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RESEARCH ARTICLE

Contradictions between commercializing seeds, empowering smallholders farmers, and promoting biodiversity in Ghana: Seed policy within a historical framework

Kojo S. Amanor[1,*]

This article critically examines the agricultural development agenda of promoting commercialization and sustainable intensification and contrasts this with farmers' own priorities, with case studies drawn from the maize and cocoa sectors in Ghana. The study investigates the relationship between agricultural development paradigms, seed breeding strategies, and the commercialization of agriculture from the 1950s to present. It returns to the debates of farming systems research, the appropriation of the agricultural varieties of farmers within the South by Northern agribusiness, and Paul Richards' framework of an Indigenous African agricultural revolution rooted in the experimental traditions of farmers to establish a critical framework for examining the commodification of seeds. It focuses on the contradictions between maintaining biodiversity, fashioning high-yielding proprietary seeds, and promoting farmer participation that became manifest in the framework of farming systems research. It argues that commercial pressures have prioritized yields and the protection of proprietary varieties over biodiversity in policy frameworks. This contrast with farmers' own concerns with adapting varieties to the conditions on their farms through their own experimentation, and maintaining a diversity of changing genetic materials including those drawn from certified varieties. This enables farmers to hedge against risk, disease, and pest attacks, while selecting varietal materials that optimize yields in the particular agroecological conditions of their farms. Although social participation is still upheld as an important value in liberal market agrarian policies, there has been a significant transformation in its usage. It no longer denotes farmer participation in the design of and experimentation with technology, but participation in the consumption of the agricultural products of agribusiness or in the agricultural technology treadmill. This contribution examines the implication of smallholder agricultural commercialization for biodiversity and for the dynamism and vitality of local farming systems.

Keywords: Plant breeding, Sustainable intensification, Agrobiodiversity, Seed sovereignty, Informal seed markets, Intellectual property, Ghana

Introduction

Transnational agricultural investments in Africa have increased significantly since the early 2000s. This has been accompanied by an international development agenda of promoting smallholder agricultural commercialization and a New Green Revolution for Africa. This agenda has been supported by a coalition of Western donor agencies, international financial institutions and development foundations, including the Gates funded Alliance for a Green Revolution in Africa (AGRA). The New Green Revolution focuses on promoting new proprietary hybrid seeds, biotechnology, synthetic inputs, and mechanized technologies and opening up new rural markets in Africa for agribusiness (Bezner Kerr, 2012; Moseley, 2017; Rock, 2022). It promotes institutional and legal reforms to create intellectual property rights in seeds. It supports the creation of land markets, collateral, and credit and financial structures to encourage the uptake of modern technology by farmers. These developments build upon the economic liberalization policies of the late 1970s that sought to privatize public agricultural research in Western countries. This framework has been extended into African countries through structural adjustment programs that opened up state agricultural services to investments by international capital. These policies are usually implemented within the context of public–private partnerships and development platforms in which African governments are encouraged to create favorable conditions for investments by transnational corporations.

[1] Institute of African Studies, University of Ghana, Legon, Ghana

* Corresponding author:
Email: kojoamanor@gmail.com

The New Green Revolution for Africa promotes agricultural markets, but also claims to support sustainable green and equitable development. Equitable development is concerned with promoting "enabling markets," in which credit facilities, loans, and contracts are extended to farmers, groups, and communities, often with an emphasis on women's access to new technologies (Gengenbach et al., 2018). This also facilitates the integration of smallholder farmers into the food commodity chains of agribusiness. It assumes that the interests of smallholder farmers converge with the commercial interests of agribusiness in using synthetic inputs to achieve maximization of yield, conveniently contributing toward corporate profits realized through higher sales of agricultural inputs (Moseley et al., 2015). The dominant narratives of sustainable development within the New Green Revolution approach focus on promoting increased productivity through the greater use of synthetic inputs and industrial agricultural technology. It is assumed that increases in productivity will alleviate the need to expand production into new areas, leading to a reduction in deforestation and land degradation (Smith, 2013; Bergius and Buseth, 2019; AGRA, 2022). However, there is little evidence to support these claims. The deforestation of the Amazon, for example, is primarily associated with the expansion of agribusiness and large agricultural estates rather than with the activities of peasant farmers. Similarly, the recent expansion of agricultural commercialization in Africa has been associated with the rise of investments in land by urban-based medium-scale farmers; this displaces peasant cultivators who are then forced to migrate to new frontier areas where land is available (Jayne et al., 2014).

The notion of a New Green Revolution rooted in agricultural commercialization and integrating farmers into agribusiness value chains has increasingly marginalized farming systems research (FSR) and agroecology approaches within mainstream agrarian development.[1] Paarlberg (2010), for instance, dismisses agroecology for being far less productive than green revolution approaches, because it rejects the use of off-farm inputs. He argues that the agroecology solutions are not significantly different from those used by African smallholders who "practice something suspiciously close to agroecology" (Paarlberg, 2010, p. 67). He characterizes these as based on low input usage, low yields, long hours of drudgery, and low returns to labor. Similarly, Farrington (1995) has characterized FSR as rooted in an anti-growth and anti-development frameworks that has hindered its ability to generate significant off-the-shelf technologies for farmers. While this has become a common perspective in mainstream agricultural development, this misrepresents the core objectives of FSR and agroecology and places agricultural technology development within a narrow, simplistic, and dogmatic framework, without any multifaceted socioeconomic context.

Prior to the rise of the contemporary neoliberal agricultural development agenda, FSR played an important role in attempting to solve the constraints of the Green Revolution within mainstream programs of agricultural technology generation. It sought to understand the underlying agroecological and economic rationale of peasant agriculture in diverse and risk-prone environments and to build a capacity within newly established national agricultural institutions to undertake research into peasant-based agriculture and facilitate reflexive learning. As a result of the shift to a corporatist agenda of integrating smallholders into agribusiness food chains, the framework of FSR has been increasingly at odds with mainstream agriculture. Consequently, the more critical and ideological frameworks within FSR converged around the concepts of agroecology and food sovereignty to create a social movement that became highly critical of the corporate-driven agricultural research agendas. Within agroecology, mainstream agricultural development is seen as fostering a dependency among peasant farmers on commercial agricultural technologies, which ultimately undermines their knowledge systems, innovatory capacities, and autonomy (Altieri and Toledo, 2011; Martínez-Torres and Rosset, 2014). The food sovereignty and agroecology movements advocate for the defense of the rights, values, and cultures of peasant agriculture and indigenous people against the expansion of agribusiness. In contrast, the main focus within FSR has been on integrating and institutionalizing farmers' knowledge and genetic resources into mainstream agricultural research to overcome difficulties in creating varieties that met the needs of farmers in rainfed risk-prone environments. FSR has been largely co-opted into commodity-oriented research, albeit within public research systems. Within this sphere it has attempted to negotiate contradictions between adaptive research systems involving farmer participation and farmers' genetic varieties, and the commodification of research. This ultimately results in the release of commercial varieties that displace local varieties and crop biodiversity. The relative long history of FSR, as compared to agroecology, and its internal tensions provide a useful framework for examining the transformations that have occurred recently within international and national agricultural research systems, which integrate them into international agribusiness agendas, and the implications of these developments for smallholder farmers. The role of FSR in incorporating farmers into the participatory breeding of modern varieties also provides a useful framework in which to

1. Farming systems research refers to a set of interdisciplinary diagnostic research methods used to understand smallholder farming strategies and decision-making and to understand the major constraints in public agricultural research establishments in developing countries in generating technologies for smallholders farmers (Collinson, 2000). Agroecology originally referred to a holistic and integrated approach to sustainable agriculture based on a farming systems approach that analyzed the relationship between smallholder farming systems within ecological and social frameworks. With the expansion of agribusiness and commercial agriculture in developing countries, it has grown into a social movement articulating alternatives modes of agricultural development to the dominant capitalist industrial agribusiness based on preserving community and peasant cultural values (Altieri and Toledo, 2011; Martínez-Torres and Rosset, 2014; Giraldo and Rosset, 2017).

examine farmers' experimentation as a modern activity concerned with adapting technology to contemporary local farming conditions, rather than as a system of traditional cultural values of peasant farmers.

The main achievements in FSR are reflected in the development of new proprietary commercial varieties adapted to a variety of conditions, not in the development of farmers' own varieties. However, FSR has embodied contradictions between commodity-oriented research based on adapting new seed lines to local conditions, the building of research capacities among smallholder farmers, and the development of a theoretical critique of the limitations of commodity-oriented adaptive research. A critique of the Green Revolution and commodity research initially developed out of practical attempts to develop a research agenda that was responsive to the needs of smallholder farmers, rather than from a specifically ideological framework. The persistence of mainstream agricultural research in reinventing package technologies of modern seed varieties and agribusiness inputs, which became repackaged in the 1980s in the Sasakawa Global 2000 (SG 2000) program and in the 2000s in AGRA, led to a deepening of the critique of Green Revolution approaches. Therefore, a focus on the historical framework of FSR in smallholder farming systems and the debates around the commodification of research provides useful insights in the nature of agricultural technology development, but also in the contradictions embodied in contemporary systems of corporate-driven agriculture research.

