikliği ile mücadele ederek üretimi arttırabileceklerini oldukça ikna edici biçimde ileri sürmekteler. Bu nedenle, bilim ve teknik üretimi paradigmaya üretimi arttırabilecekleri teknik araçların yanı sıra, üretimi anlayışı evrenselleştirebilecekleri ve meşrulaştırabilecekleri bir söylemsel araç sunmaktadır.

Üretimci paradigmanın yol açtığı sorunlara dönük reform talepleri görünür hale gelmiştir. Bir grup reformist, sistemin temel yapısını, başta iktisadi ve siyasi, muhafaza ederek küçük ölçekli, teknik ve çoğunlukla bilimsel ilerlemeye dayanan revizyonlar aracılığıyla sistemin daha verimli hale getirilmesini önermektedir. Gıda Egemenliği ve Agroekoloji hem bir tarım modeli hem de toplumsal hareketi ifade eden itirazlar ise toplumsal adaletsizliği ve iktisadi eşitsizliği giderek yapısal dönüşümler talep etmektedir. Oldukça önemli itirazlar ve denenmeye değer alternatifler üreten bu yaklaşımlar, açlık başta olmak üzere toplumsal, iktisadi ve ekolojik sorunları küreselleşen kapitalist üretim ilişkilerine dayandırmaktadır. Bu nedenle üretim ve tüketim ağlarının yerleşmesini, tarımsal faaliyetlerin girdi bağımlılığından kurtulması önermektedir. Bu itirazlar karşısında üretimci paradigmanın savunucularının başvurduğu bir yöntem, özellikle küresel yönetim mimarisindeki etkisi aracılığıyla, bu ‘radikal’ reform taleplerini yenileyerek içeriğini boşaltma yönünde olmaktadır. Son yıllarda tarım-gıda politikalarının temel çerçevesi haline dönüşen Doğa Temelli Çözümler ve İklim-Akıllı Tarım gibi kavramlar, Agroekolojik itirazların yapısal olmayan, teknik kısımlarını barındırarak dönüşümcü itirazların gücünü azaltmaktadır. Bu bölümdeki kapsamlı literatür incelemesi, üretimci paradigmanın kurumsallaşması sürecinde bilim, teknoloji, politika ve iktisat arasındaki ilişkiyi ortaya koymaktadır. Tarımsal pratiklere dair teknik/teknolojik araçlar ile gıdanın küresel yönetişimini oluşturan norm, kural ve kurum gibi toplumsal araçlar arasındaki bağlantıyı göstererek, bu araçların ve çözümlerin inşası ve yayılmasındaki güç mücadelelerine dikkat çekmiştir. Bilimsel ve teknolojik gelişimin ulusal ve uluslararası seviyelerdeki politik ve iktisadi bağlam üzerinden okunmasının faydasını göstererek, tezin amacı, argümanı ve izlediği kuramsal çerçeveyi desteklemektedir.

Tezin üçüncü bölümü toplumsal düzenlemelerin inşası ve sürdürülmesinde bilim ve teknolojinin rolünü iktisadi ve politik bağlam ile bir arada ele alarak sorgulamayı mümkün kılan bir kuramsal alan açmaktadır. Tez, bilimsel bilgi üretim süreçleri ile mümkün kılınan teknik-teknolojik çözümlerin, toplumsal süreçlerin yönlendirmesi ile belirli hedeflere dönük tasarımlara ve işlevlere dönüştüğünü ileri sürmektedir. Dolayısıyla teknik ve politik ya da materyal olan ve toplumsal olan arasında bir karşılıklı üretim süreci öngörmektedir. Bir başka deyişle, tarımsal pratiklerde kullanılan araçlar ile tarımın neden ve nasıl yapılması gerektiğini güdüleyen kurumlar ve normlar arasında tek taraflı olmayan bir ilişkiyi ileri sürmektedir. Bu argümanı tezin incelediği çalışma alanı üzerinde değerlendirebilmek için öncelikle uluslararası kurumsallaşmaya dair mevcut iki kuramsal çerçeve incelenmiştir. Uluslararası rejimler üzerine açıklamalar üreten Rejim Teorileri ve sosyal inşacı norm çalışmaları bu bağlamda değerlendirilmiştir. Bu değerlendirme, bitki ıslah pratiklerinin sürdürülmesi için kritik önemde olup üzerinde oldukça ihtilafli bir geçmiş barındıran bitki genetik kaynaklarının yönetişimi üzerinden gerçekleştirilmiştir. Bitki genetik kaynaklarının yönetişimine dair bağlayıcı ve kural koyucu uluslararası bir sözleşme olan Gıda ve Tarım için Bitki Genetik Kaynaklarına İlişkin Uluslararası Anlaşma (ITPGRFA), bu maksatla barındırdığı kurallar, normlar ve inşa ettiği kurumsal mekanizma ile tanıtılmıştır. Anlaşma taraf devletlerin gen ve tohum bankalarında yer alan bitki genetik kaynaklarına erişimi kolaylaştıran ve bu erişimden doğan faydaları taraflar ile paylaşmayı mümkün kılan Çoktarafli Sistem adında bir kurumsal iş birliği mekanizma inşa etmiştir. Taraf devletler, yedi yıl süren müzakereler sonucunda, 64 bitki çeşidine ait kaynakları bu sisteme dahil etmeyi kararlaştırmıştır.

