SAARC J. Agric., 21(1): 1-12 (2023) *DOI: https://doi.org/10.3329/sja.v21i1.66340*

SUSTAINABLE TRANSFORMATION OF AGRIFOOD SYSTEMS: A CIRCULAR ECONOMIC AND AGROECOLOGICAL PERSPECTIVE

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ABSTRACT

Agri-food systems have increasingly faced complex socio-economic and biophysical challenges. Poverty, inequalities, low productivity, food insecurity, resources degradation, loss of biodiversity, and climate change are some of the pertinent challenges demanding immediate attention. There is an increasing realization that current dominant model of development characterized by excessive use of resources, constantly poses negative externalities to the environmental health, climate and human welfare. Since agricultural development policies and practices are key to addressing these issues, there have been compelling calls for adequate policy environments for the profound transformation of agri-food systems to achieve better nutritional, environmental, and sustainability outcomes. Circular economy and agroecological approaches are widely recognized as providing credible pathways to develop inclusive, sustainable and resilient agri-food systems. While there is plethora of studies on agroecology and circular economy in international arena but studies on potential application and implications of these measures in Nepalese context remain unexplored. Furthermore, the circular economic framework is mainly used in industries and yet to be adapted in the agriculture sector. Based on systematic reviews and analysis of academic literatures we propose a framework for sustainable transformation of agrifood systems that encompasses both the circular economic and agroecological principles. We argue that the framework offers plausible solutions to the pressing need of reducing negative externalities of agri-food systems. However, agricultural research, education and development systems are traditionally entrenched by reductionist traditions that poorly accommodate the complex epistemological issues of circular economy and agroecology, and hence are the potential barriers for effective application in Nepalese context.

Keywords: Agroecology, Circular economy, Agri-food systems.

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Received: 23.01.2023 *Accepted: 23.05.2023*

INTRODUCTION

An agri-food system is the combination of food production, processing, marketing, consumption, and the combined implications of these processes. It includes all elements and activities related to production, processing, distribution, and consumption of food, (such as people, environment, institutions, infrastructures, and inputs), and the associated outcomes - nutrition and health, socio-economic status, and environmental conditions (Caron et al., 2018). In fact, poverty, inequalities, food insecurity, hunger and malnutrition, degradation of natural resources, loss of biodiversity, and climate change are connected with the ways we produce, distribute, and consume food (El Bilali, Callenius, Strassner, and Probst, 2019) and hence are the part of agri-food systems. Agri-food systems are thus, at the center of today's socio-economic and environmental challenges.

Nepalese agri-food system predominates the smallholder producers as more than 56% farm households operate on an average less than 0.5 ha land size, and additional 40% command the parcel size of 0.5 ha-3.0 ha of agricultural land (Roka, 2017). Women constitute major components of the workforce in farming as out of a total 66 % economically active population engaged in farming, 73% are female against 60% of the male counterparts (Roka, 2017). Furthermore, there is an increasing trend of outmigration of the working age males from villages leading to further increase in the feminization of agriculture. Ironically, women farmers have been constrained by severe challenges in accessing productive resources, finance, training, and extension support services due to deep-seated gender-based inequalities.

Nepalese agri-food system is highly vulnerable to the climate change. Rising temperatures, changing rainfall patterns, and climate change-induced disasters have recurrently caused huge losses in agriculture production and productivity. The COVID-19 pandemic that started from the end of 2019, further exposed the weaknesses and socio-ecological fragility of our agri-food systems. The pandemic disrupted agricultural activities and supply chain thereby exposing farmers to uncertainties in food production, marketing, employment, and incomes. Small farmers particularly producing fresh vegetables, fruits, fish, milk, eggs, and chicken affected due to lack of markets during the periods of lockdowns and trade restrictions.