Although loss of biodiversity hardly features in the modern Malthusian narratives of the need to intensify production, it was of fundamental concern to agricultural debates in the 1980s and 1990 around the implications of the rising commercialization of seeds, expansion of biotechnology, and the control of the seed industry by transnational corporations. Hence, it is worthwhile to return to this literature to understand the origins and evolution of debates about agricultural intensification, sustainability, and commercialization. This needs to be understood in the context of both the critique of the Green Revolution and debates that occurred in the 1980s around intellectual property rights in crop genetic resources in the United Nations and the Food and Agricultural Organization of the United Nations (FAO).

The significance of FSR cannot be reduced to its impact on farmers' yields. Its main objective was to facilitate a better understanding of the dynamics of peasant-based agriculture in diverse and risk-prone environments, to encourage the development of national research services that built better linkages with farmers, and to create a framework for developing technologies that were better adapted to the conditions in which poorer farmers operated. Therefore, this article focuses on 4 aspects of FSR: its role in facilitating the development of national agricultural research services and their capacity to undertake adaptive research; its appreciation of the role of farmers' experimentation in agricultural technology development; the recognition of the vulnerability of intensively cultivated monocultures to pests and diseases; and the importance of agrobiodiversity and preserving the common proprietary genetic resources of farmers against commercial pressures of proprietary ownership of seeds. It examines the development of seed research within a historical framework that examines the development of national agricultural research systems against the backdrop of the expansion of agrarian capitalism and shifting paradigms of agricultural development. The second part of this study focuses on case studies of the maize and cocoa sectors in Ghana, tracing institutional developments within these 2 sectors from the 1950s to the present. These 2 sectors possess the longest history of crop research development in Ghana. This section contrasts the commodity-oriented focus of research stations with farmers' own experiences and experimental approaches and their attempts to diversify the properties of seeds. This article draws upon a large amount of secondary literature and a number of research papers I have written in the maize and cocoa sectors since the 2010s. These use a number of different research methods, including the analysis of policy and research documents to develop a history of development within research institutions and farming systems and perceptions and changing paradigms of agricultural development; interviews with development agents, researchers, seed breeders cereal traders; and semi-structured interviews with over 230 farmers conducted between 2010 and 2012 in maize and rice producing areas in 4 settlements in the Bono East and Northern Region of Ghana (Amanor, 2010, 2013), and over 500 cocoa farmers in 10 settlements in the Eastern and Western North Regions of Ghana in 2020 (Amanor et al., 2022). Since the case studies are presented in detail in a number of readily available works, the salient features are summarized rather than described in detail. My main concern here is to reflect upon the findings of these case studies in the context of a historical analysis of the institutional development and framing of agricultural crop research in Ghana, and recent transformations within international agricultural research. This explores the tensions in the interface between national and international research centers and smallholder farmers, and in the discourses about agricultural development, environmental conservation, protecting biodiversity, and the role of agricultural commercialization.

Farming systems research

FSR arose in the 1970s in the context of the disappointing performance of Green Revolution technologies in many parts of the South, including a large part of Africa. This was particularly associated with areas characterized by rainfed agriculture and environments that were highly diverse and complex. This contrasted with the irrigated environments of Southeast Asia where Green Revolution technologies performed significantly better. FSR sought to understand the reasons why Green Revolution technologies performed badly in these rainfed environments. This required a detailed understanding of local farming practices and strategies, and of the characteristics of the local varieties used and maintained by farmers. Studies of cropping systems revealed that rainfed farming systems in Africa were characterized by conditions of uncertainty and risk, and that farmers adapted to these by cultivating a diversity of crops and varieties of crops adapted to differing environmental conditions. This included early and late maturing varieties, and cultivars with differing resistance to pests and diseases. Varieties were also adapted to different types of vegetation and soil catenas. The wide variety of genetic materials utilized by African farmers assured them some yield under erratic rainfall conditions, with some varieties compensating for the failures of others. Thus a major concern in local farming strategies was to manage risk through diversification (Norman, 1978; Simmonds, 1984; Collinson, 1988; Chambers et al., 1989; Collinson, 2000; Brush, 2004; Bingen and Gibbon, 2012; Behera and France, 2016; Schnurr and Dowd-Aribe, 2021).

In most African countries, particularly those administered under indirect rule, the building of any meaningful agricultural research system only began to occur in the 1950s when new structures of bureaucratic administration were created, including the first agricultural experimental research stations (Hodge, 2007). Thus, the colonial expert played a truncated role in the emergence of African agricultural research. Some of these experts continued to work in African countries in the early years of independence to facilitate the building of national research and development capacity. But many moved to the international agricultural research centers (IARCs) that were created in the postwar period. This fostered close ties, but also a relationship of dependency, between the IARCs and the emerging national agricultural research capacities. One of the central objectives of FSR was to build the capacity of national research to improve the relevance of its research agenda for smallholder farmers and gain a better understanding of the dynamics of local farming systems (Collinson and Lighfoot, 2000). A second objective was to overcome the weaknesses of existing research knowledge by creating new institutional linkages with farmers, and to draw upon the existing knowledge of farmers that lay beyond the confines of experimental stations. This resulted in a participatory dimension of learning and knowledge dissemination (Biggs and Clay, 1981). Therefore, FSR was rooted in incremental knowledge acquisition based on learning by doing, reflexivity, and interacting with farmers.

The recognition of the significance of local farming strategies and crop varieties resulted in the incorporation of farmer participatory trials into mainstream crop breeding programs. This enabled researchers to adapt new crop varieties to farmers' needs and strategies, through the development of feedback mechanisms in which researchers continually refined their crops on the basis of evaluation by farmers (Rhodes and Booth, 1982). It also led to the collection of local cultivars within international agricultural centers, providing scientists with access to a wide range of genetic material that could be used and incorporated into certified varieties. IARCs played an important role in facilitating adaptive trials in national agricultural research centers, in which promising genetic lines were crossed with farmers' varieties to fine-tune them to local conditions. This was instrumental in the development of the capacity of national agricultural research centers to release certified varieties adapted to local farming environments.

The rise of new high-yielding varieties in the 1980s that were adapted to local conditions and also responsive to synthetic fertilizers benefited from the application of the FSR approach. This also encouraged the relaunch of Green Revolution approaches in Africa under the SG 2000 program, with the support of Norman Borlaug, the architect of the Asian Green Revolution. SG Global 2000 sought to stimulate demand for new varieties and inputs through mass distribution of seeds and fertilizer packages to farmers. This resulted in a lively debate about the appropriateness of standardized input packages for African conditions, which was highlighted in *Development Policy Review* in 1995 and 1996. In these journal issues Borlaug and Dowswell (1995) argued that the major challenges in African agriculture were rooted in population growth, a looming food crisis, and poor public service management of agriculture. These problems could only be solved by reforming and privatizing agricultural services to achieve a more comprehensive delivery of modern technology. Farrington (1995) countered this and argued that the main problems lay in the nature of agricultural technology generation. African farmers operated under diverse, risk-prone environments characterized by complex interactions between different system dynamics. The ability to identify varieties suitable for the large number of niches required the development of a sophisticated research system, which would not be achieved merely by privatization and the development of infrastructure. This required a new approach to technology rooted in more participatory institutional structures (Farrington, 1995). Jiggins et al. (1996) argued that there were wide variations in production systems in Africa over time and space, which were not easily grasped within a single model, or solvable by standardized technology packages. In some farming systems there was evidence of degradation of natural resources, but others exhibited clear trends of rising productivity and improved resource management. Jiggins et al. (1996) argued that the scenario of an African agrarian crisis was concocted out of highly selective data, which did not take into consideration the relative success with roots, tubers, millet, and sorghum, and ignored many indigenous crops, such as cola. Furthermore, the data compared crops grown by smallholders without inputs with modern varieties cultivated with inputs. When protected with insecticides, local cultivars often achieved comparable yields to improved seeds. They argued that an analysis of African farming systems needed to account for the negative impacts arising out of unsuccessful adoption of modern varieties, where for instance farmers abandoned their own knowledge and skills adapted to particular localities to embrace agricultural modernization, but without any notable gain in yields (Jiggins et al., 1996).

