J. Hortl. Sci.
Vol. 17(1) : 19-24, 2022

Review

Diversified farming systems for changing climate and consumerism

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ABSTRACT

When we think about environmental degradation and climate change, the first things that come to our mind are cars and factories, but not how we grow, consume and dispose of. If we collectively put these things together, we account for nearly one-third of the human-induced climate change. That certainly put agriculture at the crossroads of system-level transformation towards healthy food, people, and the planet. Such food-system transformation requires a paradigm shift towards nature-friendly nutrition-rich diverse fruits and vegetables, and it should constitute at least 30-50% of our food plate from the current average of less than 10%. The only way left for us is to return to an ecological intensification with feedback loops that inter-links vital elements of complex agroecological transition within the planetary boundary limits. Farming in harmony with nature, carbon-neutral, enrich micro-hydrology and restore biodiversity to co-benefits the people and the planet. The context-specific regenerative agriculture practices that are ecologically sustainable and economically viable found to be best fit models for smallholder farmers and home gardeners. It is based on the sound ecological philosophy of production follows structure, composition and functions, and where ecosystem services and wellbeing become default returns on their own. The recent advances in digital augmentation with ICTs enabled citizen science to provide powerful tools to aid the integration of frontier technology with indigenous knowledge. This leads to an ideal agroecosystem integrated with diverse crops, multi-purpose tree species, animals, and peoples in collective action to restore broken food systems and combat climate change.

INTRODUCTION

The ever-increasing human population and increased demand for food and industrial needs have put tremendous pressure on natural resources and human capital. Agriculture is still a dominant sector in every aspect of sustainable development with a limited natural resource base and faces severe environmental constraints that are likely to worsen due to climate change. There is a definite need for an integrated approach for managing the world's agricultural resources to sustain productivity while safeguarding environmental flows. The ambitious conservation efforts and food system transformation are central to conserving terrestrial biodiversity (Leclere et al., 2020). A better farming system is required to bend the curve by combining production, consumption, conservation and restoration with significant co-benefits to the people, culture and nature. The farming systems data and information are critical factors to understanding current trends and status of agricultural resources and finding optimal approaches to achieve reduced vulnerability and sustainable intensification in developing countries that depend upon dryland production systems for food security and livelihoods. Therefore, an open-access policy to geospatial information, technology, and fair knowledge sharing and management mechanisms are becoming an integral part of the food security equation. Geospatial technology (remote sensing, global positioning system, and geographical information system) has progressed rapidly in the 21st century. It will keep expanding its role in almost every aspect of food security, including research, programs, policies outreach.

Enormous efforts are underway throughout the world to gather data and information on crops, rangeland, livestock, and other related agricultural resources and their production mechanisms. However, these are collected at very coarse resolution in many instances, ranging from several hundred meters to tens of kilometres. Such information or data are often used in global and regional scale models to assess status or trends at the landscape level or even larger units. However, at these scales, such data may fail to reflect ground realities that are often very different from information or data collected at larger scales and, therefore, fail to capture the agroecosystems' complex nature. This is particularly prominent in the developing world, where small landholdings and production systems are highly diverse and complex. Complexity is associated with many factors, including environmental conditions, landscape structure, functions, soil health, water availability, topography, localized weather events, poverty distribution, infrastructure, migration, local policies on land tenure, market access, and conflicts. Such an array of contextual conditions push for an integrated system approach to manage more productive, stable, and environmentally sound resilient agriculture production. They provide a science-based circular approach for addressing complex and interactive sets of increasingly regenerative practices for functional food systems (Fig. 1). Implementation and intervention of new management paradigms to ensure food security and improved livelihoods require better information in space and time. Therefore, data-driven digital augmentation is vital in transforming agri-food systems for better resilience under changing climate, diet, and demography.