Agri-food system transformation rationale

For the last six decades, agricultural policies and programs in Nepal, as elsewhere have greatly been influenced by the green revolution (GR) strategies for productivity growth that aims at rapid intensification of farming through excessive use of irrigation, synthetic fertilizers, agrochemicals, and high yielding varieties. The GR strategies have been successful in dramatic increase of yield of major staples particularly wheat, maize, rice, and potatoes in most of the South Asian countries in last five decades. However, despite its success in yield increment, GR is associated with unintended negative consequences to the society, ecosystems, and environment.

The GR technologies are applicable mainly in high potential areas on large scale farms with fertile soils, and abundant availability of water for irrigation that benefit only the rich farmers. However, Nepal is overwhelmingly dominated by small-scale farmers mainly relying on rainfed agriculture and living in less-favored hinterlands with poorly developed inputs, credits, and outputs markets, rarely benefiting from the GR strategy.

Paradoxically, this reinforced the myth among policymakers that small-scale agriculture is non-profitable (Pingali, 2012), and thus the small holder farmers have simply been neglected in the policies and programs thereby failing to improve their farm productivity, resources-use efficiency, and to gain better market access. This has resulted into the persistence of poverty and inequality forcing almost 52% of the population deprived of basic food security even today (Karki, Burton, Mackey, and Alston-Knox, 2021).

The high yielding varieties (HYVs) of the field crops that are more responsive to the external inputs particularly synthetic fertilizers and agrochemicals in irrigated fields got priorities in policies and programs as the key drivers of productivity gains under green revolution strategy. However, over extractive, and intensive farm practices particularly the overuse of fertilizers and chemical pesticides in combination with irrigation, has resulted into soil degradation water pollution, groundwater depletion, loss of biodiversity and other environmental effects.

On top of that, the liberalized economic policies adopted by the country since 1990s increasingly commodified food, subsuming into the markets, thereby encouraging people to move away from traditional largely a localized, and highly diverse food consumption practices to an industrial commodity system of universal mass consumption. This has resulted into a drastic shift in our everyday food habits moving away from having a diverse, context-specific, cultural, and nutrients-rich diets to homogenous, highly processed, micronutrients-poor, and calorie-dense limited (corporate) food items leading to increasing incidences of diet-related non-communicable diseases such as diabetes, cancer, and kidneys and heart related ailments.

Thus, agri-food systems are now, considered as the crux behind the socio-economic and environmental challenges of the contemporary world and the international community has recognized that a transformation in the way we use natural resources is a precondition for achieving prosperous, secure, and resilient societies. However, agri-food policies in general are still inadequate in addressing the negative externalities of conventional agrifood systems (Meah and Puskur, 2021). Therefore, there have been compelling calls for developing adequate policy environments for the profound transformation of agri-food systems to achieve better nutritional, environmental, and sustainability outcomes.

Theoretical underpinnings of agri-food system transformation

Circular economic perspective along with the agroecological principles are increasingly recognized as providing alternative paradigms of food production, distribution and consumption that broadly help fix the emerging crisis of the conventional agri-food systems.

Circular economy (CE)

Circular economy is an emerging principle of regenerative system in which use of resources and energy, and production of waste and emission, are minimized at optimum level by slowing, closing, and narrowing material and energy loops (Geissdoerfer, Savaget, Bocken, and Hultink, 2017). A circular economy strives to have a positive impact on people, businesses and the planet through application of fundamental principles of reducing, reusing, refusing, rethinking, recycling and repairing or regeneration (Boon and Anuga, 2020). Van Berkum et al. (2019) define circular economy as standing against the conventional linear economic model of 'take-produce-consume-discard' and entailing three economic activities- reuse, recycle and reduce existing (used) materials and products. Table 1 presents key principles of circular economic perspective.