FSR led to the increasing realization that farmers are engaged in dynamic processes of experimentation. Richards (1996) argues that the world of farmer experimentation in crop varieties is not only constituted by their indigenous varieties but also embraces modern varieties, in which farmers hold a deep but critical interest. While some farmers are concerned with selecting pure genetic materials, others are more interested in the experimental adaptation of a wide variety of genetic materials and crosses, and welcome the introduction of exotic materials and modern varieties to broaden their gene pool. Richards (1996, p. 222) notes:

> *Farmers in Mogbuama say "it is the nature of rice to change" and they see themselves as actively assisting this process, by carefully collecting variants of a crop. While some farmers select for genetically pure materials others welcome the possibility of experimental adaptation implicit in genetically mixed landrace material, especially where introductions of exotic material has broadened the local gene pool.*

The plant genetic world of farmers is constituted by their own preservation of genetic materials, external acquisitions, and inadvertent crosses that occur outside of their experimentation. Richards (1996) describes the case of Three Months, a short-maturing variety based on African *glaberrima* rice, which was taken by farmers from genetic materials discarded by rice breeding stations. This leads Richards to advocate a line of experimentation that reverses the norms conducted in formal rice research. This involves improving local *glaberrima* varieties with genetic materials derived from *O. sativa*, rather than improving modern varieties with genes derived from local landraces. Richards (1996) notes that farmers often prefer a portfolio of different varieties, which they can adapt to different conditions, rather than a single high-yielding, outperforming variety. He argues that low-input low-output varieties may produce more promising genetic materials for farmers than high-output varieties that require large amounts of inputs under marginal conditions. Under the conditions of economic recession and adverse ecological change, which characterized the 1980s and 1990s, "glaberrimas [were] undergoing something of a renaissance in parts of Sierra Leone" (Richards, 1996, p. 222).

From this perspective, farmers' varieties are the product of a process of experimentation and adaptation, in which the varieties are ever changing and in a process of interaction with farmers. Thus, the most important elements to support and preserve are the creative interactions between farmers, environments, and crop varieties; and the continual sharing of knowledge. Unfortunately, the dynamism of this approach to agriculture is not reflected in agricultural policy prescriptions, which have largely been shaped by the rise of agribusiness, and the marketing of commercial varieties (Kloppenburg, 1988; Buttel, 1991; Swanson et al., 2003; Clapp, 2018). It is thus important to understand how the structural changes that occurred in agriculture during the 1980s have come to shape and redefine the agricultural development agenda, and transform notions of participation.

Intellectual property rights and farmers' varieties

The rise of farmer participation and interest in farmers' knowledge systems in developing countries coincided with a period of expansion of biotechnology, the increasing privatization and control of genetic resources by transnational corporations, and cutbacks in national agricultural research and extension services (Mooney, 1983). The positioning of IARCs within the global seed industry as producers of semi-finished products for further adaptive research by national agricultural research centers has facilitated the appropriation of the genetic materials of the South (Mooney, 1983; Kloppenburg, 1988). The rationale behind this was to support the development of national research by releasing improved germplasm that national breeders could refine and adapt in their own breeding programs. However, this has enabled northern companies to freely access the genetic materials collected from farmers in these centers for the development of their own commercial varieties.

The creation of scientific seed breeding in the North has resulted in a few high-yielding crop varieties wiping out the genetic diversity that had previously existed (Mooney, 1983; Kloppenburg, 1988). While these new varieties offered many advantages, their uniformity increased vulnerability to diseases. To counter these threats breeders had to return back to the centers of genetic diversity to seek out genetic materials that offered resistance to disease. As a consequence of this, the genetic contribution of the South to the North has been considerable. Unfortunately, lessons have not been learnt from the past by northern transnational corporations, which continue to actively promote the uptake of a few high-yielding varieties that they control, resulting in heightened erosion of the remaining genetic diversity in the south, which is appropriated and converted into intellectual property rights and commercial varieties claimed by Northern transnational corporations (Kloppenburg, 1988).

In the early 1980s, in the era of North-South dialogue and the New International Economic Order, the negative impact of the expansion of the activities of multinational corporations in the South generated considerable debate and concern within academic and development circles. This resulted in research that critically analyzed the modes through which the structures of international agricultural research support the commodification of knowledge, its appropriation by multinational corporations, and the implications for genetic diversity (Mooney, 1983; Kloppenburg and Kenney, 1984; Sell, 2009; Clapp, 2018). Most alarmingly, these new varieties achieved high yield through dependence on the use of agrochemicals. Increasingly the handful of corporations that control seed production have strong economic bases within the agrochemical and petrochemical industries (Mooney, 1983; Kloppenburg and Kenney, 1984). These transnational corporations have increasingly moved into the South, marketing agrochemicals and high-yielding proprietary seeds that displace local varieties of farmers and local farming practice. This results in rapidly expanding monocultural cropping systems (Brush, 2004; Weiss, 2007; Altieri and Toledo, 2011; Clapp, 2018; Stone, 2022).

By the early 1980s the rise of intellectual property rights in seeds and the appropriation of farmers' knowledge to create new genetic varieties began to be challenged within the United Nations and the FAO led by Latin American countries. This was taken up by developing countries, calling for the full and free exchange of plant genetic resources. However, this was resisted by Northern nations, with arguments that: "the inclusion of such material would rob commercial breeders of the fruits of their labour and compensation" (Mooney, 1983, p. 40). These demands for reforms in international agricultural seed breeding were closely related to the calls for a New International Economic Order, which originally emanated from the United Nations Economic Commission for Latin America.[2] African states took up this call for reform, which they presented in the Lagos Plan for Action to deal with the economic recession. This was fiercely resisted by the growing forces for neoliberal reforms in the West, which presented an alternative program of structural adjustment (Ake, 1996; Arrighi, 2002). This argued that the main problems in the Africa were the products of internal political constraints, poor governance and political distortions by states, and prescribed a palliative of rolling back the state, privatizing public services, and opening up the economy to private investment (Bates, 1981; World Bank, 1981). The program of market liberal reform gained ascendancy and was implemented throughout Africa.

The long-term consequences of global market liberal reforms for the seed sector included the privatization of crop improvement services; the creation of legislation to facilitate intellectual property rights in seeds; the reorganization of the agricultural sector by agribusiness under the concept of value chain governance; and the expansion of biotechnology under corporate ownership. This has frustrated the growing recognition among researchers working within international agricultural research of the need to address the looming environmental and social problems emerging out of the expansion of agribusiness and commercialization of agricultural resources, and the pressures of the corporate lobby (Buttel, 1991; Bennet, 2002; Clapp, 2018). The transition to a commercial agricultural system has effectively disoriented FSR within mainstream research, which has become lost in the new hierarchies of food chain governance established by transnational corporations that emphasizes standards, grades, and proprietary brands and leave little scope for local experimentation and adaptation.

The following section examine the impact of commercialization on crop research in Ghana, tracing developments within the maize and cocoa sectors. This contrasts the strategies of farmers with the priorities of national agricultural research services. It also examines the impact of economic liberalization on national agricultural research sectors and the transformations brought about by privatization and investments by international capital.

Agricultural research in Ghana

Ghana consists of 3 major agroecological zones: high forest, transitional, and savanna. The high forest zone is largely under cocoa cultivation, with oil palms, rubber, root and tubers, and swamp rice comprising the most important crops. Cocoa is by far the most important export crop with Ghana, providing over 20% of global supplies. The major crops in the transition zone consist of maize, yam, vegetables, and pulses, with cashew and mango now constituting important export tree crops. The major crops of the savanna zone consist of cereals—in which maize is increasingly displacing millet and sorghum, rice, and pulses.

From the 1890s, cocoa developed as the most important export crop whose cultivation was experimented upon and taken up by Ghanaian farmers before colonial rule. Following independence, the government sought to promote national food security through the modernization of the food sector. The main focus in the early independence period was on building state farms and farmer cooperatives in the northern and transitional zones. During the early 1970s the main focus in agricultural policy shifted to providing support for a class of national capitalist farmers within the rice sector in northern Ghana. Although the large commercial farm sector collapsed in the mid-1970s, the transition zone emerged as the main producer of food crops for urban markets in the 1970s, largely produced by smallholder farmers under rotational bush fallowing cultivation. Recently, a class of medium-scale commercial farmers has become significant within the northern sector. Many recent initiatives promote smallholder uptake of external inputs and new seeds.

The major crops in which national seed breeding capacities have developed include cocoa, maize, oil palms, and cowpeas. However, many of the national seed breeding programs are in decline as input delivery systems are increasingly privatized and dominated by foreign companies. During the heyday of national crop research in the 1980s and 1990s, allocation of research funding was highly concentrated on a few crops. Cocoa research received over 45% of agricultural research funding while contributing about 17% of Agricultural Gross Domestic Product (AGDP). The prioritization of research in national agricultural research was measured in terms of allocations of research time of researchers per pear to specific commodities. In 1988, 16 person years per year were allocated to cocoa research, 11 to maize, 6 to oil palm, and 5 to cowpea (Council for Scientific and Industrial Research and International Service for National Agricultural Research, 1991). Most research time was allocated to the dominant or priority crops within international agricultural research rather than those that are most prominent among smallholder cultivators. Thus, root and tuber crops (including yams, plantains, and cassava), which account for over 40% of AGDP only received 7 person years of research time

2. Mooney's publication *The Law of the Seed* was also commissioned by the Dag Hammarskjöld Foundation in the context of recognizing the importance of seed issues to its vision of a New International Economic Order and its framework of "Another Development," defined as development that is "need-oriented, endogenous, self-reliant, ecologically sound, and based on structural transformation" (Development Dialogue Editorial, 1983, p. 1).

allocation since they lacked a high profile in international agricultural research (Council for Scientific and Industrial Research and International Service for National Agricultural Research, 1991; Plan Consult, 1993).