Uluslararası Rejim Kompleksi analitik çerçevesinin bitki genetik kaynakları üzerine ileriye sürdüğü argümanlar aktarılmıştır. Bu çalışmalar, bitki genetik kaynakları alanındaki rejim çoğulluğu ve ihtilafına dikkat çekerek, bu kompleks yapının oluşumunda devletler arası mücadele ve rekabeti ön plana çıkartmıştır. Bitki genetik kaynaklarının ortak mülkiyet anlayışından özel mülkiyet kurallarına tabi oluşunu, uluslararası kurumlar üzerinden okuyan öncül bir çalışma, biyoteknolojik aygıtlar aracılığıyla sağlanan kar elde edebilme imkanının teknoloji zengin gen fakiri ülkeler ve gen zengini teknoloji fakiri ülkeler arasında bitki genetik kaynaklarının paylaşımına dair ihtilaf yarattığını ve mevcut ortak mülkiyet rejimini sarstığını ileri sürmüştür.

Sonrasındaki düzenlemelerin ise teknoloji zengini ülkelerin pozisyonunu teyit edecek biçimde inşa edildiğini ileri sürerek bunu ülkeler arası güç eşitsizliği üzerinden açıklamıştır. Bu açıklama uluslararası kurumsallaşma ve teknoloji arasında bir bağ kurmakla birlikte, teknolojinin kavramsallaştırılması dışsallaştırma yoluyla gerçekleşmiştir. Bir başka deyişle, biyoteknoloji alanında sağlanan teknik ilerlemenin bitki genetik kaynaklarını kullanarak bitki ıslahını geliştirmesine yalnızca teknik bir dönüşüm olarak vurgulanmıştır. Dolayısıyla bu teknik araç ile bitki genetik kaynaklarını özel mülkiyet rejimine sokan ulusal kanunlar ve uluslararası sözleşmeler arasında, örneğin Uluslararası Yeni Bitki Çeşitlerini Koruma Sözleşmesi (UPOV), Dünya Ticaret Örgütü Tarım Antlaşması gibi, bağ doğrusal bir biçimde ele alınmıştır. Benzer şekilde teknolojik dönüşüm ile bitki genetik kaynaklarını özel mülkiyet rejimine dahil etmenin uygunluğu, meşruluğu ve toplumsal kabulüne dair, yani normatifliğinin inşasına dair herhangi bir bağlantı kurulmamıştır. Bu nedenle bilimsel değişimin, mevcut pratikleri şekillendirmesi güç dengesi uyarınca kurumsallaşan kurallar üzerinden kavramsallaştırılırken, bu toplumsal düzenlemenin kabulü sorgulanmamıştır.

Benzer bir eğilim Sosyal İnşacı norm çalışmalarında da görülmektedir. Norm odaklı bir perspektifle incelenen ITPGRFA bünyesinde çok sayıda normatif kavram dikkat çekmektedir. Örneğin antlaşma metninde bitki genetik kaynaklarının korunması, sürdürülebilir kullanımı, kullanımdan doğan faydaların adil ve eşitlikçi biçimde paylaşılması antlaşma amaçları olarak tanımlanmıştır. Bu amaçlar ise gıda güvenliği ve sürdürülebilir tarım gibi iki hedef ile ilintilemiştir. Dolayısıyla beş farklı ve ilişkilendirilmiş normatif ifade yer almıştır. Bu durum açık bir şekilde norm çoğulluğunu yansıtmakta ve kurumsalcı perspektif tarafından rejim kompleksinin bir sonucu olarak değerlendirilmiştir. Antlaşma bitki genetik kaynaklarının erişime açılmasını, yani bitki ıslahçıların kullanımını, mümkün kılarak bunu bilime dayalı bitki ıslahı aracılığıyla gıda güvenliğinin sağlanması idealiyle eşleştirmiştir. Aynı zamanda bu erişimi dengeleyecek biçimde erişimden doğan faydaların paylaşılmasını kurumsallaştırmıştır. Böylece hem bitki ıslahçıları hem de çiftçileri arasında bir ara yol inşa etmeyi amaçlamıştır.

Bir başka deyişle bitki genetik kaynaklarının kullanılarak yeni bitki çeşitlerinin üretilmesi ve bunların fikri mülkiyet kurallarına tabi olabilmesinin önünü açarken, bu