Table 1: Key Principles of Circular Economic Framework

Sl No	Principles	Explanation
1	Reduce	This refers to reduction in both the resource consumption and discharges into the environment thereby reducing environmental pressure and ensuring natural resource security
2	Refuse	This refers to refusing to adopt any materials, resources, strategies and approaches that are seemingly unsustainable.
3	Reuse	Using and reusing of raw materials and natural resources in a cyclical sequence which adds the most value to the economy and causes the least damage to the environment.
4	Recycle	This refers to the mechanisms by which waste materials are reprocessed into useful products, materials or substances. What are conventionally considered as waste materials become resources in this process
5	Rethink	Principle of rethinking refers to reconsidering current unsustainable and unfair lifestyles and the ways of production and consumption.
6	Regenerate/Repair	Regeneration or repair implies repairing a resource/product to enable it to be continuously used instead of abandoning/throwing it away.

Source: Boon, E. K. and S. W. Anuga, 2020.

Circular economic perspective was originally conceptualized in industrial context. However, it offers alternatives to the indiscriminate use of resources in conventional agrifood systems through promotion of a regenerative production system. Regenerative farming is the central feature of circular agri-food systems that directly contribute to sustainability and resilience (Morseletto, 2020).

CE offers mechanisms of reducing usage of the production inputs, reusing of resources and materials, and optimizing all possible options to reduce wastes in one hand and recycling of the wastes wherever possible on the other, without compromising levels of overall production. Refusing refers to the principle of not using the materials, methods and practices that are unsustainable. Rethinking principle is related to current lifestyles and the ways we engage in production, processing, distribution and consumption processes. All these measures aim at mitigating the negative externalities of the agri-food systems to the environment, climate, and human welfare.

Agroecology

Agroecology is considered as a science, a set of farming practices and a social movement that favors limited use of external/synthetic inputs, stresses indigenous knowledge, promotes participatory practices of knowledge generation and dissemination, and emphasizes on addressing social inequalities in agrifood systems (HLPE, 2019). Agroecology examines and informs the functioning of agroecosystems including ecological, biophysical, economic, socio-cultural, and political designs, mechanisms, functions, and relationships of food production, distribution and consumption (Akram-Lodhi, 2021). It offers a systemic and holistic ways to improve agri-food system by minimizing the use of synthetic external inputs and high energy, particularly through harnessing natural processes of beneficial interactions among the components of agroecosystems (Wezel et al., 2020). Agroecology emphasizes small-scale farmers and localized production and consumption systems along with the principles of sustainability and farmers' autonomy in food production (Bellamy and Ioris, 2017). Agroecology is a transdisciplinary field that encompasses ecological, socio-cultural, technological, economic, and political dimensions of entire food system. To make the agroecological approaches distinct and concrete, various scholars and agencies have devised number of principles that guide practices and provide measurable criteria for assessment.

The Food and Agriculture Organization of the United Nations (FAO), through a multi-stakeholder's consultative process, has developed 10 interlinked and interdependent principles as the salient 'elements' of agroecology that are crucial guideline for the agri-food system transformation towards sustainability (Table 2).

Table 2: Key Principles of Agroecology

Sl No	Principles	Explanation
1	Diversity	promoting and prospering diversities of species, ecological functions, and knowledge, activities, and livelihoods options of various stakeholders of the agri-food systems.
2	Co-creation and sharing of knowledge, practices, science, and innovation	fostering participatory processes of knowledge generation, and sharing, through multi-stakeholder engagements including farming communities for mutual learning between science and society. Agroecology aims at blending traditional and indigenous knowledge, producers' and traders' practical knowledge, and global scientific knowledge.
3	Synergy	enhancing integration and complementarity among different components of agroecosystems and promoting positive ecological interaction for creating synergies.
4	Efficiency	promoting agricultural systems with the necessary biological, socio-economic and institutional diversity and alignment in time and space to support greater efficiency.
5	Recycling	using local renewal resources and supporting biological processes that drive the recycling of nutrients, biomass, and water within production systems, thereby increasing resource use efficiency and minimizing waste and pollution.
6	Resilience	enhancing socio-economic and ecological resilience through reducing dependence on external inputs and diversifying and integrating the various components of farm enterprising.
7	Human and social values	emphasizing human dignity, equity, inclusion, and justice through empowerment of people to become their own agents of change.
8	Culture and food traditions	Supporting for provisioning healthy, diversified and culturally appropriate diets based on local tradition and identity, while maintaining the health of ecosystems.
9	Responsible governance	strengthening policy and institutional mechanisms to recognize, support, and improve smallholder and peasant producers, ensuring equitable access to land and natural resources.
10	Circular and solidarity economy	ensuring proximity and confidence among producers and consumers through a circular and solidarity economy that prioritizes local markets and supports local economic development by creating virtuous cycles.

