Trends in Agricultural Ecological Transformation and Paths for Developing Ecological Agriculture in China: Postprint

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Abstract

After experiencing forms such as slash-and-burn agriculture, traditional small-scale farming, and industrialized agriculture, human agriculture is entering an ecological stage. The turning point for countries to implement agricultural ecological transformation typically occurs when per capita GDP reaches approximately 10,000 to 30,000 US dollars. Different countries, regions, and the international community have adopted different transformation strategies, pathways, and nomenclatures based on their respective social contexts. China' s socio-economic development level has approached and reached the inflection point for implementing agricultural ecological transformation. Since 2015, China has continuously introduced a series of major policy measures to comprehensively promote the ecological transformation of agriculture from the perspectives of development goals, guiding principles, development models, implementation instruments, and management systems, and ecological agriculture has gained widespread recognition and attention from society. Clarifying the relationship between the concept of ecological agriculture and other related concepts is conducive to forming synergy for agricultural ecological transformation. After analyzing the advantages and challenges of China' s agricultural ecological transformation, this article proposes strategies for China' s future agricultural ecological transformation.

Full Text

Introduction

In the *Opinions on Accelerating the Transformation of Agricultural Development Patterns* (August 2015), the State Council proposed shifting agricultural development from a focus on quantitative growth to emphasizing quantity, quality, and efficiency equally; from relying primarily on material inputs to relying on

technological innovation and improved labor quality; and from extensive operations that depend on resource consumption to sustainable development, thereby establishing a modern agricultural development path that is highly efficient, produces safe products, conserves resources, and is environmentally friendly. This transformation of agricultural development patterns has garnered increasing attention. What are the characteristics of this agricultural transition? Does international experience offer similar models? What are the advantages and challenges of China' s agricultural transformation pathway? How should China choose its path for eco-agricultural development?

1. Main Agricultural Forms and Agroecological Transition

Before the origins of agriculture, humans obtained food through hunting, fishing, and gathering. Later, due to climate and environmental changes and population pressure, humans independently began domesticating organisms in different regions with suitable species and environmental conditions. Agriculture emerged in China' s Yellow and Yangtze River basins, the Mesopotamian plains of Iran and Iraq, the Indus River valley at the border of India and Pakistan, the Nile River valley in Egypt, Central America represented by southern Mexico, and South America represented by northern Peru. From then on, humanity embarked on the path of actively producing food through agriculture. These agricultural origins created splendid ancient agricultural civilizations. However, except for China, these agricultural civilizations were all interrupted and eventually disappeared. The deep-rooted cause was primarily the rapid population expansion in these cradles of agricultural civilization, which intensified the contradiction between food demand and agricultural supply capacity. This pressure further spawned a chain of malignant events including ecological destruction, social unrest, and foreign invasion, ultimately leading to the fall of these civilizations. Chinese agricultural civilization also experienced similar crises, and only avoided the fate of other civilizations due to special conditions such as vast territory and ample room for maneuvering [1]. Throughout the history of world agricultural development, several main developmental forms can be identified.

1.1 Primitive Slash-and-Burn Agriculture

People cleared natural vegetation to open up land for cultivation. After two to three years, due to soil erosion and nutrient depletion, land productivity declined sharply, prompting people to move to other areas to open up new land for agricultural production. The abandoned farmland was then left to undergo natural vegetation succession. Under conditions of low population density, this slash-and-burn system was a relatively sustainable agricultural form. Today, this production method can still be observed in many third-world countries as well as in China' s south subtropical and tropical regions. However, with population growth, this agricultural production method faces problems such as insufficient land rotation time, interrupted succession and renewal, massive vegetation destruction, and inadequate output efficiency, forcing most regions

to abandon it.

1.2 Traditional Small-Scale Agriculture

This has been the main agricultural form in China' s farming regions for thousands of years and was also the primary agricultural form in many planting regions worldwide before industrialization. Traditional small-scale agriculture primarily relied on human and animal power and the natural resources of farming areas, with generally small production scales but fixed cultivation plots and residential locations. Even pastoral production based primarily on animal husbandry and fishery production based on fishing and aquaculture mainly depended on the natural resources within the production area and their own human resources, also falling within the category of traditional small-scale agriculture. During this stage, farmers, herders, and fishermen had close contact with nature and accumulated rich experience in respecting, protecting, and utilizing nature. Much of this experience is extremely valuable and worthy of exploration and inheritance. To this end, the United Nations and many countries including China have carried out the protection, research, and exploration of important agricultural cultural heritage [2]. Although most of the world' s agriculture remains in this traditional small-scale form, industrialized agriculture' s advantages in labor productivity and commercialization rates have already posed a tremendous challenge to it.