süreçte elde edilecek maddi, bilimsel ve kurumsal faydaları geliştirmekte olan ülkelerin çiftçilerine sağlayarak sürdürülebilirlik gündemine katkıda bulunmayı hedeflemiştir. Her ne kadar bazı rejim çalışmaları bu normatif ifadeleri rejim içerisinde yer alan birer norm olarak kabul etmişse de anaakım norm çalışmacılarının bu gündeme dair bir çalışması bulunmamaktadır. Bunun en önemli sebebi benimsenen norm kavramsallaştırmasıdır. Norm çalışmaları pratikler ile onların toplumsal kabulü arasındaki süreci eylem ve norm arasında doğrusal biçimde kurmaktadır. Bir başka deyişle, normlar bir şekilde kurumsallaşarak sabitlenmiş toplumsal olgular anlamına gelmektedir. Bu durum normatifliğin kökenini normların varlığı ya da yokluğuna dayandırmaktadır. Bir başka deyişle, pratiklerin normatifliği, araştırmacının analitik çerçevesi uyarınca tanımlayacağı ya da tanımlamayacağı normlar üzerinden okunmaktadır. Anaakım norm çalışmaları, kısıtlı ve dar kapsamlı bir biçimde oluşturulan norm kavramsallaştırması nedeniyle, normların tespit edilemediği durumlarda pratiklerin normatifliğinden bahsetmeyi imkânsız kılmaktadır. Aslında bu durum şaşırtıcı değildir, zira sosyal inşacılığın toplumsal olgulara dair daha dinamik ve dönüşüm halindeki yaklaşımın aksine norm çalışmaları mevcut Uluslararası İlişkiler teorileri arasına girişlerini normları dar bir analitik çerçeveye hapsederek başarmıştır. Fakat son dönemde Uluslararası Pratik Teorisi'nin norm çalışmaları ile kurduğu bağlantı sayesinde, norm olgusu yerine normatifliğe vurgu yapan çalışmalarda artış gözlenmiştir. Bu çalışmalar kurumsallaşmış toplumsal olgular yerine kurumsallaşma sürecine ve normatifliğin çoklu kaynaklarına odaklanmayı mümkün kılmıştır. Üstelik norm çalışmalarının toplumsal, düşünsel ve söylemsel odaklılığının aksine, materyal faktörlerin ve davranışsal pratiklerin de normatifliği üretici ya da zayıflatıcı niteliğini göstermişlerdir. Bu çalışma grubu özellikle teknolojik gelişimin normatifliğin sürdürülmesi ya da normatif olmayan pratiklerin icra edilebilmesindeki failliğini vurgulayan çalışmalar gerçekleştirmiştir. Dolayısıyla bilimsel fikirler, teknolojik aygıtlar ve normatiflik arasında bir bağ kurmak daha mümkün hale gelmiştir.

Bu çalışma grubunun teknoloji ve toplumsal süreçlere dair kavramsallaştırması aslında uzun yıllardan bu yana Bilim ve Teknoloji Çalışmaları (STS) ile geliştirilen bir çerçeveden beslenmektedir. Teknolojinin toplumsal yaşamdaki rolüne dair yapılan anaakım kavramsallaştırmalar, Teknolojik Belirlenimcilik ekolünden beslenerek,

teknik aygıtların inşasını onlara içkin niteliklere dayandırmaktadır. Bu bakımdan tekniğin icadında toplumsal süreçlerin rolünü göz ardı ederek tarafsız, apolitik ve lineer bir teknolojik gelişim modelini benimsemektedir. Teknolojinin etkisini ise toplumsal ilişkilere dışsallaştırarak ve dahası onu doğrudan şekillendirerek sosyal analizin dışına taşımaktadır. Buna karşılık Teknolojinin Sosyal İnşası ise teknolojinin oluşumunda ve teknik aygıtların tasarımında toplumsal ilişkilerin gömülü olduğunu, siyasi, politik, kimliğe dayalı toplumsal olguların ve süreçlerin teknolojinin değişim ve yayılım aşamalarını belirlediğini ileri sürmektedir. Öte yandan, Teknolojik Belirlenimi aşmak amacıyla yalnızca toplumsal süreçlere odaklanan ve materyal faktörlerin etkisini ortadan kaldıran uç sosyal inşacı yaklaşımlar, Toplumsal Belirlenimcilik gerekçesiyle eleştirilmiştir. STS çalışmaları, toplumsal düzenlemelerin teknoloji üzerinde ve teknolojinin toplum üzerindeki etkisini karşılıklı ve bütünleşmiş biçimde ele alarak, materyal ve toplumsal olan arasındaki karşılıklı bir bağlantı kurmuşlardır. Bu tezde sıklıkla kullanılan ortaklaşa üretim (co-production), sosyo-teknik, sosyo-materyal gibi kavramlar bu bütünleşmeyi temsil etmektedir.

Bu kuramsal açılımlarla birlikte ITPGRFA bir kez daha, fakat bu kez metinden ziyade uygulama pratikleri ve ilkeleri üzerinden, değerlendirilmiştir. Bu değerlendirme ile antlaşma metninin kapsayıcı ve dengeli içeriğine rağmen uygulamada bu dengenin kaybolduğu, çiftçilerin haklarının ikinci planda kalarak kurumsallaşmadığı, buna karşılık ıslahçı haklarının metinde tanımlanan hareket alanından daha geniş biçimde gerçekleştiğini göstermiştir. Örneğin, antlaşma metni ile tanımlanan bitki genetik kaynaklarına kolaylaştırılmış erişim, yalnızca ıslah, araştırma ve eğitim amaçlarını kapsamaktadır. Dolayısıyla herhangi bir girişimcinin Çoktarafli Sistem üzerinden elde ettiği tohumu çoğaltarak pazarlaması ya da fikri mülkiyet haklarına dahil etmesi mümkün değildir. Zira bu durum anlaşmanın ortaya çıkmasına neden olan, gelişmekte olan ülkelerin gelişmiş ülkelere yönlendirdiği biyolojik hırsızlık anlamına gelmektedir. Anlaşma tohumları erişime açarak daha verimli bitkilerin geliştirilmesini amaçlamaktadır. Fakat hangi geliştirme yöntemleri bu kapsamdadır?