Source: FAO, 2018, Wezel et al., 2020.

Framework for sustainable transformation of agrifood systems

The transformation of conventional agrifood systems towards a sustainable, circular resilient, and inclusive system requires systemic changes in all aspects from production, to marketing, and consumption behavior. The High-Level Panel of Experts on Food Security and Nutrition (HLPE) commissioned by the UN Committee on World Food Security devises a five-level framework developed by Stephen

Gliessman and his colleagues for the sustainable transformation of agri-food systems adopting agroecological principles (Gliessman and Engles, 2015; HLPE, 2019). The same framework looks useful to develop a roadmap merging both the agroecological and circular economic principles as a plausible means for transforming the conventional agri-food systems of Nepal.

As depicted in the framework below (Table 3), the goal of level 1, is to make production more efficient through minimum use of inputs at farm levels by the promotion of the agroecological and circular practices such as nutrient recycling, reusing of the resources, using natural predators for pest control, using stress tolerant varieties, improving plant nutrient uptake, etc. This goal can be achieved by using reduction, recycling, and reusing principles of circular economy.

Table 3: Framework for sustainable transformation of agri-food systems

<table>
<tr><th>Change process</th><th>Transitional goals</th><th>Corresponding Circular economic/ agroecological principles</th><th>Applies to</th></tr>
<tr><td rowspan="3">Transformational</td><td>Level 5:
A new agri-food system - localized, inclusive, equitable and justiciable</td><td rowspan="2">participation, social values and diets, fairness, land and natural resource governance and connectivity.</td><td rowspan="2">Agri-food System</td></tr>
<tr><td>Level 4
Closing gaps between producers and consumers through development of alternative food networks (localized food markets, short food chain, participatory guarantee systems)</td></tr>
<tr><td>Level 3
Redesign agroecosystems (promoting diversities, and integration, regenerating the degraded systems, cicularity)</td><td>Co-creation of knowledge, practices, and innovations</td><td rowspan="3">Agroecosystem</td></tr>
<tr><td rowspan="2">Incremental</td><td>Level 2
Employ sustainable alternatives to the conventional practices (inputs, and technologies)</td><td rowspan="2">Rethinking and refusing unsustainable practices, inputs reductions, resources reusing, nutrient recycling, regenerating soil health/animal health, promoting diversities, considering efficiency and synergies.</td></tr>
<tr><td>Level 1
Increasing resource-use efficiency within the existing conventional inputs/practices</td></tr>
</table>

Source: Acharya, 2022, Wezel et al., 2020

Level 2 of the transformation process leads to developing adequate low cost, local alternative means of inputs and technologies for sustained use by the farmers without fundamentally reorganizing the farming systems. Agroecological and circular principles such as inputs reductions, recycling, reusing, regenerating soil health/animal health, promoting economic and ecosystem diversities, and building synergy guide actions to achieve the goals of level 1 and level 2 of the transition.

From level 3 to 5 involves transformational process and covers the entire food system beyond the specific agroecosystem or a particular landscape. The goal of level 3 is to redesigning overall farming systems based on ecological and circular principles and natural processes (Anderson et al., 2021). Various ecological farm practices such as intercropping, integrating crops, livestock, and fishes, manuring, composting, agroforestry, mixed farming, promoting local seeds/breeds etc. are intentionally introduced with the clear aim of reducing external inputs, prospering the biodiversity, regenerating soil health, farm environment and diversifying on-farm incomes at landscape levels.