Following the introduction of economic liberal reforms, agricultural sector research and extension in Ghana has become characterized by complex networks and platforms of international agribusiness concerns, national private corporations and traders, state agencies, nongovernmental organizations (NGOs), venture capital firms, and microfinance corporations, and farmer associations (Guyver and MacCarthy, 2011; Sarpong and Anim-Somuah, 2014; Kolavalli et al., 2015; Amanor, 2020). In the largest export sectors, such as cocoa, the main agribusiness corporations establish national platforms through which they bring together a number of partner organizations to establish control over the food value chain and the distribution of inputs (Amanor, 2020).

Maize varieties, farmer adaptation, and markets in Ghana

The origins of modern maize plant breeding in Ghana can be traced back to the outbreak of American Rust disease in Africa in 1949 (McCann, 2005). This decimated production on the Gold Coast and led efforts to create an experimental agricultural research station at Kwadaso to search for local rust-resistant varieties. In 1958, a Hybrid Seed Maize Production Unit was created, but the difficulty of producing hybrids led to a refocus on open-pollinated varieties in 1961 (Delimini and Wobil, 1998). In 1964, the Crop Research Institute was inaugurated at Kwadaso. The major focus of its research was to identify international varieties that performed well under local conditions, which could be multiplied and distributed to farmers by the Seed Multiplication Division.

By the 1970s, national seed breeding institutions began to develop the capacity to adapt promising international lines to local conditions through crossing them with local varieties. This arose out of close linkages with International Agricultural Research Centers, including the International Institute for Tropical Agriculture and the International Maize and Wheat Improvement Center, and the West African Rice Development Association. These relationships provided training for Ghanaian seed breeders and access to the genetic collections within these centers. Ghanaian plant breeders were able to screen these varieties for performance under local conditions, cross them with other varieties, and evaluate their performance through farmer participatory trials and farmer evaluation of the varieties (Amanor, 2010). In 1979, this research capacity was expanded with support from Canadian International Development Aid to the Ghana Grains Development Project. Working within an integrated FSR framework, this addressed issues concerned with yield, disease, resistance to stress, maturing periods, and adaptability to different ecological conditions. This included a program of on-farm trials and demonstration plots, conducted by research and extension agents, to rapidly adapt varieties to existing farm conditions and support the rapid dissemination of new varieties to farmers.

During the mid-1980s, the first certified maize varieties of maize were released in Ghana. These included La Posta, Dobidi, Kwanzie, Aburotia, and Safita-2. They bore local names, reflecting the process of adaptation to local conditions and use of local varieties in adapting international lines. Aburotia and Safita-2 were early maturing varieties. However, these new improved varieties were susceptible to outbreaks of maize streak virus in the 1980s and were replaced by new varieties in 1988, which included Okumaso, Abeleehi, Dorke, and Obaatanpa (Tweneboah, 2001). Obaatanpa, a much-heralded Quality Protein Maize variety, gained repute, popularity, and markets in other African countries.

Unfortunately, the beginnings of success in maize breeding intersected with the period of structural adjustment and the privatization of government agricultural services. Seed production was restructured within Ghana and organized into 2 agencies, the Ghana Grain and Legumes Board, which was concerned with regulating seeds and producing foundation seed, and the Ghana Seed Company (GSC), which had the mandate to produce certified seed. With support from United States Agency for International Development (USAID) the GSC was transformed into a semi-autonomous corporation, with a long-term concern to privatize it when it became commercially viable. After 10 years of poor performance, and an inability to attract foreign investors, the GSC was closed down and restructured. The seed growers were reconstituted as a private association contracted by the state and other parties to produce seeds. Most of these seed growers have struggled; they have been unable to establish viable privates sector companies and became reliant on the state and NGO programs for contracts (Amanor, 2010). There remains a low demand for certified seed among farmers. While they readily adopt modern varieties, they usually multiply them from their own selected seed stocks rather than purchase them from agrodealers. As a consequence, the earlier dynamism of release of new varieties has stagnated. While new varieties continue to be released by national services, constraints within the national seed multiplication system have resulted in the decline of the national output of certified seeds. Many of the new civil society and public–private partnerships that promote the uptake of modern maize varieties and inputs now rely on imported seeds from transnational corporations.

The removal of agricultural subsidies following the implementation of structural adjustment depressed demand for fertilizers and certified seeds, since this resulted in a significant increase in the price of fertilizers. Hailu (1990) estimated that in 1981 the price of one bag of maize could purchase 5.5. bags of fertilizer as compared to 3.3 bags in 1986. Between 1990 and 1994 an average of 24,568 tonnes of fertilizer was imported per annum, as compared to an average of 38,595 in the period 1985–1989. The opening up of food markets also enabled increasing staple food crops to be imported, depressing local market prices. Thus imported rice increasingly replaced maize within the urban diet. Rice imports increased from around 30,000 tons a year during the

1970s and 1980s to between 500,000 and 650,000 tons per annum since 2010.[3]

During the 1960s and 1970s, the government of Ghana promoted the opening up of a new zone of food production based on mechanized and high input agriculture in the transition zone and Northern Region. By the 1970s and early 1980s, intensive zones of maize production emerged around state farms in the middle belt of Ghana. The high cost of inputs under the structural adjustment program led to the rapid collapse of many of the state farms and large commercial estates (Amanor and Pabi, 2007). However, peasant farmers in adjacent areas shifted into maize cultivation and became major suppliers to urban areas. They took advantage of the availability of migrant labor, which had moved into the transition zone to seek employment in the large commercial farm sector, to intensify and expand their cultivation. They usually integrated maize with other crops, including yam, cassava, sorghum, legumes, and vegetables, in systems of rotational bush cultivation, in both the parkland environments of the northern transition zone and the semi-deciduous forest dry zone. Maize emerged as the dominant crop within the dry-semi deciduous forest zone, and as an important complement to yam in the transitional parkland areas. Both areas have bimodal rain seasons, enabling farmers to cultivate 2 maize crops in a year. However, the minor rain season is short and often characterized by erratic rainfall. In both areas, farmers relied on fallowing systems for managing soil fertility, rather than the use of synthetic fertilizers (Amanor and Pabi, 2007). These low input farming systems have played an important part in meeting the national demand for food. However, the continued use of local varieties and reluctance to use fertilizers by farmers challenges the legitimacy of national and international agricultural development agendas based on promoting high input agriculture. Thus, the main policy approaches have been to encourage uptake of new technologies rather than encourage existing low-input farmer initiatives.

In the late 1980s, SG 2000 worked with government extension services to provide farmers with inputs and seeds on credit. SG 2000 started working in Ghana in 1986 and focused on distributing certified maize seeds and fertilizers to farmers and establishing demonstration plots throughout the country, which also served as seed multiplication units. The SG 2000 program provided farmers with 3 years of credit in seeds and fertilizers. In many instances, farmers reverted to their old varieties and low input cultivation when the credit ended. However, the mass dissemination of Obaatanpa resulted in considerable mixing between varieties, particularly since many farmers chose to continue to plant from seeds they have harvested rather from a new stock of purchased certified seeds. The SG program also experienced low recovery of loans, which dropped to 45% in the 1990s. In 2003, the program was closed down having spent US$20 million in Ghana in promoting uptake of new farming technology (Dawson, 2002). SG 2000 has been followed by a spate of programs providing inputs and input subsidies for farmers. This included "smart" subsidies of fertilizers introduced by the state in the early 2000s, the government Block Farming Program, Planting for Foods and Jobs, and initiatives by the International Fertilizer Development Corporation, the Millennium Challenge Corporation, AGRA, and USAID to promote the uptake of new technologies. In recent years some of these programs have become associated with specific agribusiness corporations. For instance, USAID has sponsored a program in northern Ghana in which the American NGO ACDI-VOCA works with DuPont Pioneer to mobilize farmers in northern Ghana to take up cultivation of Pioneer seeds and input packages (Guyver and MacCarthy, 2011; Rock, 2022). Similarly, Wienco (the largest national input dealer in Ghana) with Yaara (one of the 2 largest fertilizer producers in the world) established Masara Narziki (a farmers' association) specifically to promote the uptake of hybrid maize and fertilizers. While the farmer's association and input distribution sector of Wienco subsequently expanded, it has recently been acquired by RMG Concept, an African subsidiary of Syngenta. This indicates the rapidly expanding interest of large transnational agribusiness corporation in African seed and input markets (Amanor, 2020).