Anlaşma uygulanması esnasında pek çok ıslah yöntemi arasından yalnızca profesyonel bitki ıslah sektörünün uyguladığı bilimsel/modern bitki ıslah tekniklerini kolaylaştırılmış erişim ile ödüllendirilmiştir. Bu yöntem bitkilerin genetik niteliklerini taşıyan ve bu nedenle bitki genetik kaynakları olarak adlandırılan tohumları bilimsel

ilkelere uygun biçimde tasarlanmış bir ıslah süreci içerisinde yalnızca hammadde olarak kullanılmaktadır. Anlaşmanın Çoktarafli Sistem'i aracılığıyla elde edilen tohum, yani genetik kaynak, sistematik bir deney tasarımı içerisinde kontrollü gerçekleştirilen çaprazlamalar ile uzun yıllar sürebilen saflaştırmaya dönük seçme işlemine tabi tutulmaktadır. Nihayetinde üretilen yeni bitki çeşidinin, üretim esnasında kullanılan bitki çeşidinden farklılıklarını açık biçimde göstermesi hedeflenmektedir. Böylece bitki ıslah alanındaki fikri mülkiyet kurallarını karşılayacak bir ürün elde edilmiş olmaktadır. Daha önce değinildiği gibi, bitki ıslahçıların ürettiği yeni çeşitler üzerindeki haklarını güvenceye alan UPOV sözleşmesi, kurmuş olduğu Bitki Çeşidi Koruma (Plant Variety Protection-PVP) sistemi kapsamında Bitki Islahçı Haklarının (PBRs) sınırlarını tanımlarken üç kriter belirlemiştir. Buna göre ıslahçıların ürettiği çeşitlerin koruma kapsamına girmesi için farklılık (Distinctness), yeksenaklık (uniformity), durulmuşluk (Stability) kriterlerini karşılaması beklenmektedir. Farklılık bitki çeşidini diğer çeşitlerden ayıracak en az bir esas nitelik barındırması, yeksenaklık çeşidin bir örnek ve homojen olup çoğaltma aşamasında varyasyonlar barındırmaması, durulmuşluk çeşidin tekrar eden kullanımının ardından aynı nitelikleri muhafaza etmesi anlamına gelmektedir. Profesyonel ıslah sistemi bu kriterleri karşılayacak biçimde dönüştürülmüştür. Fakat çiftçilerin bitki geliştirme pratikleri bu yöntemden oldukça farklıdır. Çiftçilerin bitki geliştirme pratikleri, tohumun üretim amacıyla tarlaya ekilmesi, bitkinin gelişiminin gözlenmesi, bu esnada istenen niteliklere sahip bitkilerin belirlenerek seçilmesini kapsamaktadır. Bu yöntem ile bitki geliştiren çiftçilerin talepleri, yöntemin doğrudan kullanım aşaması barındırması gerekçesiyle olumsuz sonuçlanabilmektedir. Üstelik çiftçilerin bitki geliştirme aşaması yalnızca tarımsal üretim pratiğini kapsamamaktadır. Toplumsal ilişkilerin bütününe eşlik eder biçimde tohumlar takas edilerek, hediye verilerek ve yerel ölçekte alışverişe tabi tutularak el değiştirmekte, böylece farklı tarımsal üretim tekniklerine, coğrafi koşullara ve çeşitlere maruz kalarak çeşitliliğini sürdürmektedir. Böylece genetik olarak homojen olmayan ve varyasyonlara açık kalarak evrimini sürdüren bitki çeşitleri elde edilmektedir. Üstelik bu işlem, modern bitki ıslah işleminin aksine kolektif bir ıslah yöntemidir. Dolayısıyla çiftçi ıslah sistemi, modern fikri mülkiyet rejimi ile korunmaya alınmadığı gibi, onu ihlal ettiği gerekçesiyle engellenmeye çalışılmaktadır.

ITPGRFA uygulama aşamasında çiftçi bitki geliştirme süreçlerini uygun bir ıslah pratiği olarak kabul etmeyerek, ıslah pratiğinin ne olduğunu yeniden tanımlamış, böylece taraf aktörlerden beklenen pratiği belirlemiştir. Metin bazlı bir okuma ile norm olarak tanımlayabileceğimiz çiftçi hakları ve kolaylaştırılmış erişim ihlal edilmiştir. Üstelik anlaşma metninde kolaylaştırılmış erişimin kendisi adil ve eşitlikçi bir şekilde paylaşılması kararlaştırılan faydaların ilki olarak tanımlamıştır. Dolayısıyla çiftçilerin kolaylaştırılmış erişime dahil edilmeyişi hem çiftçi haklarını hem de fayda paylaşımı normunu da ihlal etmiştir. Fakat ihlal edilen yalnızca bu normlar değildir, zira tek bir ıslah pratiğinin uygun ıslah yöntemi olarak kabul edilişi anlaşmanın ilk amacı olan bitki genetik kaynaklarının korunmasına ve anlaşmanın ulaşmaya çalıştığı hedeflerden olan gıda güvenliğine de engel olmaktadır. Modern bitki ıslah sistemi daha önce belirtildiği gibi yeknesak ve durulmuş, yani homojen ve varyasyonu sonlandırılmış bitki çeşitleri üretmektedir. Çiftçi ıslah teknikleri ile elde edilen bitkiler ise bunun tam aksi biçimde bilinçli bir şekilde genetik çeşitliliğe sahip popülasyonlar ve genetik içeriği sabitlenmemiş bireyler üretmektedir. 1960'lı yılların ortalarından itibaren Yeşil Devrim'in homojen ve standart tohumları arazilere yayılarak, geleneksel yöntemler ile çeşitlenmiş bitkilerin yerini almıştır. Çiftçilerin hızlı bir şekilde ürün verimini arttırma amacıyla geride bıraktığı homojen olmayan ve evrimi süren bitkiler kaybolarak genetik erozyon olarak adlandırılan süreci başlatmıştır. Bu durum bitki genetik kaynaklarına dair uluslararası koruma sürecini başlatan girişim olmuştur. Böylece homojenleşmeyi ve yeknesaklığı sağlamak amacıyla tasarlanan modern bitki ıslah tekniğinin, kendisini mümkün kılan ve ıslah için gerekli hammaddeyi sağlayan genetik çeşitliliği ortadan kaldırdığı anlaşılmıştır. Dolayısıyla korunması amaçlanan kaynakları yok eden bir ıslah tekniğini önceleyen; çeşitliliği garanti eden çiftçi ıslah pratiğini ise dışlayan kolaylaştırılmış erişim sistemi, anlaşmanın ilk ilkesini ihlal etmekle kalmayıp, onun tam aksine sonuçlar üretme riskini taşımaktadır.

