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Opinion

Water, energy, and food nexus with agroforestry system for sustainable development goals

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Food production program faces tight competition on land, water, energy, and efforts against the negative effects of food production on the environment [1,2]. Water scarcity becomes a global challenge that is in line with "virtual agricultural water" demand, during food production processes and embedded in national or international food trade or import [3]. Water insecurity will worsen with increasing water demand, population growth, agricultural water demand for food security, urbanization, and climate change [4]. Freshwater (approximately 80% of blue water and a large fraction of green water) is used for agricultural activities to support food production [5,6]. In addition, about 10% of irrigation water in developing countries comes from reused wastewater [6]. The division of water in agricultural activities in the era of climate change and water poverty creates antagonism caused by competition with each other for water supply. On the other side, rain-fed croplands require less water supply due to the use of only available soil water content (green water) than the irrigated crops [6].

Nature Base solution (NBS) is a strategy to overcome water insecurity because nature plays an important role in protecting the water supply by controlling water flow, maintaining water quality, and reducing natural disasters [4]. NBS involves managing ecosystems to imitate or optimize natural processes, such as vegetation, soil, wetlands, water bodies, and even groundwater aquifers better naturally [4] and forests are considered as users and regulators of the freshwater cycle [7-9]. Conversion of forest to agriculture can lead to loss of hydrological functions associated with infiltration, so infiltration-friendly agroforestry lands minimize these losses [10]. The water function of natural forests with high biodiversity is not possible with oil palm monocultures with shallow roots [11] This can be anticipated by planting fruit trees (stinky beans, dog fruit, jack fruit, etc.) in an agroforestry system. Promotes the development of multifunctional landscapes to conserve or increase the quality of catchment areas (watershed with agroforestry system) [12,13].

Mechanism and modernization in food production that its supply chain consumes a significant quantity of energy in developed countries [14] where mechanization and other modernization measures are adopted. In fact, at the global level, the food sector (including agricultural irrigation) accounts for nearly 30% of the total energy consumption [15]. This lack of cooperation among sectors has led to significant competition between the different use of energy and water for food or other purposes. This is reflected in contradictory strategies and policies, which do not effectively permit them to reach either economic or environmental sustainability, posing a risk to global food security [16]. Off-scale action and scale-up of landscapes to achieve sustainable development goals globally must be based on understanding the extrapolation and interconnectivity domains of products and services [17]. The matrices of "water for food", "energy for food" and "ecosystem for food" can be obtained and some practical related [16]. Development strategies need to create simultaneous goals on water, energy, and food to increase positive synergies between sectors, share benefits, meet the increasing demand, improve ecosystem functions and protect [16]. Therefore, environmentally friendly agriculture is required to ensure safe food access by implementing the reciprocal relationship between the energy, water, food, land,

and ecosystem (EWFLE) sectors in an integrated manner [16]. As part of the Sustainable Development agenda, land use, often a mix of forests, agroforestry, agriculture, and built-up areas, has to meet many and partly conflicting needs, including the provision of food, energy, water as well as environmental protection from floods, droughts and biological extinctions [18].

Agroforestry as an agriculture combination for productivity (Income and Food) and forestry (conserve /environment/ ecological and productive) has multifunctions (conserves and produces) [19]. A combination of forestry (SDG 15) and agriculture (SDG 2) in integrated land management is the potential in obtaining three broad groups of SDGs (demand for further human resources appropriation, sustaining the resource base, and redistributing power and benefits) [19]. Agroforestry as regenerative farming for food producers is match with the sustainable development program of SDGs [20,21]. Agroforestry is a potential optimal point to accommodate water food, and energy nexus [19,22,23]. The existence of forests and tree can conserve prevention water and soil to contribute clean water and energy (product biofuel) to cooking and undergarment of food security [19,23]. The presence of trees and forests affects water, and energy [7,8]. The interactions of forests, water, and energy provide the basis for carbon storage, cooling terrestrial surfaces, and distributing water resources. Forests and trees should be recognized as key regulators of the water, energy, and carbon cycle [7,8]. Woody plants can produce firewood whose calorific value/kg is not inferior to non-renewable energy such as coal and oil. The regulation of plants as producers of biofuels and land as food producers also becomes a trade-off in optimizing land use with agroforestry. Trees also influence the water cycle and watersheds contribute to rural micro-hydro energy. Agroforestry is multifunctional for income diversity and environmental services (clean water, biodiversity, carbon sequestration, and cultural conservation) [19,22].

Besides, increases in yields can be highly sustainable (secure) as agroforestry retains soil fertility and can reclaim degraded lands [24-26]. There are also opportunities to use agroforestry for the prevention or reversal of land degradation in the humid tropics [27]. Agroforestry was found to enhance biodiversity, erosion control, and soil fertility [28,29].

The key benefits in terms of natural resource use are as follows [30]:

1. Soil conservation in terms of protection against erosion.

2. Improvement or maintenance of soil fertility.

3. Water conservation and more productive use of water.

4. Providing environmental functions required for sustainability.

Indicators of the sustainable intensification for smallholder farming systems fall into five main domains: productivity, economic sustainability, environmental sustainability, social sustainability, and human well-being [31].

The agroforestry–food–water–climate nexus entails an in-depth and detailed discussion about agroforestry's interdependent relationship with water security and regional climate [23]. Some of the trade-offs that can be accommodated by agroforestry are energy (fuelwood) and food (crops), arable land for forest or extensive cropping, and water for agroforestry and agroforestry's impact on the water cycle [23]. Agroforestry by combining tree management with productive agricultural activities for food, is one promising option for efficient and sustainable use of land and water [30] as a form of adaptation to climate change, and in the water, energy, land, and food nexus [32]. Agroforestry and conservation agriculture should be key elements as they can improve the productivity of smallholder agricultural systems under climate change by strengthening their resilience [32]. Agroforestry can significantly contribute to the food security of rural farmers in the face of climate change [33] which can trigger significant hunger crises (sudden, widespread changes in weather, harvesting, price, and cost of input) [24]. It also boosts livelihood resilience by reducing the reliance of trees on predictable, remote product markets on the provision of free ecosystem services [8]. Bio-energy-based agroforestry is a potential option to increase energy and food security and to realize sustainable agriculture (soil and water conservation, resilient agriculture, and land use productivity) [23].

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