Although the main local variety (*Apea* or *atia*) grown by farmers in the Bono East Region has become increasingly genetically intermixed with Obaatanpa, this is not really a problem for farmers, since diversity and change over time are taken to be inherent characteristics of local varieties. Many former certified varieties that have been officially delisted have entered the lexicon of local varieties, worked upon, and adapted by farmers (Amanor, 2013). In the Bono area, many farmers cultivate both their local varieties and Obaatanpa. The local varieties are often cultivated during the major season and Obaatanpa in the minor season, where its short maturation is an asset against this shorter and more erratic minor rain season. Some farmers multiply and reuse purchased certified seeds for further planting; only acquiring new seed stock when the seed phenotypes begin to change (Amanor, 2013). Other farmers are more interested in the changes that occur in the mixtures and select for new characteristics they admire. Thus, the mixtures of seeds existing on farms are in a perpetual flux, offering farmers opportunity for selecting seeds that perform well in specific environments and cropping systems, and in responses to changes in the environment and farming system.

The maize sold in regional wholesale markets does not consist of specific varieties but a mix of different varieties. Many maize traders view different areas as having distinct qualities of maize that are not characterized by specific varieties but by the mix of varieties, the cultivation practices, and the soil and environmental qualities of the locality. In Kintampo market Ibrahim Tonko, a maize trader, noted:

3. See Index Mundi: Ghana Milled Rice Imports by Year/ indexmundi.com/agriculture/?country=gh&commodity=milled-rice&graph=imports. Sourced November 1, 2023.

> *The varieties are all mixed up . . . The maize from the Northern Region does not rise [when fermented] as well as that of the south. That is why the Accra and Kumasi traders prefer the maize from Brong Ahafo than from Tamale. The varieties in the north and here [Brong Ahafo] are mixed up. But the nature of the varieties varies in different area. Maybe this comes from the land more than the variety.* (Amanor, 2013, p. 7)

Similarly, at Wenchi market, Alhaji Zongo commented:

> *Every variety has its own strength and each area of maize has its local characteristics. Sunyani maize is different from Kintampo maize. The traders don't buy by variety; they buy everything.* (Amanor, 2013, p. 8)

There are no price differentials based on varieties, although there are price differentials for the quality of grains. For instance, powdery mildew-affected grains receive lower prices. However, certain varieties store better than others, so farmers who cultivate Dobidi or Para, which are reputed to store poorly, will generally receive poorer prices for their maize. While urban traders may not know all the varieties cultivated by farmers, the qualities they value in maize often leads them to prefer local varieties over improved varieties, since these have been selected to embody the qualities desired by consumers, and since local culinary practices are based on these genetic materials. However, traders tend to seek out the grain from specific markets rather than from specific varieties.

The evidence suggests that farmers cultivate a complex mix of maize varieties that result from the availability of seeds, but also from a conscious choice to mix varieties and select out new qualities, for their aesthetic, storage, milling, and fermentation qualities. For instance, one woman farmer, Grace Obuor of Badu, stated:

> *I like Obaantanpa as it matures early, but it does not yield as heavily as* atia *[the local variety]. So in the minor season I plant a mixture of* atia *and Obaatanpa in case the rains fail.* Atia *doesn't do well if the rains fail.*

In contrast, Stephen Tanor, also farming at Badu, explained his reasons for preferring the local varieties, and the difficulty of sourcing a single variety of seeds for planting from cultivated seed:

> *I prefer* atia *because the seeds are small and you get a better yield. The Accra maize traders also like* atia. *It also stores well. But it is difficult to get sufficient quantity of* atia *to plant [since] all the maize is mixed up.*

In a survey of 148 farmers in the settlements of Badu and Subinso, 34% stated they preferred the local maize variety, 35% preferred the improved variety, and 20% stated a preference for combined cultivation of both. Fifty-two of the farmers preferred the local variety, of which 57% identified its high yielding qualities as the main reason, and 23% its good storage qualities. Of the 54 farmers preferring the improved variety, 58% based their preference on early maturity and 26% on high yields (Amanor, 2013). Therefore, farmers' main reason for preferring local varieties relates to high yields, and their main reason for preferring improved varieties relates to early maturity—an important consideration in cultivating maize during the second short rain season. This goes against conventional wisdom, where it is assumed that certified varieties provide superior yields to local varieties (and local varieties are better adapted to local climatic factors).

Agricultural extension agents in these settlements were skeptical about these claims of farmers that their varieties provided higher yields, but conceded that this may be the result of improper use of inputs and the failure of farmers to follow recommended cultural practices (Amanor, 2013). The dominant farming practices within large areas of the maize belt in the Bono East Region are based on rotational bush fallowing, with little reliance on fertilizers. Agricultural extension services in the area only offer one uniform set of recommendations for modern maize cultivation that poorly reflects local farming conditions. Although there are areas in the Bono East Region in which maize is grown under permanent cultivation with fertilizers, with the removal of subsidies during the 1980s, many of these farms could no longer successfully compete. Subsequently, the main center of maize production shifted from areas around state farms in which permanent cultivation, tractor cultivation, and land stumping with mechanized equipment had occurred in the 1960s and 1970s, into areas of wooded fallow using rotational bush fallowing. However, agricultural research and extension did not develop recommendations specifically fine-tuned to these areas. Therefore, the task of adapting modern varieties to local conditions ultimately fell upon the farmers.

Farmers are not convinced that certified varieties produce higher yields than their local varieties. Many of them remain skeptical about claims of declining fertility of their soils and the need to use fertilizers. They point to rainfall patterns as a more significant factor influencing yields than application of fertilizers. They tend to prefer to invest their surplus capital in hiring labor for land clearance and weeding than in fertilizers. However, farmers' experimentation is not confined to their own local varieties, or built on notions of preserving and conserving local cultural practice. Farmers combine improved and local varieties in their adaptive experimentation, and select the qualities they desire from the crosses. At Badu, these crosses are referred to as "agricatia"—a cross between agricultural research varieties and the local *atia* variety. The characteristics they most admire in the local variety are related to yield small seeds with good storing and milling qualities (Amanor, 2013). Through these crosses the improved varieties become adapted to local environmental conditions, local farming practice, and to local market preferences while maintaining their early maturity. Thus, the most significant factor in the varieties cultivated is the wide mixtures of varietal genetic resources and the adaptation of all these varietal mixes through crossing for desired characteristics. From the perspective of formal seed breeding this may appear as a disaster—the pollution of certified varieties that now need to be declassified. Crop researchers frequently bemoan that it is impossible to find a pure stand of Obaatanpa foundation seed, even among certified seed breeders (Amanor, 2010). However, among farmers the release of open-pollinated varieties offers new genetic materials to hone their adaptive skills and create new lines of adaptation. Maize traders are little concerned with the attribute of new improved quality protein maize, and rather seek out the varieties of a locality rather than specific maize varieties. This shows a significant disjuncture between the priorities of research institutions, farmers' adaptive research on crop varieties, and wholesale and urban maize markets.

This association of crop qualities with particular localities is similar to the notion of the terroir, in which the particular qualities of wine-producing areas in France are associated with particular soils, climate, cultivation practices, and history (van Leeuwen et al., 2018). Similarly, in China, Huang (2011) describes "speciality markets" in which provincial administrations attempt to create famous brands of crops that associate particular villages with quality crops. The province of Jianki boasts over 2,000 "speciality villages." Provinces attempt to create linkages between producers in the villages and agribusiness corporations in which the corporation markets the village brand rather than its own corporate brand. This reverses the standardized practices and routines enforced by Western agribusiness in developing their own corporate food brands. Although no formalized structure of speciality markets exists in Ghana, many of the regional maize markets, and the networks between traders, bulkers, and farmers are often built upon the quality and reputation of maize in particular localities, which is attributed to a combination of factors including the distribution of maize varieties within a locality, environment, climate and farming practice, rather than the attributes of a specific standardized variety of maize.

The Bono area emerged as the leading center of maize production in Ghana during the 1980s when there was a significant uptake of new maize varieties, particularly of early maturing varieties for minor season cultivation. However, agricultural extensions recommendations are rarely followed, and farmers have adapted the new modern varieties to their local farming systems. These developments have not endeared the world of agricultural development. Rather than support these low-input systems, agricultural development initiatives have rather looked for alternative areas with more opportunities to promote their high-input technology initiatives and support the paradigms of enabling development based on integration into agricultural technology and input markets. Consequently, most of the recent development initiatives in smallholder maize are now concentrated on the northern regions. The poorer soils of the north make this a potentially more attractive site for integration farmers into agricultural technology and input markets. Northern Ghana is more suited to mechanization; ploughing destroys the fragile, thin topsoils of these areas making farmers dependent upon use of fertilizers to compensate for the loss of soil structure (Amanor and Iddrisu, 2021). The low inherent fertility of soils in the north results in a greater amenability of farmers to packages of technology that combine ploughing services with fertilizers and new seeds. Nevertheless, the most pressing concern for these farmers is labor constraints, not the superior yields of modern seeds. Thus, the provision of tractor ploughing services can be used to encourage farmers to adopt technical packages of seeds and fertilizer. Demand for modern seeds is often induced by NGOs providing an array of services and credit to farmers on condition they adopt modern seeds. It is likely that these programs are largely driven by the desire to find new markets for commercial inputs and seeds. This marks a significant shift in focus in contemporary research frameworks, away from building capacity to adapt open-pollinated genetic materials to local conditions through participatory trials and interactions with farmers. The current agricultural policies are much more geared toward the creation of services to facilitate transnational agribusiness investments, uptake of private sector seeds, and more intensive use of inputs.