Modern ıslah pratiğini kurumsallaştıran erişim ilkeleri yalnızca korumayı değil aynı zamanda gıda güvencesini de riske atmaktadır. Homojen çeşitler ile dikimi gerçekleştirilen araziler, iklimsel faktörler, hatalı uygulamalar ve bitki zararlıları karşısında tüm popülasyonu, bu durumda tüm mahsulü, riske açık hale getirmektedir. Dolayısıyla yaşanan herhangi bir olumsuz süreç çiftçinin iktisadi anlamda güvencesiz kalmasına yol açmaktadır. Üstelik homojen çeşitler salgın hastalıkların hızlıca

yayılmasına imkân tanıyarak bölgesel sonuçlara yol açabilmekte ve gıda güvencesini riske atabilmektedir. Öte yandan çiftçilerin ıslah ettiği homojen olmayan çeşitler, bu tür olumsuz faktörlerden muaf olmamakla birlikte, popülasyon ölçeğinde kayba uğrama riski daha düşüktür. Bir başka ifadeyle, farklı genetik niteliklere sahip bitkiler ile çeşitlendirilmiş bir mahsul hem çiftçiye iktisadi anlamda güvenceye almakta, hem de toplumun gıda güvencesini sağlamaktadır.

Bilindiği gibi bitki genetik kaynaklarını korumak, onlar yok olmadan güvenceye almak ve genetik çeşitliliklerini sürdürmelerine, yani varyasyonlar geçirmelerine, izin vermeye dayanmaktadır. Bu koruma yöntemlerinden birisi *Ex Situ* olarak adlandırılan, tohum ve gen bankalarında muhafaza etmektir. Diğer bir yöntem ise *In Situ* olarak adlandırılan ve bitkilerin arazilerde, kullanım yoluyla varlığını sürdürmesidir. Bu iki yöntem genetik çeşitliliğin arttırılmasına dönük iki farklı yöntemi desteklemektedir. *Ex Situ* yöntem ile muhafaza altına alınan bitki çeşitleri, genetik evrimi yavaşlatılarak, kimi zaman ise tamamen durdurularak korunmaktadır. Bu depolardan elde edilen genetik kaynaklar ıslahçıların çeşitli teknikler ile ürettikleri yeni bitki çeşitlerine temelini oluşturmaktadır. Böylece çeşitlilik, ıslahçı aracılığıyla sağlanmaktadır. *In Situ* yönteminde ise dinamik bir koruma mantığı hakimdir. Bitkiler kullanılarak, takas edilerek ve çevresel faktörlere uyumluluk sağlayarak genetik çeşitliliğini arttırmaktadır.

Sonuç olarak geleneksel bir norm kavramsallaştırmasına dayanarak normatifliği normlara indirgeyen bir okuma, bu iki normun kurumsallaşmış bir biçimde ihlal edilişiyle birlikte onların varlığını sonlandırmak zorunda kalmaktadır. Fakat öncelikle bu ihlali tespit edebilmeleri gerekmektedir. Metin ve söylem odaklı bir araştırma stratejisi bu tespiti mümkün kılmamaktadır. Anlaşmanın uygulanış ilkelerine ve pratiklerine dönük bir inceleme, metin ve söylem odaklı bir normatifik arayışının örtülü bıraktığı pek çok süreç ve gelişmeyi görünür kılmaktadır. Bu inceleme aynı zamanda teknolojinin ve tekniğin toplumsal ilişkilere, kural ve normların değişimine nasıl dahil olduğunu göstermektedir. Bitki ıslah süreçlerindeki görüldüğü gibi teknikler birden fazla izlek çizmektedir. Fakat bunlardan hangisinin kurumsallaşacağı tekniğin üstünlüğünden ziyade hangi aktörleri hangi amaçlara ulaştıracağına bağlıdır. ITPGRFA bu şekilde incelenmesi iki açıdan önemlidir. İlki üretimi paradigmanın küresel gıda yönetiminde ne ölçüde kurumsallaştığını ve bunu nasıl tespit

edilebileceğini anlamaya yaramaktadır. İkincisi ise görünürde farklı paradigmalara imkân tanıyan bir düzenlemenin aslında dönüştürücü toplumsal hareketleri mevcut sisteme dahil edilerek nasıl ehlileştirildiğini göstermektedir. Üstelik bu ehlileştirme düzenlemeye meşruluk sağlayarak ona dönük itirazları zorlaştırmaktadır.