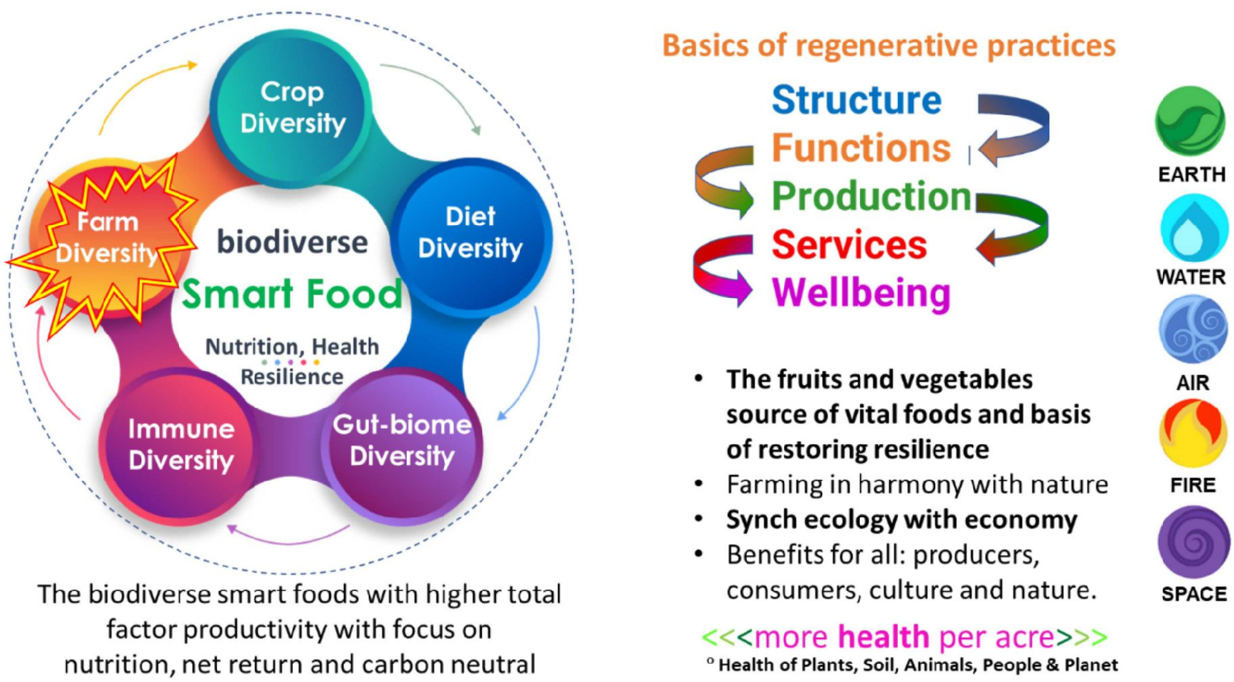

Fig. 1. Functional food systems for restoring nutrition and climate resilience.

Food for climate action

We often associate the root causes of climate change with factories, airplanes, traffic-congested roads, and deforestation. But equally important is the food we eat and how we grow it. The enormous challenge and the vast opportunities for action on climate change have distinguished the issue as the most pressing topic of reforms. The first step towards climate action is how we reshape our mindsets and way of living with less and healthy food habits. The environmental impact of unsustainable agricultural practices varies from how we produce food to how we consume and dispose of it. When we examine the global diet in the last three decades, we can see drastic trends and how we have become dependent on a few staple crops (primarily cereals) and industrially farmed meats. This results in a significant and negative impact on the climate and our ability to grow food now and in the future, water availability, global nutrition, and overall planetary health. There is a pressing need to return our increasingly homogenous agriculture into a highly diversified agroecosystems to ensure the health of the population, our world, and its ecosystems.

An integrated agro-ecosystems

The dynamics of agricultural production is driven by environmental factors such as drastic fluctuation in temperature, erratic precipitation tends, and water supply is often the most limiting factor for profitable agricultural production. They are characterized by persistent water scarcity, extreme climatic variability, high susceptibility to land degradation, desertification, and loss of natural resources, including biodiversity, at elevated rates. However, we often fail to understand and/or hardly emphasize to understand and quantify the underlying factors and drivers responsible for building the resilience 'agroecosystems' as shock observers to withstand the changes. Refining conventional yield centric production into climate resilient agroecosystems requires systematic combinations of plant, trees and animal species and management practices to specific agroecological zones. Pursuing sustainable livelihood goals is based on several factors, including crops, climate, soils, markets, capital, trade, and tradition. It demands an integrated approach with an ecologically sound functional production system to improve livelihoods. Therefore, the international and national initiatives emphasize diversified agroecosystems through strategic research, outreach, and enabling policies to achieve sustainable development goals.

The core value of the innovative systems is their synergies to enhance the adoption rate of technologies and management practices through more significant interaction of stakeholders and researchers. While it also needs to emphasize reducing vulnerability. The conventional intensification of agriculture with a mere focus on yield alone is prone to high risk and exposure due to several associated factors such as climate, soils, lack of capital, poorly developed markets, demographic challenges, and ever-increasing pressure on the natural resources. These systems are characterized by intricate combinations and high diversity in agronomic practices, cropping patterns and intensity, water use, rangeland, trees, livestock, fish, landholding size, etc. Because of their complexity and diversity, it is necessary to characterize these systems at very high spatial resolutions to understand the risk and vulnerability factors. The contextual mapping presents emerging and future land use trends will better allow researchers and decision-makers to diagnose vulnerabilities and intervene to improve livelihoods by taking into account such factors as land cover dynamics, cropping pattern and intensities, water use and availability, changing demographics, infrastructure, poverty, markets, climate change, etc. The information generated in the preliminary analysis help to assess vulnerable areas for possible pathways to increased resilience to and mitigation of risks, whether it could be biophysical (e.g., land degradation and drought), ecological (e.g., dwindling agrobiodiversity), or socioeconomic (e.g., price shocks or policy changes in land tenure).