Cocoa hybrids, monocultures, and agroforests

As in the case of maize, the main genetic resources in Ghanaian cocoa originate from South America. From the late 19th century, Ghanaian farmers began experimenting with and integrating Amolenado cocoa into forest plots, alongside a variety of forest timber and fruit trees and root and tuber crops, which were used as shade trees to protect cocoa. However, the expansion of monocultures of cocoa resulted serious disease problems by the late 1930s, particularly in old cocoa frontiers with mature trees, of which swollen shoot virus disease was the most severe. The colonial government introduced a cutting out campaign of diseased cocoa as the solution, followed by the introduction of new hybrids, based on Brazilian genetic stock. The vulnerability of cocoa was partly attributed to the decline of forests and to drier conditions that created stress in shade-loving Amolenado varieties. New hybrid varieties were created which preferred drier conditions and also provided heavy yields with the application of fertilizers. Hybrid cocoa is less tolerant of shade and humidity than the older varieties. Researchers attributed the spread of swollen shoot virus disease to complex ecological interactions between the virus, mealybugs, *Pseudococcus* insects, ants, and forest canopy shade trees preserved by farmers (Collingwood, 1971). They advocated the removal of more shade trees that harbored the agents of disease and the planting of cocoa in neatly spaced rows to maximize yields. This was a radical departure from the practices that farmers had themselves developed to cultivate cocoa, which were based on preserving many forest canopy trees for shade, and planting cocoa alongside forest trees. This did not really solve the problem of disease since the hybrid cocoa was still vulnerable to a wide range of diseases other than swollen shoot. As a consequence, large quantities of pesticides and fungicides have to be applied to these new hybrids, with ever diminishing returns to investment and increasing costs for farmers.

The Amazonian hybrids have been replaced with a new generation of higher yielding hybrids. Nevertheless, many farmers continue to plant both Amolenado and Amazonia cocoa from seeds they select from their own trees (Amanor et al., 2022). What they classify as Amolenado or Amazonia are often mixtures whose qualities farmers associate with the characteristics of the old varieties. Although the agricultural services provide farmers with free hybrid seedlings, many of them prefer to select seeds from their favorite trees on their farms.

The cocoa services in Ghana have developed a uniform set of technical recommendations for all forest environments. They project that current yields average between 300 and 400 kg per hectare but can be raised to 1,000 kg per hectare if farmers follow adopt the recommended seeds and input packages and recommended cultural applications. The uniformity of these recommendations is surprising, given the wide range of conditions that occur in the forest zone from the highly acidic soils of the evergreen forests of the west to the more alkaline soils of the moist semi-deciduous forest zone. Data from experimental trials in different areas show considerable variations in yields in different localities. Ruf and Bini (2011) show that the use of fertilizers has mixed outcomes, depending upon the nature of soils and histories of cultivation in different localities. Their data showed that while yields of 4,000 kg/ha could be achieved on experimental plots in newly cleared cocoa forests in the Nzema area, this dropped to around 1,000 kg/ha in old cocoa plantation areas in Ashanti. Moreover, there can be no clear correlation between fertilizer use and yields, since there can be considerable losses to pests and diseases. Therefore, data on yields is likely to occlude many inconsistencies and attenuating factors.

Since the 1970s, a number of studies have pointed out the problems of the increasing use of agrochemicals within cocoa. These argue that dependence on the high usages of agrochemicals is not really suitable for an industry dominated by small farmers who can little afford them (Collingwood, 1971). From the 1950s onward, most of the wealthy farmers, who were prominent in early cocoa production (Hill, 1963), shifted out of the cocoa sector as disease became a major problem of cocoa, absorbing increasing amounts of capital and resulting in declining profit margins (Hill, 1963; Collingwood, 1971). The high usage of agrochemicals also poses a potential health danger to both humans and forest fauna (Padi and Owusu, 1998). Increasingly, the Ghanaian government has intervened to fill the shortfalls in the use of agrochemicals by farmers, through the introduction of mass spraying campaign. Odijie (2018) notes that the government has been forced to increase the intensity of spraying as diseases become more prevalent. In 2014, as a result of the escalating cost of inputs, the government canceled its mass subsidized spraying program. This led to a reduction of 18% in national output the following year, which led to the reinstatement of the program (Odijie, 2018).

Most of the literature depicts low rates of uptake of inputs by farmers, particularly of fertilizers. For instance, the International Cocoa Initiative (2017) estimated that only 36% of cocoa farmers in Ghana could afford farm inputs. An International Institute of Tropical Agriculture survey carried out 2009 suggests that 17% of Ghanaian cocoa farmers used chemical fertilizers (Gockowski and Sonwa, 2011). Hainmueller et al. (2011) found that 21% of cocoa farmers applied fertilizer and 37% used agrochemicals. Most farmers cannot afford to expend resources on the high costs of labor, agrochemicals, and fertilizers. They usually have to make choices in the allocation of resources. Since the overgrowth of weeds and attack by pests and diseases have a major and immediate impact on the performance of cocoa, expenditure on agrochemicals and labor tend to take precedence over the purchase of fertilizers. But contemporary hybrids are heavy feeders on soils, and without fertilizers they tend to perform poorly and may fail to be productive after a short period of time and require replanting. Consequently, some farmers prefer to cultivate Amolenado cocoa rather than plant modern hybrid varieties because they consider it more robust with better longevity.

Contemporary technical recommendations involve the increasing removal of shade trees in cocoa plantations. However, many farmers are unable to afford the recommended fertilizer applications. The removal of shade trees without the application of fertilizers results in rapid soil depletion, environmental stress, decline of yields in cocoa trees, and rapid senescence (Gockowski and Sonwa, 2011; Gyau et al., 2015). Recently, there has been a shift in recommendations toward promoting cocoa agroforests, in which farmers are encouraged to plant more trees to provide shade for cocoa (Gockowski and Sonwa, 2011). This appeals to narratives about climate change, sustainable development, environmental conservation, and sustainable intensification, in which increasing use of synthetic inputs accompany agroforestry practices (Gockowski and Sonwa, 2011). These narratives are presented with little reflection on the impact of agrochemicals on the environment and on the health of the farmers themselves (Schroth and Harvey, 2007; Nasser et al., 2020). Sadly, a crop that naturally thrives in forest conditions has been transformed into a product requiring the increasing injection of large quantities of agrochemicals to survive.

Odijie (2018) suggests that the majority of revenues gained by the Cocoa Board in Ghana are spent on providing subsidized inputs for farmers. The major beneficiaries are the large transnational corporations that control the supply of inputs. While there has been a remarkable expansion in the national output of cocoa in Ghana since the early 2010s, this has been achieved without any notable expansion in the yields of farmers. However, the increase in output has been accompanied by a decline in world market prices, while prices of fertilizers and agrochemicals have been increasing. This has eroded the living standards of cocoa farmers and their capacity to invest in inputs. According to Fountain and Huetz-Adams (2015), farmers in West Africa only gain 6% of the value within the cocoa commodity chain, the vast majority of which is absorbed by the transnational corporations that process and market the crop (and provide the inputs). West African farmers produce over 70% of cocoa beans in a global industry worth US$150 billion per annum, yet 60% of West African farmers continue to live below the poverty line. Thus, the realities and messiness of the intensification of cocoa production and the mounting disease problems belie the positive narratives of smallholder agricultural commercialization dominating policy discourses. While the main narratives around successful cocoa cultivation are framed around new hybrid varieties and input applications, the major problems experienced by cocoa farmers are associated with vulnerability to disease and environmental stress, and the escalating costs of agrochemical applications.

Conclusion

The insights generated via FSR and farmer participatory research during the 1980s have largely been abandoned as agricultural research has shifted from a public to a private system under the control of agribusiness. The recognition of the importance of farmers as important partners in preserving, maintaining, and developing genetic resources has largely receded, since agribusiness corporations are now seen as the main force in promoting increase in productivity that can secure global food security. As Mooney (1983) argues, claims to ownership of varieties as the product of the research of commercial corporations and recognition of the important contribution of farmers to genetic resources are mutually incompatible. The commercial impulse has led to the marginalization of the recognition of farmers' contribution to genetic resources. Advances in genetic engineering have precipitated a declining awareness of the importance of maintaining farmers' varieties, rather than genes and genetic information that can be manipulated in laboratories.