Tezin dördüncü bölümü 19. yüzyıl boyunca Avrupa'da bitki ıslahı alanında meydana gelen bilimsel ve kurumsal değişimler incelenmektedir. Bir önceki bölümde özetlenen kavramsal çerçeveyi takip eden bu bölüm, son derece teknik ve aynı derecede stratejik bir bitki ıslahı altyapısının kurulmasında bilim ve siyaset arasındaki etkileşimin erken bir örneğini göstermeyi amaçlamaktadır. Botanik biliminin emperyal bir kuruma dönüşümü anlatılarak, onun sömürgeci kökenleri araştırılırken, aynı zamanda bilimsel fikirlerin ve teknik araçların imparatorlukların genişlemesinde rolü gösterilerek sömürgeci gücün botanik kaynaklarına ışık tutulmaktadır. Bu bölüm, 19. yüzyılda gerçekleşen ve ilk Biyo-Korsanlık eylemi olarak bilinen kötü şöhretli bir yolculuğu takip etmektedir. İngiliz botanikçiler iki bitki türünü doğal yaşam alanlarından taşımayı ve plantasyonlarda geliştirmeyi başardılar. Bu bitkiler Kınakına ve Kauçuk ağacıydı. İlki sıtma sorununu çözdü, böylece Afrika'da sömürgeci genişlemeyi sağladı ve Hindistan'da İngiliz kontrolünü artırdı. İkincisi ise sanayi devrimini körükledi, yeni pazarlar açtı ve kapitalist üretim ilişkilerini genişletti. İngilizler bitkileri toplamayı, taşımayı, kullanmayı ve geliştirmeyi diğerlerinden çok daha iyi bir şekilde başardılar. Bu faaliyetler bitkileri tanıma ve kontrol etme becerisi gerektiriyordu ki bu da botanikçiler ve onların yeni oluşturdukları epistemik kültür sayesinde mümkün oldu. Bu yüzyıldaki botaniğine hâkim olan epistemik kültür, bilimsel uygulamaların yöntem ve amaçlarını dönüştürerek faydacı mantığa dayanan bir bilgi sisteminin üretilmesine yol açtı. İngiliz imparatorluk kurumları ve onların geniş kaynakları, botanikçilerin ve doğa bilimcilerin başarısı için çok önemliydi. Bir zamanlar Kraliyet ailesi için hizmet veren Kew Botanik Bahçeleri ve doğa bilimcileri, bir kamu kurumu olarak Britanya İmparatorluğu'nun alet çantasına eklendi. Botaniğin bir bilim olarak yükselişi ve imparatorluk kurumlarının genişlemesi, doğa bilgisi ile toplumsal kurumlar arasındaki ortak üretim sürecinin açıklayıcı örneklerinden biridir. Bu bölüm, bilgi üretim sürecinin epistemik kültürler tarafından koşullandırıldığı ve bunun da siyasi ve kurumsal bağlamlar tarafından şekillendirildiği sonucuna varmaktadır.

Tezin beşinci bölümü, 20.yüzyılın ilk yarısındaki bitki ıslah tekniklerinde değişimleri incelemektedir. Bir önceki yüzyılda mümkün hale gelen bitkileri bağlamlarından kopartma pratiği, 20. Yüzyılda yeni bir epistemik kültürün ortaya çıkmasıyla daha da sistematik hale gelmiştir. Bu bölüm, 19. yüzyılın ikinci yarısında evrim teorisi üzerine yapılan tartışmaları tanıtarak başlamakta ve Darwin'in takipçileri tarafından belirli bir Darvinci yorumun nasıl oluşturulduğunu göstermektedir. Bunu takiben, Gregor Mendel'in ünlü deneyi tanıtılmakta ve takipçilerinin gen merkezli bir kalıtım mekanizmasını nasıl kurumsallaştırdığı gösterilmektedir. Ardından, devlet müdahalesinin bu bilimsel sonuçları ulusal çıkarlar ve üretimci paradigma doğrultusunda bitki ıslahı stratejileri üretmek üzere nasıl yönlendirdiğini açıklamaktadır. Bu bölümde, bilimsel fikirlerin ve siyasi-iktisadi gelişmelerin Amerika Birleşik Devletleri ve Avrupa genelinde gen merkezli bir bitki ıslahı paradigmasının ortaya çıkmasına ve hızla benimsenmesine nasıl yol açtığı incelenmektedir. 20. yüzyılın başlarında, bir dizi bilimsel keşif ve bunların teknik uygulamalara dönüştürülmesi, bitki ıslahında ürün çeşitliliğinden yararlanma yolları üzerine epistemik bir topluluğun ortaya çıkmasına yol açtı. Bu teknik müdahale, bitkinin 'kaotik' ve 'öngörülemez' ekolojik adaptasyonunu atlamayı mümkün kıldı. Genlerin izole edilebileceği ve bitkilerin saflaştırılabileceği inancı, bilimin doğa üzerindeki zaferi olarak alkışlandı. Sonuç olarak genler, bitkileri temsil etmeye başladı. Dolayısıyla genleri toplamak ve saklamak, bitkilerin kendisinden daha 'rasyonel' ve önemli hale geldi. Bitki ıslahı bu zaferin izinde modernleşti. Bu süreç açıkça bilim insanlarını ve onların zaferini içeriyordu. Ancak zafer için bilim insanları ve onların fikirlerinden daha fazlası gerekiyordu. Mendel'in deneyi kalıtımın tek bir yorumunu ya da tek bir bitki ıslah yöntemini dikte etmemiştir; ancak yine de bu şekilde yorumlandı. Bitkilerin gen, bitki ıslahının bilim olarak yeniden tanımlanması devlet kurumları ve özel ıslahçıların. Bu ilerleme devletlere siyasi, iktisadi ve toplumsal konularda önemli çözümleri hızlı bir şekilde sağladı. Bu nedenle 20. yüzyıl, bilim insanları bitkileri genlere indirgediği için değil, toplumsal aktörler onu bu yöne indirgediği için genetik indirgemecilik yüzyılı olarak bilinmektedir.