An ideal agroecosystem is an inclusively functioning system integrated with diverse crops, multi-purpose tree species, and bio-pulverizing livestock to produce vital food, real-forage, natural fiber, simultaneously preserving the soil health and restoring ecosystem functions. This collective action of the feedback mechanisms leads to restoring planetary health and combating climate change. To successfully implement such an approach in the climate-vulnerable agri-food systems, one must first identify suitable areas for ecologically sound agricultural production and consumerism. These domains are an essential entry point for any sustainable developmental goals, whether they are choice of crops (legumes in cereals), varieties (short duration), diversification (ration and intercropping), or efficient feedback loops (use of residuals)

Increasing system research with evolving digital technology has opened the room to reverse the global trend in homogenous cereal cropping. Incorporating agroecosystem research with in-the-field citizen science and new technology creates an ideal environment for integrating local knowledge with innovative solutions and testing the formula. Once proven, the science makes sustainable production and consumption more viable and scalable than before because it considers modern variations in settings due to prevailing conditions. The data-driven analytics created tremendous opportunities to address the gaps at multiple levels such as data, yield, nutrition, ecology, economy, and resilience for demand-driven ecological interventions across scales such as space, time, and the package of sustainable land management practices (Figure 2). Our ongoing efforts in demand-driven interventions aim at accelerating these innovative and sustainable agroecosystems (Figure2) and food gardens (Figure 3) by modelling them for possible areas and then targeting specific sites with the appropriate interventions. They have proven an argument for scaling these interventions into mainstream production and consumption by successfully testing them. The prospects and potential role of inclusive agroecosystems in combating climate change, supported by paradigm shifts in diet patterns and lifestyle, are clearly defined.

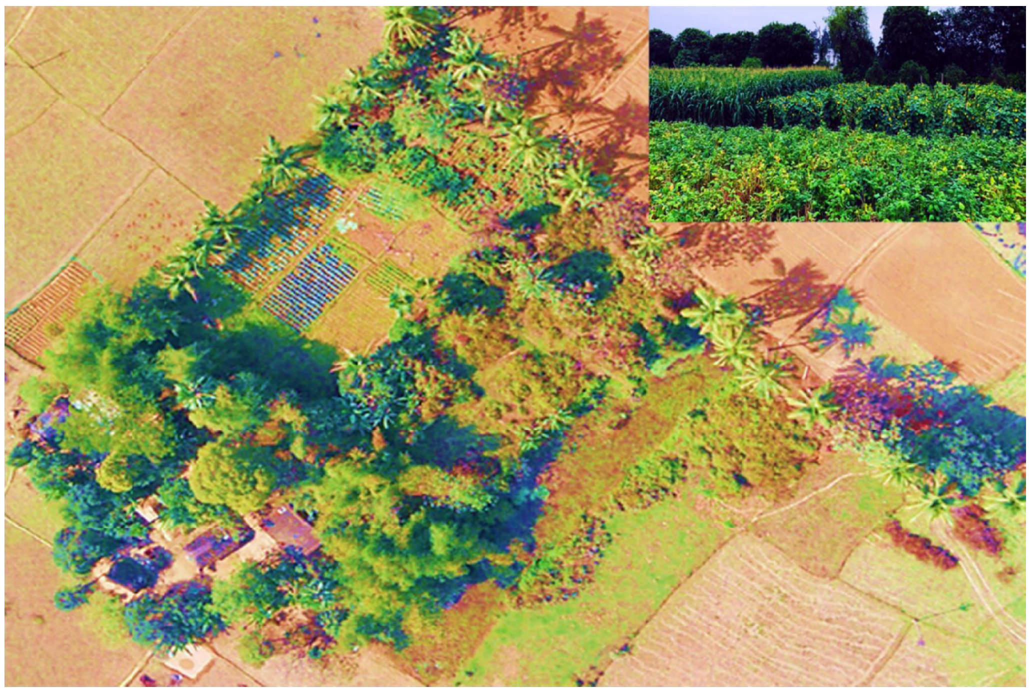

Fig. 2. An example of diversified family farming growing variety of fruits, vegetables, spices and condiments. (Aerial and inlet photos: C. Biradar)

Fig. 3. Green Gold Food Forest model for home gardens with rich in diversity of the fruits, vegetables and herbs growing in 40 x 60 feet space. (Photo. C. Biradar)

Transforming food systems

The current food systems are upsetting the ecological balances, and myriad externalities expose the system's vulnerabilities. Be it the considerable nutrition gap between our present diet consumption and a scientifically balanced diet that is planet-friendly falls within the planetary boundary as proposed by an EAT-Lancet report. However, the unfortunate erosion of tens of thousands of species culminated in the hegemony of a handful of staple food crops that dominate our calories. This calls for going back to farming with stacking functions and multi-later agriculture with trees, crops and livestock.