With the development of neoliberal discourses, the critique of standardized bureaucratic practices and top-down state practices that was common in farmer participatory research has been transformed into a critique of the state and state-led agricultural modernization, and the need to privatize agricultural service delivery. This is not really a fair assessment, since the period of state-led agriculture development in most of Africa has been relatively short. It only extended from the late 1950s to the early 1990s. This involved beginning from scratch with the training of research personnel and building of institutions. The relationship between national agricultural services and IARCs was fruitful to a certain extent, and by the 1980s the national research services began to release certified varieties adapted to local conditions, often based on farmer participation in adaptive trails. However, at the juncture when national agricultural services began to develop the capacities to release adapted varieties their activities were seriously curtailed, as structural adjustment policies demanded privatization of state agricultural services and cutbacks in expenditure on public services. This led to a noticeable decline in the release of certified plant varieties from the 1990s onward.

The cocoa and maize sectors in Ghana provide interesting contrasts. In the cocoa sector, hybrid varieties were released to farmers as early as the 1960s, while with maize there has been little emphasis on hybrid seeds until the 2010s. The emphasis on open-pollinated varieties in maize has led to the release of a much larger number of varieties adapted to local conditions than in the cocoa sector. These varieties have also been incorporated into farmers' own experimentations, in which modern varieties constitute part of the assemblage of genetic materials with which farmers experiment to improve their stock of seeds, rather than constituting demonstrably superior varieties. Since the 2010s there has been a significant shift in policy toward promoting imported hybrid maize varieties produced by transnational corporations, accompanied by attempts to integrate smallholder farmers into commercial food chains. By contrast, in the cocoa sector, hybrid varieties have dominated public sector breeding since the 1960s and have been widely adopted by farmers. However, neither the investment of a large proportion of state agricultural resources in the cocoa sector and in the development of hybrid varieties nor the growing investments of agribusiness in improved seeds and inputs have translated into significant increases in yields and rising prosperity for farmers. Instead the cocoa sector is plagued by diseases, pests, and escalating expenditures on agrochemicals, which make it difficult for farmers to meet the costs of the requisite inputs.

In both the cocoa and maize sectors, uptake of inputs continue to be low among farmers, in spite of more than 30 years of providing inducements, soft loans, and "smart subsidies" to farmers under privatization and NGO programs. The bleak realities of contemporary seed and input initiatives in Ghana do not correspond with the dominant mainstream agricultural narrative of achieving sustainable production and rising productivity through the use of industrial technology. While loss of biodiversity and rising use of agrochemicals with negative impacts on the environment maybe the trade-offs of promoting sustainable intensification, these may be high costs to bear for programs whose benefits are questionable, contested, and embraced with ambivalence by farmers. The path not treaded has been to build a highly modern and critical research tradition incorporating environmental, biodiversity and productivity concerns into one framework that responds to the knowledge and capabilities of farmers and builds upon their experimental knowledge. This seeks to educate both farmers and researchers with the knowledge of the locality and the latest advances in science through an incremental approach to building capacity (as highlighted by Paul Richards). The potential of this approach within mainstream agricultural research has been sacrificed to the narrow commercial gain of transnational agribusiness.

Data accessibility statement

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References

Ake, C. 1996. *Democracy and development in Africa*. Washington, DC: The Brookings Institution.

Alliance for a Green Revolution in Africa. 2022. *Accelerating African food systems transformation* (Issue 10). Nairobi, Kenya: Alliance for a Green Revolution in Africa.

Altieri, MA, **Toledo, VM.** 2011. The agroecological revolution in Latin America: Rescuing nature, ensuring food sovereignty and empowering peasants. *The Journal of Peasant Studies* **38**(3): 587–612.

Amanor, KS. 2010. Participation, commercialisation and actor networks: The political economy of cereal seed production in Ghana. Futures Agricultural Consortium Working paper 16. Institute of Development Studies, University of Sussex.

Amanor, KS. 2013. Dynamics of maize seed production systems in the Brong Ahafo Region of Ghana: Agricultural modernization, farmer adaptive experimentation and domestic food markets. Future Agricultures Consortium Working Paper no. 61. Institute of Development Studies, University of Sussex.

Amanor, KS. 2020. Transnational corporations, financialization and community development in West Africa Cocoa. *Community Development* **56**(1): 59–78.

Amanor, KS, **Iddrisu, A.** 2021. Old tractors, new policies and induced technology transformation: Agricultural mechanisation, class formation, and market liberalisation in Ghana. *Journal of Peasant Agriculture* **49**(1): 158–178.

Amanor, KS, **Pabi, O.** 2007. Time, space and rhetoric in agricultural change in the transition zone in Ghana. *Human Ecology* **35**(1): 51–67.

Amanor, KS, **Yaro, J**, **Teye, J.** 2022. Long-term change, commercialisation of cocoa farming, agroecosystems and forest rehabilitation in Ghana. APRA Working Paper 80. Institute of Development Studies, University of Sussex.

Arrighi, G. 2002. The African crisis: World systemic and regional aspects. *New Left Review* **15**(May/June): 5–36.

Bates, R. 1981. *Markets and states in tropical Africa: The political basis of agricultural policy*. Berkeley, CA: University of California Press.

Behera, UK, **France, J.** 2016. Integrated farming systems and the livelihood security of small and marginal farmers in India and other developing countries. *Advances in Agronomy* **138**: 235–282. DOI: http://dx.doi.org/10.1016/bs.agron.2016.04.001.

Bennet, E. 2002 Jul. The summit-to-summit merry-go-round. *Seedling, GRAIN.*

Bergius, M, **Buseth, JT.** 2019. Towards a green modernization development discourse: The new green revolution in Africa. *Journal of Political Ecology* **26**(1): 57–83.

Bezner Kerr, R. 2012. Lessons from the old Green Revolution for the new: Social, environmental and nutritional issues for agricultural change in Africa. *Progress in Development Studies* **12**(2–3): 213–229.

Biggs, SD, **Clay, EJ.** 1981. Sources of innovation in agricultural technology. *World Development* **9**(4): 321–326.

Bingen, J, **Gibbon, D.** 2012. Early farming systems research and extension experience in Africa and possible relevance for FSR in Europe, in Darnhofer, I, Gobbon, D, Dedieu, B eds., *Farming systems research into the 21st century: The new dynamic*. Dordrecht, the Netherlands: Springer: 49–72.

Borlaug, NE, **Dowswell, R.** 1995. Mobilising science and technology to get agriculture moving in Africa. *Development Policy Review* **13**(2): 115–129.

Brush, SB. 2004. *Farmers' bounty: Locating crop diversity in the contemporary world*. New Haven, CT: Yale University Press.

Buttel, F. 1991. The restructuring of the American public agricultural research and extension technology transfer system: Implications for agricultural extension, in Rivera, WM, Gustafson, DJ eds., *Agricultural extension: Worldwide institutional evolution and forces for change*. Amsterdam, the Netherlands: Elsevier: 43–56.

Chamber, R, **Pacey, A**, **Thrupp, LA** eds. 1989. *Farmer-first: Farmer innovations and agricultural research*. London, UK: IT Publications.

Clapp, J. 2018. Mega-mergers on the menu: Cooperate concentration and the politics of sustainability in the global food system. *Global Environmental Politics* **18**(2): 12–33.

Collingwood, CA. 1971. Cocoa Capsids in West Africa. Report of the International Capsid Research Team 1965-71. London, UK: International Office of Cocoa and Chocolate Alliance.

Collinson, M. 2000. Introduction, in Collinson, M ed., *A history of farming systems research*. Wallingford, UK: CABI: 1–4.

Collinson, M, **Lightfoot, C.** 2000. The future of farming systems research, in Collinson, M ed., *A history of farming systems research*. Wallingford, UK: CABI: 391–420.

Collinson, MP. 1988. The development of African farming systems: Some personal views. *Agricultural Administration* **29**(1): 7–22.

Council for Scientific and Industrial Research and International Service for National Agricultural Research. 1991. Review of the Ghana agricultural research system volume 1: Report. The Hague, the Netherlands: International Service for National Agricultural Research.

Dawson, J. 2002. Empowering Ghana's cereal producers in the marketplace, in Kapila, S, Mead, D eds., *Building businesses with small producers: Successful* *business development services in Africa, Asia and Latin America*. Ottawa, Canada: The International Development Research Centre.

Delimini, LL, **Wobil, J.** 1998. Ghana seed sector analysis. A report prepared for the IITA/GTZ Project on the Promotion of Seed Production and Marketing in West Africa. Accra, Ghana: Ministry of Food and Agriculture.