1.3 Agricultural Industrialization

With the industrialization that began in the West at the end of the 18th century, leading to scientific and technological progress, enhanced industrial capacity, expanded commodity markets, and mature market mechanisms, the process of agricultural industrialization gradually accelerated starting in the early 20th century. Agricultural operations were largely replaced by agricultural machinery, and constraints on high yields such as insufficient soil nutrients and pest hazards were solved through industrial synthesis of chemical inputs. Land productivity, labor productivity, agricultural product commercialization rates, and operational profitability all improved.

1.4 Agricultural Ecological Transition

Beginning in the 1960s, global environmental awareness awakened, and people discovered that industrialized agriculture consumed large amounts of nonrenewable energy, severely polluted soil and water environments, intensified the greenhouse effect, and threatened food safety. Even traditional small-scale agriculture, under population pressure and improper management, could cause ecological and environmental problems such as soil erosion, declining groundwater levels, overgrazing of grasslands, and overfishing of fisheries. Therefore, people had to actively seek alternative agricultural methods that match resources and environment and adapt to ecological conditions to achieve sustainable development. This transformation of agricultural development patterns can be called

agricultural ecological transition. If the goal of agriculture in the slash-and-burn and traditional small-scale agriculture stages was merely social benefit of providing adequate food and clothing, then in the agricultural industrialization stage, economic benefits were added to agricultural objectives. In the agricultural ecological transition stage, human pursuit of agricultural objectives has expanded to include social, economic, ecological, environmental, and socio-cultural benefits.

2. International Experience in Agricultural Ecological Transition

The international community' s exploration of sustainable agricultural development can be traced back to the early stages of industrialization, but conscious and systematic exploration of agricultural ecological transition has concentrated mainly after the 1960s.

2.1 Agricultural Ecological Transition Processes in Various Countries

In the search for alternative agriculture, initial explorations began with individual practices, such as Austria' s "biodynamic agriculture," Japan' s "natural agriculture," Europe' s "ecological agriculture," and North America' s "organic agriculture." In 1991, the UN Food and Agriculture Organization (FAO) convened the World Conference on Agricultural Environment in the Netherlands, after which the *Den Bosch Declaration and Agenda for Action on Sustainable Agriculture and Rural Development* was published. This became the catalyst and turning point for systematically steering world agriculture toward sustainable development. In 1992, the EU began implementing "multifunctional agriculture" and revised its "Common Agricultural Policy" accordingly [3]. In 1992, Japan began promoting "environmentally conservation-oriented agriculture" and enacted the corresponding *Basic Law on Food, Agriculture and Rural Areas* along with agricultural regulations and economic incentive measures [4]. In 1998, South Korea began agricultural transformation by implementing "environment-friendly agriculture" and also formulated the *Act on the Promotion of Environment-Friendly Agriculture and Fisheries and the Management and Support of Organic Foods* [5]. In 1999, the United States began promoting "best management practices" based on resources and environment, with each state issuing agricultural best practice guidelines that specifically enumerated relevant measures and incentive policies [6]. Driven by international sustainable agricultural development, the bottom-up agroecology movement in Latin America originated in the 1990s and directly influenced agricultural development decisions in relevant countries. For example, driven by the agroecology movement, Brazil' s Congress passed legislation supporting agroecological development in 2003. The international organic agriculture movement and organic food certification also developed rapidly during this period [7]. Since 2014, the FAO has attached great importance to Agroecology, holding international symposiums on agroecology in 2014 and regional symposiums for Latin America, Asia-Pacific, and Africa in 2015. In 2016, the

FAO hosted an international agroecology symposium in Yunnan, China. Agricultural ecological transition has become a powerful global trend.

2.2 Lessons from International Agricultural Ecological Transition

Different types of countries and regions, due to different socio-economic backgrounds in agricultural development, have varying timing and breakthrough points for agricultural ecological transition.