Tezin altıncı bölümü birbiriyle bağlantılı iki gelişmenin izini sürmektedir: Yeşil Devrim yoluyla modern bitki ıslahı pratiklerinin küreselleşmesi ve bitki genetik kaynaklarının korunmasına yönelik uluslararası çabalar. Bu iki gelişme birlikte gen

merkezli bitki ıslahı sistemini uluslararası düzeyde kurumsallaştırmıştır. Bölümün ilk kısmı, Yeşil Devrim'in mucize tohumları ve modern bitki ıslah sistemi aracılığıyla üretimci tarım paradigmasının gelişmekte olan dünyaya yayılmasını aktarmaktadır. Endüstriyel ve üretimci tarım vizyonunun yaygınlaştırılmasında Kamu-Filantropi iş birliğinin rolü vurgulanmaktadır. İkinci bölüm, uluslararası düzeyde genetik kaynakların korunması gündeminin ortaya çıkışını incelemektedir. Bitki genetik çeşitliliğinin korunması için uygun yöntemlere ilişkin bilimsel ve kurumsal çatışmalar hakkında ayrıntılı bir analiz sunmaktadır. Bu bölüm, iki güç kaynağının, epistemik kültür ve aktör-ittifaklarının, genetik kaynak koruma programının üretimci paradigma doğrultusunda tasarlanmasında fikirleri ve kurumları nasıl şekillendirdiğini göstermektedir. 1960'lardan itibaren Amerika Birleşik Devletleri ve Rockefeller Vakfı arasındaki iş birliği, üretimci paradigmayı gelişmekte olan ülkelere yaymayı başarmıştır. Bu gelişme teknolojik bir yayılmadan daha fazlasına işaret etmektedir. Gen merkezli modern ıslah sistemini genişleterek, üretimci paradigmanın kurumsal ağına yeni aktörler eklemiş, böylece genetik indirgemecilik fikrini ve bitkilere genetik içerikleri için değer vermenin uygunluğunu yaymıştır. Yeşil Devrim'in ilk sonuçları hem politikacıları hem de çiftçileri geleneksel tohumlarını modern tohumlar ile değiştirmeye ikna edecek kadar umut vericiydi. Yeşil Devrim geliştirilmiş bitki çeşitlerini yaydı, fakat bununla birlikte genetik çeşitliliğin hızla azalmasına yol açtı. Genetik erozyon terimi gündeme hâkim oldu ve genetik çeşitliliğin nasıl korunacağına dair ilk bilimsel toplantılar başladı. Bu toplantılar koruma programının yöntemi ve yönetişimi üzerine bilimsel ve kurumsal bir tartışmaya döndü. Bazı bilim insanları bitkilerin yerel halk için önemini ön planda tutarak doğal ortamlarında korunması (In Situ) için umutsuzca bastırırken, diğerleri üretimci paradigma güdümünde evrensel bitki geliştirme stratejisinin parçası olarak bitkilerin gen bankalarına korunmasını savunuyordu. Bu bölünme kısmen genetik disiplindeki bilimsel tartışmalardan kaynaklanıyordu, ancak aynı zamanda dünyayı beslemeye yönelik rakip vizyonların da bir yansımasıydı. Kısa süre sonra bu kez FAO ve CGIAR kurumları arasında genetik kaynakları kimin yöneteceğine dönük kurumsal bir mücadele başladı. Sonunda daha geniş kaynaklara sahip olan CGIAR gündemi ele geçirmeyi başardı. Böylece Uluslararası Bitki Genetik Kaynakları Kurulu (IBPGR) kuruldu. Kısacası bu mücadele, In Situ yöntemi veya FAO liderliğindeki hibrit bir yöntem yerine CGIAR'ın kontrolünde Ex Situ metotların benimsenmesiyle sonuçlandı. Ex Situ, bitki

ıslahçıların epistemik kültürünün tercih ettiği bir yöntemdi. Bu yöntemin kurumsallaşması için bilimsel argümanlar, teknik tasarımlar, politik ve ekonomik kaynaklar gerekiyordu. Bu kararlar birlikte bitki genetik kaynaklarını koruma fikri, araziler ve ıslahçılar arasında bir transfer noktasına dönüştü. Dolayısıyla koruma gündemi, modern ıslah sistemine tarımın üretimi paradigması doğrultusunda geliştirilmek üzere hammaddeleri sağlamak ile görevlendirildi. Başka bir deyişle, bitkilerin kendisinden ziyade ıslah sektörünün tedarik hatlarını korumak için tasarlandı.