Development Dialogue Editorial. 1983. The law of the seed: Another development and plant genetic resources. *Development Dialogue* **21**(1–2): 1–2.

Farrington, J. 1995. Mobilising science and technology of fostering organisational change? A response to Borlaug and Dowswell. *Development Policy Review* **13**(2): 131–133.

Fountain, AC, **Huetz-Adams, F.** 2015. Cocoa barometer 2015, Cocoa Barometer [online]. Available at http://www.cocoabarometer.org/. Accessed December 5, 2019.

Gengenbach, H, **Schurman, RA**, **Bassett, TJ**, **Munro, WA**, **Moseley, WG.** 2018. Limits of the New Green Revolution for Africa: Reconceptualising gendered agricultural value chains. *The Geographical Journal* **184**(2): 208–214.

Giraldo, OF, **Rosset, PM.** 2017. Agroecology as a territory in dispute: Between institutionality and social movements. *The Journal of Peasant Studies* **45**(3): 545–564.

Gockowski, J, **Sonwa, D.** 2011. Cocoa intensification scenarios and their predicted impact on CO emissions: Biodiversity conservation and rural livelihoods in the Guinea rainforest of West Africa. *Environmental Management* **48**(2): 7–21.

Guyver, P, **MacCarthy, M.** 2011. The Ghana grains partnership. *International Journal of Agricultural Sustainability* **9**(1): 35–41.

Gyau, A, **Smoot, K**, **Diby, L**, **Kouame, C.** 2015. Drivers of tree presence and densities: The case of cocoa agroforestry systems in the Soubre region of Republic of Côte d'Ivoire. *Agroforestry Systems* **81**: 149–161.

Hailu, Z. 1990. Adoption of modern farm practices in African agriculture: Empirical evidence about the impacts of household characteristics and input supply systems in the Northern Region of Ghana. Nyankpala Agricultural Research Report 7. Eschborn, Germany: GTZ.

Hainmueller, J, **Hiscox, M**, **Tampec, M.** 2011. *Sustainable development for cocoa farmers in Ghana*. London, UK: International Growth Centre, London School of Economic and Political Science.

Hill, P. 1963. *The migrant cocoa-farmers of southern Ghana: A study in rural capitalism*. Cambridge, UK: Cambridge University Press.

Hodge, JM. 2007. *Triumph of the expert: Agrarian doctrines of development and legacies of British colonialism*. Athens, OH: Ohio University Press.

Huang, CC. 2011. China's new-age small farms and their vertical integration: Agribusiness or co-ops? *Modern China* **37**(2): 107–134.

International Cocoa Initiative. 2017 Dec 1. Cocoa farmers in Ghana experience poverty and economic vulnerability. Available at https://www.cocoainitiative.org/news/cocoa-farmers-ghana-experience-poverty-and-economic-vulnerability. Accessed November 11, 2021.

Jayne, TS, **Chamberlin, J**, **Headey, DD.** 2014. Land pressures, the evolution of farming systems and development strategies in Africa: A synthesis. *Food Policy* **48**: 1–17.

Jiggins, J, **Reijntes, C**, **Lightfoot, C.** 1996. Mobilising science and technology to get agriculture moving in Africa: A response to Borlaug and Dowswell. *Development Policy Review* **14**(1): 89–103.

Kloppenburg, J. 1988. *First the seed: The political economy of plant biotechnology*. Cambridge, UK: Cambridge University Press.

Kloppenburg, J, **Kenney, M.** 1984. Biotechnology, seeds, and the restructuring of agriculture. *Critical Sociology* **12**(3): 3–16.

Kolavalli, S, **Mensah-Bonsu, A**, **Zaman, S.** 2015. Agricultural value chain development in practice: Private sector-led smallholder development. IFPRI Discussion Paper 1460. Washington, DC: International Food Policy Research Institute.

Martínez-Torres, ME, **Rosset, PM.** 2014. Diálogo de saberes in La Vía Campesina: Food sovereignty and agroecology. *The Journal of Peasant Agriculture* **41**(6): 979–997.

McCann, JC. 2005. *Maize and grace: Africa's encounter with a New World crop, 1500-2000*. Cambridge, MA: Harvard University Press.

Mooney, PR. 1983. The law of the seed: Another development and plant genetic resources. *Development Dialogue* **21**(1–2): 1–172.

Moseley, WG. 2017. The new green revolution for Africa: A political ecology critique. *The Brown Journal of World Affairs* **23**(2): 177–190.

Moseley, W, **Schnurr, M**, **Bezner Kerr, R.** 2015. Interrogating the technocratic (neoliberal) agenda for agricultural development and hunger alleviation in Africa. *African Geographical Review* **34**(1): 1–7.

Nasser, F, **Maguire-Rajpaul, VA**, **Dumenu, WK**, **Wong, GY.** 2020. Climate-smart cocoa in Ghana: How ecological modernisation discourse risks side-lining cocoa smallholders. *Frontiers in Sustainable Food Systems* **4**: 73.

Norman, DW. 1978. Farming systems research to improve the livelihood of small farmers. *American Journal of Agricultural Economy* **60**(5): 813–818.

Odijie, M. 2018. Sustainability winners and losers in business-biased cocoa sustainability programmes in West Africa. *International Journal of Agricultural Sustainability* **16**(2): 214–227.

Paarlberg, R. 2010. *Food politics: What everyone needs to know*. Oxford, UK: Oxford University Press.

Padi, B, **Owusu, GK.** 1998. Towards an integrated pest management for sustainable cocoa production in Ghana. Proceedings of the 1st Sustainable Cocoa

Workshop, 20 March–3 April 1998, Panama, hosted by Smithsonian Institute, Washington DC.

Plan Consult. 1993. Roots and tubers: A report by the Commodity Committee of National Agricultural Research project. Vol. 4. Accra, Ghana: Plan Consult.

Rhodes, RE, **Booth, RH.** 1982. Farmer-back-to-farmer: A model of generating acceptable agricultural technology. *Agricultural Administration* **11**(2): 127–137.

Richards, P. 1996. Culture and community values in the selection and maintenance of African rice, in Brush, S, Stabinsky, D eds., *Valuing local knowledge: Indigenous people and intellectual property rights.* Washington, DC: Island Press: 209–229.

Rock, J. 2022. *We are not starving: The struggle for food sovereignty in Ghana*. East Lansing, MI: Michigan State University Press.

Ruf, F, **Bini, S.** 2011. Cocoa and fertilizers in West-Africa. Paper presented at the International Supply Management Congress, 11–16 December 2011, Amsterdam, the Netherlands. Available at www.researchgate.net/publication/326093032_Cocoa_and_fertilizers_in_West-Africa. Accessed April 1, 2020.

Sarpong, DB, **Anim-Somuah, H.** 2014. Brokering development: Enabling factors for public-private-producer partnerships in agricultural value chains. Summary of Ghana case study. Institute of Development Studies, University of Sussex. Available at https://www.ids.ac.uk/publications/brokering-development-enabling-factors-for-public-private-producer-partnerships-in-agricultural-value-chains-summary-of-ghana-case-study. Accessed April 20, 2023.

Schnurr, MA, **Dowd-Uribe, B.** 2021. Anticipating farmer outcomes of three genetically modified staple crops in sub-Saharan Africa: Insights from farming systems research. *Journal of Rural Studies* **88**: 377–387. DOI: http://dx.doi.org/10.1016/j.jrurstud.2021.08.001.

Schroth, G, **Harvey, CA.** 2007. Biodiversity conservation in cocoa production landscapes: An overview. *Biodiversity and Conservation* **16**(8): 2237–2244.

Sell, SK. 2009. Corporations, seeds and intellectual property rights governance, in Clapp, J, Fuchs, D eds., *Corporate power in global agrifood governance*. Cambridge, MA: The MIT Press: 187–224.

Simmonds, NW. 1984. The state of the art of farming systems research. Agricultural Symposium. Washington, DC: World Bank.

Smith, P. 2013. Delivering food security without increasing pressure on land. *Global Food Security* **2**(1): 18–23.

Stone, GD. 2022. *The agricultural dilemma: How not to feed the world*. London, UK; New York, NY: Routledge.

Swanson, BE, **Samy, MM**, **Sofranko, A.** 2003. The new agricultural economy: Implications for extension programs. *Journal of International Agricultural and Extension Education* **10**(2): 35–40.

Tweneboah, CK. 2001. *Modern agriculture in the tropics with special reference to Ghana, food crops*. Accra, Ghana: Co-Woods Publishers.

van Leeuwen, C, **Roby, JP**, **de Resseguier, L.** 2018. Soil-related terroir factors: A review. *OENO One (Vine and Wine*) **52**(2): 173–188.

Weiss, T. 2007. *The global food economy: The battle for the future of farming*. London, UK: Zed Books.

World Bank. 1981. *Accelerated development in sub-Saharan Africa; an agenda for action*. Washington, DC: World Bank.

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