Level 4 aims at shortening the food chains as much as possible by closing the gaps between producers and the food consumers, reducing food wastes and losses, through development of local cooperative markets, post-harvest technologies and institutionalizing participatory guarantee systems for quality assurances of the local food products. At this stage, connections between producers and consumers are strengthened to support the socio-ecological transformation of the food system (Anderson et al., 2021). Achievements of level 1 through 4, lay the foundation of level 5. A wider transformation of policies, rules, and institutional culture focusing on reduced use of resources, resource recycling, social justice and deliberative democracy are expected with achieving the level 5 goals.

Sustainable transformation of Nepalese agri-food systems: prospects and challenges

The Agriculture Development Strategy (ADS) of Nepal categorizes Nepalese agri-food systems broadly into two categories (MoALD, 2015).

a. **Small-scale commercial** undertakings covering 25% of the rural population that operate on more than 1 ha of land holding size and bring more than 30% of their total production in the markets for sales.

b. **Subsistence agri-food system** that covers slightly above 27% of the rural households operating on 0.5-1 ha of landholding size.

Remaining more than 47% rural households are either near landless with less than 0.5 ha agricultural landholding or landless having no land in their command.

The ADS focuses on expediting the commercial agricultural production among the first category of rural population largely through the green revolution approaches. ADS aims at exploiting all possible commercial prospects of agri-food system ‘to produce more’ by using high yielding varieties/breeds, and external inputs as like the

conventional industrial mode of farming. This policy thrust has already been fueling the unsustainable use of land, water, and other natural resources particularly in commercial production pockets of peri-urban and other accessible areas through rampant use of synthetic fertilizers, pesticides, and irrigation water. With this emphasis at the outset, ADS also repeats the same mistake of the green revolution era in the South Asia, when the subsistence farmers were largely ignored as inefficient producers and becomes irrelevant for addressing the dire needs of more than 75% rural households. The entry point of the sustainable transformation of Nepalese agri-food systems should therefore be the fundamental reorientation of the policy priorities from exclusive focus on commercial producers towards the subsistence communities. Development of a just, sustainable, and resilient agri-food systems which are localized and inclusive, having a well-developed mechanism of nominal use of resources, recycling and reusing of resources with minimum waste products should be the ultimate purpose of agri-food system transformation.

It is noteworthy that the subsistence farmers of Nepal are generally remotely located with limited access to modern extension support services, inputs, financial services, and technologies and are operating without using costly external inputs. They are knowledgeable about their local environment, and they use the natural processes of nutrient recycling, mixed farming, green manuring, composting, and other indigenous means to maintain the farm productivity. This type of compulsive practices, though are the bliss for sustainability, have rarely become the part of deliberate interventions of mainstream development. In absence of external interventions, the subsistence farmers in general are protected from rampant use of costly external inputs that are detrimental to the environment, but at the same time, poor farmers are unable to enhance resource use efficiency and farm profitability and reduce other means of environmental degradation such as soil erosion, and overuse of water.

Hence, for sustainable transformation of agri-food systems, first we need to be ready to institutionalize deliberate efforts with sustainability framework to protect and prosper the unspoiled farmlands of the smallholder farmers in one hand and enhance their resource use efficiency and profitability on the other. Therefore, in majority of the subsistence pockets of rural areas, level 1 and level 2 of the transformation process can be the appropriate entry point. In accessible areas where small scale commercial pockets have already been developed, we have to introduce the level 3 and level 4 interventions depending upon the specific contextual situations.

Co-creation of knowledge, practices and innovations is the most critical aspect of the transformation process for achieving the sustainability goals. The innovation process in this paradigm essentially requires an interdisciplinary, participatory, and holistic approaches. However, the agricultural research, extension and education institutions in Nepal are heavily influenced by the reductionist technological paradigm barring the prospect of co-creation of knowledge and innovation.