Transition timing: The United States reached a per capita GDP of 10,000 USD in 1978 and proposed the "Low-Input Agriculture Program." In 1999, with per capita GDP at 34,600 USD, it proposed "resource- and environment-based best management practices." The EU reached 10,000 USD per capita GDP in 1987 and 17,800 USD in 1992, and deeply concerned by severe groundwater pollution, proposed the development direction of "multifunctional agriculture." Japan reached 10,000 USD per capita GDP in 1983 and 31,000 USD in 1992, when it also proposed the development direction of "environmentally conservation-oriented agriculture." South Korea reached 10,000 USD per capita GDP in 1994, and in 1998 canceled its agricultural development approach targeting yield and proposed the direction of "environment-friendly agriculture." There is a famous "Kuznets Curve" in environmental protection that describes how pollution levels first increase then decrease with socio-economic development. Analyzing agricultural transitions in various countries reveals that the "Kuznets Curve" inflection point for industrialized countries entering the agricultural ecological transition stage is when per capita GDP reaches 10,000–30,000 USD.

Pathway selection: (1) In smaller countries, transformation has emphasized economic incentive policies under unified legal norms. For example, the EU' s revised "Common Agricultural Policy" stipulates that farmers and agricultural enterprises must meet basic "cross-compliance" standards—causing no environmental damage, no food safety problems, no animal cruelty, and no destruction of traditional culture—to receive basic EU agricultural subsidies. South Korea and Japan have also enacted relevant national legal systems, where only those meeting relevant indicators can receive agricultural subsidies, tax reductions, and preferential loans. (2) In larger countries, approaches have involved locally recommended eco-friendly measures adapted to different regions, using incentive methods compatible with local economies. For example, when implementing best management practices (BMPs) based on resources and environment, each U.S. state issues specific measures and reward/subsidy methods. Minnesota' s agricultural BMP manual stipulates that land planted with grass or legume cover receives 123.5 USD per hectare in subsidies, and sloped land planted with native plants as horizontal vegetative buffer strips exceeding 4 hectares receives 578 USD per hectare [8]. The EU' s additional green subsidy measures and standards beyond cross-compliance are also specifically formulated by each country. (3) In regions with weaker government decision-making and implementation capacity, agricultural ecological transition has taken a bottom-up development path mobilized by civil society organizations, typified by the agroe-

cology movement in Central and South America. (4) In countries with stronger government decision-making and implementation capacity, project-based promotion by the government has been implemented. Successful examples include China' s government-promoted projects such as "returning farmland to forest," "grassland-livestock balance," "soil testing and formula fertilization," and "water-saving agriculture." (5) In multilateral international forums, parallel advancement through participatory coordination and consensus-building among different stakeholders has been adopted. The most typical example is the FAO' s operational approach in promoting international agricultural ecological transition. The 1991 International Conference on Agriculture and Environment adopted the *Den Bosch Declaration and Agenda for Action on Sustainable Agriculture and Rural Development*, which played an important role in adjusting the direction of world agricultural development. In recent years, FAO' s series of international conferences on agroecology have also adopted this multi-stakeholder consultation approach to reach consensus reflected in declarations or communiqués, forming an important basis for promoting international agroecological development.

3. The Concept of Eco-Agriculture in China

When implementing agricultural ecological transition, different countries assign a name to the new agricultural form to facilitate communication. The EU calls it "multifunctional agriculture," South Korea calls it "environment-friendly agriculture," Japan calls it "environmentally conservation-oriented agriculture," etc. In China, the agricultural practice method for implementing ecological transition can be called "eco-agriculture."

3.1 Definition of Eco-Agriculture

In China, there are many definitions of eco-agriculture. Despite significant differences in wording, their substantive connotations are largely similar. Using the concept of ecosystem services from recent years, we can redefine Chinese eco-agriculture as follows: Eco-agriculture is an agricultural approach that actively adopts ecologically friendly methods, fully exploits the service functions of agricultural ecosystems, and promotes sustainable agricultural development.

"Ecosystem service functions" refer to the capacity of ecosystems to provide various products and services for human benefit, including material products, ecological environment regulation, and spiritual and cultural cultivation. Agricultural ecosystems can also provide these ecosystem service functions, commonly understood as agriculture' s ability to generate social, economic, and ecological environmental benefits, or that agriculture has production, living, and ecological functions.