Sonuç olarak, 200 yıllık bir süreyi kapsayacak biçimde bitki ıslah tekniklerinin değişimini takip eden bu tez, 20.yüzyıl bitki ıslah yöntemlerinin endüstriyel tarımın genel eğilimiyle birlikte geliştiğini ve doğrudan hammadde sağlamak için tasarlandığını doğrulamaktadır. Tez, bilim ve teknolojinin rolü üzerine önemli gözlemler sunmaktadır. Bunlardan ilki bilimin doğrudan teknik aygıtlar ve bilimsel kültürler aracılığıyla bitkileri genlere dönüştürmeyi başardığıdır. Fakat bu başarımlar mutlaka farklı toplumsal aktörlerin aktif katılım ve ittifakını gerekli kılmıştır. Dolayısıyla bu tez, teknolojik belirlenimciliğe itiraz ederek, bilimin teknolojiye dönüşümündeki politik süreçleri göstermiştir.

Bu tez mevcut literatüre farklı biçimlerde katkı sunmaktadır. İlk olarak, bu tez teorik çerçevesi itibarıyla, normatifliğe dair pratik odaklı bir yaklaşım ile Bilim ve Teknoloji Çalışmaları (STS) çıktılarından faydalanmıştır. Bu tercih analize önemli ölçüde katkı sunmuştur. Kullanılan teorik çerçeve bilim, teknoloji ve politika arasındaki çok boyutlu bağlantıları kavramsallaştırmayı mümkün kılmıştır. Özellikle pratiklerin toplumsallığı ve materyalliğine dönük bütüncül bir yaklaşım, teknolojik buluşlar ve onları çevreleyen siyasi bağlamı bir arada takip etmeyi mümkün kılmıştır. Dahası, bilgi üretim süreçlerini toplumsal ve politik bir faaliyet olarak kavramsallaştırmaya imkân tanıyan bu çerçeve, epistemik kültürlerin ve bilimin kurumsallaşmış izleklerinin etkilerini tespit etmeye imkân tanımıştır. Dolayısıyla bu tez uluslararası kurumsallaşma süreçleri üzerine bilim ve teknoloji odaklı bir çalışmada kullanılması durumunda teknolojik ya da toplumsal belirlenimciliğe düşmeden nedenselliği dağıtmaya imkân tanımaktadır. Böylece son dönemlerde görünür hale gelen teknolojiyi uluslararası siyasete içkinleştirme çağrılarına bir yanıt ve katkı sunmaktadır. Buna ek olarak, tezin bulguları bilim ve teknoloji arasında var olduğu

kabul edilen doğrusal bağlantının toplumsal aktörler ile onların siyasi, kültürel ve ekonomik kaygılarından nasıl etkilendiğini ortaya koymaktadır. Bu tespit sosyal bilimlerin genelinde yaygın olan temel bilim ile uygulamalı bilimi, bilim ve teknoloji ile siyasi ve iktisadi olanı ayırmaya dönük eğilimle çelişmektedir. Bu ayrıcı yaklaşımlar, analitik olarak hatalı olmasının ötesinde, aynı zamanda topluma dönük sonuçlar yaratmaktadır. Bu bulgular mevcut STS çalışmalarını destekleyerek katkı sunmaktadır.

İkinci olarak, eleştirel norm çalışmalarına yeni bir çalışma alanı sunmaktadır. Tezin özellikle ikinci bölümünde çoklu normatiflik iddiaları ve küresel gıda yönetimindeki ihtilafli konular aktarılmıştır. Geleceğe dair alternatif fikirler ve reform önerileri açık bir şekilde teknik ve bilimsel tartışmaların ötesindedir. Paydaşlar arasındaki keskin ayrım farklı bilgi sistemleri ve dünya görüşlerinden beslenmektedir. Bu tartışmalar, ampirik bakımdan zengin vakalar sunduğu gibi, aynı zamanda teorik ilerleme için bazı önemli hatlar barındırmaktadır. Üçüncü olarak, eleştirel tarımda çalışmaları bilimsel söylemin üretimi paradigmayı meşrulaştırıcı ve destekleyici rolünü belirtmektedir. Bu tez mevcut bulguları desteklediği gibi aynı zamanda pratik odaklılığı ile yeni inceleme alanları sunmaktadır. Tez pek çok kez önemsiz görünen teknik ya da bilimsel pratiklerin sonuçlarını vurgulamıştır. Bu nedenle, bu tez teknik bilgi ve detay odaklı incelemelerin üretimi paradigmanın yaygınlaşmasına dönük açıklamaları kuvvetlendireceğini göstermektedir. Bugün biyoteknoloji ve dijital tarım gibi yeni pratikler hızlı bir şekilde kurumsallaşmaktadır. Eleştirel çalışmalar bu tür bilimsellik söylemiyle desteklenen çözümleri yeni üretimi paradigmanın bir uzantısı olarak değerlendirmektedir. Bu gelişmeler eleştirel, tarihsel ve detaylara hassas bir bilim ve teknoloji anlayışının yeni tekniklere karşı bir direniş imkânı sunmasının ötesinde, aynı zamanda ona alternatifler üretmenin yolu olduğunu hatırlatmaktadır.

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