Food well preserved with chemicals, clean looking, travelled over thousands of miles, often does not fit into the category of healthy and sustainable food. Most modern food travels over a mile, often harvested much before its maturity, sprayed with toxic chemicals to increase its self-life in the supermarket shelves or factory bins. Over 80% of its vital nutrition is lost in several ways and processing starting from its grown, harvested, transported, preceded, cocked, served, freezes, heated, reheated. Most vital nutrition lost in the processing to consumption chain end up in eating junk food. Little vital nutrition left in the food, which demands more consumption than needed, leads to 'belly total hungry cells. We eat more food but feel hungry always because body cells not getting the healthy nutrition they need. Ideal food for a healthy body and cells must constitute freshly harvested food grown in healthy soils. Many people don't know what actual organic food tastes are. It just tastes the vegetables we used to eat 20-30 years ago to what we get now. Ask village elders they will tell no taste and flavour in the Vegetables these days because all these vegetables are grown in dead soil with tons of chemicals. We need eight carrots to have the same nutrition we obtained from one carrot 30 years ago. This applies to almost all food we grow these days. 80 population in chronic health issues which is mainly attributed to the food we eat and the lifestyle. Our culture is agriculture; indeed, the culture of humanity is agriculture. Still, it has the most vital lever to fix most of the problems humanity, the wild and the environment facing now.

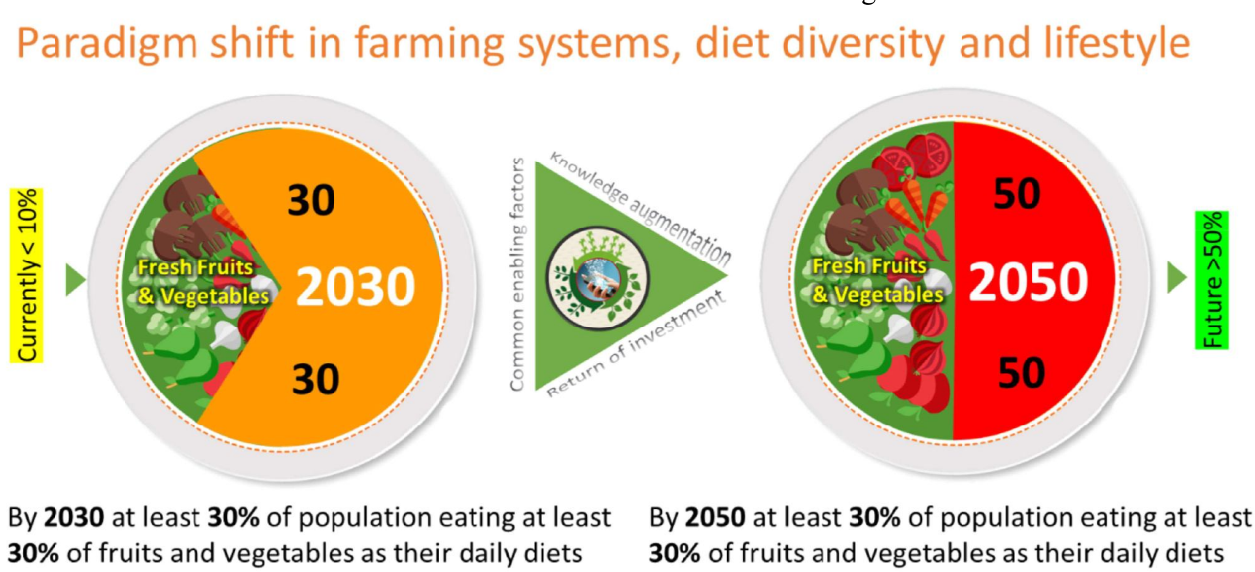

Fig. 4. The vision 30:30:30 and 50:50:50 is all about increasing the production and consumption of fruits and vegetables from mere less than 10% at present to 30% and 50% by the year 2030 and 2050, respectively.

An approach aimed at integrating an array of species diversity in reviving lost agrobiodiversity, integrated cultivation practices, and diverse dietary habits as building blocks of sustainable, resilient, and resource-efficient food systems. It puts forth the need for a crucial paradigm shift from mono-cropping to integrated resource-efficient agri-food systems and from more calories per acre to more nutrients (health) per acre (Fig. 4). It is only possible to build resilience and incorporate sustainability by restoring healthy food systems and rebuilding the living soil via a diversified cropping system with various plant species in the smart family agriculture. The production follows functions and needs to leverage technology and local intelligence to rebuild functional agri-food systems for a sustainable future and planetary health.

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