"Ecologically friendly methods" refer to agricultural models and technical systems that respect, protect, comply with, and learn from nature, rather than behaviors that ignore, confront, or destroy nature. Eco-agricultural models

refer to the tangible structures (hardware) of agricultural ecosystems, which can be understood at the biological level, ecosystem level, and regional landscape level. At the biological level, eco-agriculture encourages full utilization of biodiversity; at the ecosystem level, it vigorously promotes the establishment of cycling systems through various material and energy flow channels; at the landscape level, it emphasizes ecological function zoning management within regions, interspersing natural landscapes into agricultural landscapes, and valuing landscape structural diversity and visual effects [9–10]. The technical system of eco-agriculture is the combination of technologies selected according to the production system (model) (software). Technologies must be coordinated with each other and with the model to form a system. Taking crop production as an example, the technical system typically includes: (1) resource-saving and resource-substitution technologies related to inputs, (2) crop nutrient regulation and plant protection technologies related to production processes, and (3) farmland drainage and crop straw treatment technologies related to outputs [11].

3.2 Relationship with Related Concepts

With agricultural ecological transition, many terms have emerged domestically and internationally for new agricultural development approaches. Clarifying the relationship between these terms and the concept of eco-agriculture will help better coordinate relevant forces and promote sustainable agricultural development.

Modern eco-agriculture: China' s traditional small-scale farming has already accumulated much ecological wisdom about the unity of heaven and humanity. However, to adapt to rapid scientific and technological development and tremendous socio-economic changes, eco-agricultural development needs to absorb modern science and technology, establish new management entities, and appropriately expand operational scale. To distinguish it from traditional eco-agriculture, the concept of "modern eco-agriculture" has emerged [12].

International ecological agriculture: Internationally, ecological agriculture (ecological agriculture) was once defined as small-scale agriculture that does not use pesticides or chemical fertilizers and fully utilizes the farm' s own natural resources [13]. Later, ecoagriculture was also viewed internationally as a landscape functional zoning management approach for agriculture, similar to landscape models in Chinese eco-agriculture [14]. However, recent international perspectives on ecological agriculture have become similar to the concept used in China [15].

Agroecology: In recent years, Agroecology has developed rapidly internationally and is promoted by the FAO. Agroecology includes three meanings in international usage: as an academic discipline, as an agricultural practice, and as a type of social transformation. When Agroecology refers to an academic discipline, it essentially means "agroecology." When Agroecology refers to an

agricultural practice, it is equivalent to China' s "eco-agriculture." When Agroecology refers to social transformation, it means the eco-agriculture movement and corresponding changes in social management and market models [7].

Circular agriculture: Circular agriculture aims to reverse the linear thinking of industrialized agriculture, change the pattern of large inputs and outputs, and emphasize the resource utilization of agricultural waste, with key concepts of reuse, recycle, and reduce. This is an important aspect emphasized by eco-agricultural models at the ecosystem level [16].

Low-carbon agriculture: Low-carbon agriculture addresses the problems of industrialized agriculture' s massive consumption of fossil energy and serious greenhouse gas emissions, advocating for reduced carbon emissions and increased carbon storage in agricultural production processes. Methods adopted by low-carbon agriculture include changing agricultural energy structures, increasing production and utilization of renewable energy, and increasing biological carbon sequestration and system carbon stocks through methods such as increasing soil organic matter and perennial vegetation. Eco-agriculture also pays attention to agricultural carbon balance, while also focusing on nitrogen balance, phosphorus balance, water balance, etc. Therefore, eco-agriculture is compatible in direction and methodology with low-carbon agriculture [17].

Climate-smart agriculture: Under conditions of intensifying global change, climate-smart agriculture proposes that agriculture should both passively adapt to climate change and actively reduce adverse impacts on climate. Climate-smart agriculture also addresses the standardized production patterns of industrialized agriculture, hoping to establish a more resilient agricultural production system through methods such as changing energy structures, adjusting input composition, and utilizing biodiversity. Although its objectives more prominently highlight climate change adaptation, the specific means used by climate-smart agriculture do not depart from the scope of eco-agriculture [18].