Agricultural research is mostly non-participatory and compartmentalized, focusing on the yield maximization of particular crop or livestock, and rarely emphasizes to enhancing the entire farming system. Agricultural scientists use the conventional metrics of performance measurement that value the direct output, i.e., yield and rarely consider the environmental costs and benefits. Most of the technologies are developed in controlled environment and promoted as being 'modern' and 'scientific' which in most cases are irrelevant to heterogenous groups of smallholder farmers operating in complex, dynamic and risk-prone situations. On the other hand, well-adapted alternative technologies what the smallholder farmers have been practicing since long are rarely explored or even acknowledged by the scientific communities resulting in serious lack of data on such useful practices. The mainstream research and development practices may address the environmental concerns, but mostly as a part of the policy compliance only.

In fact, our agricultural knowledge system and development practices are overwhelmingly dominated by the perspective of the developed West, which is linear economy approach characterized as the 'take-make-dispose' development model. The fundamental of this development model is indiscriminate use of resources and energy, the limitations of which have already been realized widely. We should not make mistake following the same path. Our development trajectory should be characterized by low resources and energy use as depicted in the figure 1 below, and the circular economic and agroecological principles help realize this goal.

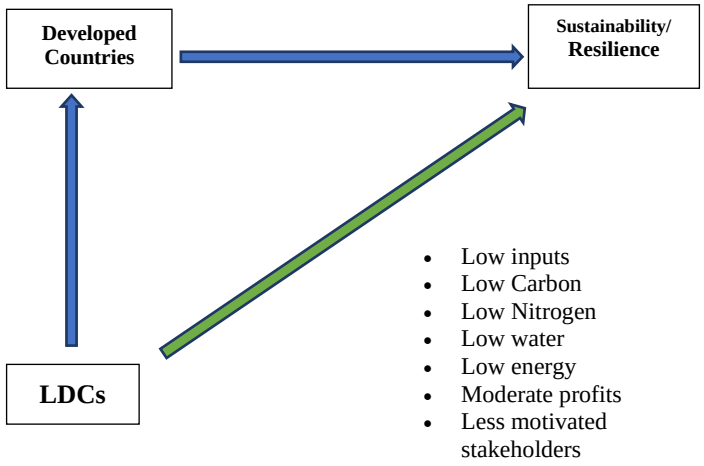

Figure 1: Development trajectories: Developed and least developed countries

Source: Pathak, 2022

We conclude this discussion here devising following 4R measures as prerequisite for effective implementation of the agroecological and circular economic framework in the direction of sustainable transformation of agri-food systems in Nepal.

I. ***Reorienting*** agricultural development policies and programs towards the subsistence farmers. Developing policy environment that recognizes the value of small-scale food producers and focuses on strengthening them should be the key strategy (Smallholder focus).

II. ***Reforming*** agricultural research and extension systems. Institutionalizing interdisciplinary/transdisciplinary and participatory approaches, and a holistic and constructivist perspective in agricultural research and development practices.

III. ***Recognizing*** indigenous knowledge, skills, and practices. Exploring, optimizing, and extensively promoting many of the locally adapted indigenous farming practices.

IV. ***Re-building*** farmers' agency for collective action. Strengthening primary producers' organizations, promoting collective action.

CONCLUSION

Agroecology and circular economic perspectives offer plausible pathways of transformation of conventional agri-food systems towards an inclusive, sustainable, and resilient food systems. Based on systematic reviews and analysis of academic literatures we have proposed a framework for sustainable transformation of agrifood systems that encompasses both the circular economic and agroecological principles. We argue that the framework offers plausible solutions to the pressing need of reducing negative externalities of agri-food systems. However, agricultural research, education and development systems are traditionally oriented towards commercial and industrial mode of farm enterprising which need a fundamental reorientation and reformation. Furthermore, the proposed transformation framework is apparently a linear, and deterministic one. However, in practice the transformation process involves a contextual, non-linear, and messy process.

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