Agricultural cleaner production: In response to the passive approach of waiting for pollution to occur before treatment, people have proposed changing resource input structures and reforming production processes to establish a more proactive cleaner production model that reduces pollutants from the source. Eco-agriculture can obviously construct an agricultural cleaner production system through model building and technology selection [19].

Organic agriculture: Inspired by Eastern agriculture, organic agriculture originated in Europe. Organic agriculture emphasizes the "organic approach" of not using chemical fertilizers, pesticides, hormones, or GMOs in agricultural production, and emphasizes utilizing integrated farming-forestry-animal husbandry systems, biodiversity systems, and internal cycling systems. Eco-agriculture encompasses a diversified technical system ranging from rational use of chemical fertilizers, pesticides, and hormones to complete non-use of chemical fertilizers, pesticides, and hormones. From this perspective, organic agriculture is a "special band" in the full "spectrum" of eco-agriculture [20].

Natural agriculture: Natural agriculture originated in Japan, emphasizing the use of agriculture's natural forces and adopting farming methods that involve no tillage, no chemical fertilizers, no pesticides, and rejection of industrial inputs. Similar to organic agriculture, natural agriculture can be said to belong to a "special band" of eco-agriculture [21].

4. Analysis of China' s Agricultural Ecological Transition

China' s agricultural development shares similarities with global agricultural development but also has many unique aspects. Only by understanding the characteristics of China's agricultural development can we correctly guide China' s agricultural ecological transition.

4.1 Characteristics of China' s Traditional Agriculture

Ancient European civilizations were repeatedly destroyed by nomadic peoples and entered so-called "Dark Ages." Although the Chinese heartland was also invaded by nomadic peoples, the relatively advanced Chinese farming civilization was instead adopted by rulers of different backgrounds. China' s traditional farming civilization' s pastoral production model was clearly different from the Western world' s crop production and grazing rotation system. China' s traditional household animal husbandry was merely subsidiary to crop production, with continuous crop cultivation on farmland. In the early 20th century, when the Western world was still in the early stages of agricultural industrialization, many Western agricultural experts who came to the East were shocked by the refinement and sustainability characteristics of Eastern traditional farming practices in China, India, Korea, and Japan. They wrote a series of books introducing Eastern agricultural experience, including *Farmers of Forty Centuries* [22] and *An Agricultural Testament* [23]. These works had a major influence in the West, promoting the development of the international organic agriculture movement and later agricultural ecological transitions in various countries. In fact, the impact of different farming civilization models extends far beyond agriculture itself, also reflecting in social organization, modes of thinking, and aesthetic characteristics. Chinese traditional agricultural practices over thousands of years have aspects very worthy of our identification, exploration, inheritance, and promotion. Examining the development of world civilizations, neither East nor West needs to feel inferior or arrogant; they need to learn from each other, draw on each other' s strengths, and discard their weaknesses.

4.2 Development Trajectory of Chinese Agriculture

The development of Chinese agriculture can generally be seen to follow this trajectory: (1) Chinese traditional agriculture already contained many concepts and practices of "following natural timing and measuring land capacity," emphasizing "timely conditions, geographical advantages, and human harmony"and the "unity of heaven and humanity."This was an unconscious stage. To this day, such

traditional agricultural practices still remain in some remote areas. (2) In the early days of the People's Republic, agricultural industrialization has been the direction pursued by Chinese agriculture, with proposed development directions of agricultural mechanization, irrigation, chemicalization, and electrification. However, until the 1960s, China's industrial capacity to support agriculture remained backward, consistently constraining the process of agricultural industrialization. It was not until the early 1970s that chemical fertilizer and pesticide industries developed rapidly. Agricultural mechanization only developed rapidly in the last decade. Currently, China' s supply of agricultural chemical fertilizers, pesticides, and plastic films is no longer problematic and can even be exported. The main contradiction has shifted to issues of irrational and excessive use. (3) Influenced by the awakening of global environmental awareness and personally witnessing the deterioration of rural ecological environments in China, a group of Chinese scholars and visionaries proposed the concept of eco-agriculture in the late 1970s and began exploring eco-agricultural practices in various regions during the 1980s. Entering the 1990s, the Ministry of Agriculture launched two batches of eco-agricultural demonstration counties nationwide, building 100 eco-agricultural demonstration counties. This work concluded in 2002. (4) For a period afterward, work related to the agricultural ecological environment shifted to a stage of implementing individual projects, such as returning farmland to forest, biogas projects, fertile soil projects, grassland-livestock balance, soil testing and formula fertilization, and green prevention and control. (5) In 2012, the 18th Party Congress proposed ecological civilization construction. Due to rising living standards and intensifying ecological and environmental problems accumulated during the industrialization process, the entire nation has paid increasing attention to agricultural resources, environment, and ecological issues, as well as agricultural product quality. In the early reform and opening-up period, China's agricultural development goals changed from simply "high yield"to "high yield, high quality, and high efficiency," which was supplemented in 2002 as "high yield, high quality, high efficiency, ecological, and safe." The 2015 Central No. 1 Document clarified that agricultural development goals are "highly efficient output, safe products, resource conservation, and environmental friendliness." China' s per capita GDP in 2014 was 7,400 USD, but most provinces and cities in the eastern region had already reached and exceeded 10,000 USD per capita. Facts indicate that the inflection point of China' s agricultural "Kuznets Curve" has arrived. The Ministry of Agriculture began a new round of national eco-agricultural pilot work in 2014. Eco-agricultural construction has received increasing attention.

4.3 Trends and Prospects of Agricultural Ecological Transition

Trends in agricultural ecological transition: Since 2015, the state has issued a series of major policy measures that comprehensively promote agricultural ecological transition from the perspectives of development goals, guiding ideology, development patterns, implementation methods, and management systems (Table 1). In August 2016, the National People' s Congress reviewed the

Environmental Protection Tax Law of the People' s Republic of China (Draft), and in September, the national deepening reform leadership group reviewed and approved the *Guiding Opinions on Constructing a Green Financial System*, respectively promoting the ecological transition of the national economy from the perspectives of taxation and finance. The number of Chinese literature items related to eco-agriculture reflects societal attention to eco-agriculture. This literature has been continuously increasing (Figure 1), with annual relevant publications reaching over 100,000 since 2005. Currently, both government determination and public expectations create a favorable external environment for China' s agricultural ecological transition. Analyzing the advantages and challenges of China' s agricultural ecological transition reveals: (1) China' s advantages in developing eco-agriculture include experience from traditional agriculture, accumulated experience from long-term eco-agricultural exploration, in-depth research by scientists on eco-agricultural methods and mechanisms, and strong government determination and execution. (2) Challenges for China' s agricultural ecological transition include insufficient per capita resource endowments, already apparent ecological and environmental constraints, ongoing exploration of the relationship between actual grain yields and "storing grain in land and technology," and the need to mobilize the enthusiasm of rural grassroots masses and agricultural enterprises in protecting the agricultural ecological environment. Compared with the EU, South Korea, Japan, North America, and other countries, China still has many deficiencies and gaps in property rights systems, behavioral norms, reward and punishment systems, and technical standards for promoting agricultural ecological transition, requiring collaborative efforts and unremitting improvement.

Strategy for agricultural ecological transition: To correctly guide China' s agricultural ecological transition, strong measures need to be taken at both specific sites and across broader areas: (1) China needs to continue high-level basic and applied scientific research at typical sites, reserve scientific and technological achievements, and emphasize systematic research involving long-term, large-scale comparisons of different agricultural methods and their ecological and environmental impacts. (2) Conduct field application demonstrations of existing research results: evaluate the practicality of achievements, adapt achievements for broader application through local improvements, and initiate bottom-up specific suggestions for government policies and supporting regulations for achievement application. (3) China more urgently needs to emphasize broad-area actions, go deep to the grassroots level, timely discover and summarize mass practices and excellent traditions, widely carry out education and training related to agricultural ecological transition, cultivate ecological awareness, and impart ecological knowledge. (4) Local areas also need to actively establish operational and systematic legal red lines for the agricultural ecological environment and green action lists for eco-agriculture that require economic incentives [24].

Overall, China' s agricultural ecological transition already has direction and preliminary actions—it can be said to be on the road—but the system is not yet perfect, and actions have not become popularized and normalized, so it can be

said not yet to be on track. In the future, further leveraging China' s advantages in traditional agriculture and government leadership, overcoming various challenges, adopting appropriate technical and management measures, and actively promoting eco-agricultural construction will facilitate China' s successful completion of agricultural ecological transition.

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Note: Figure translations are in progress. See original paper for figures.