Perennial Agriculture: Landscape Resilience for the Future

Engage in an Important Shift of agricultural systems. Agricultural systems have to be shifted to achieve sustainability through its multiple functions and benefits beyond yield levels.

"Perennialize" Agriculture. Perennial agriculture, including perennial grains, oil seeds and legumes as well as forages and trees can take sustainable intensification to the next level and achieve productivity goals as well as social benefits and functioning ecosystem processes and services.

Invest in Research. Today we have many technologies available to perennialize agriculture. Investments must be made through public and private sector partnerships to ramp up research, mainstream perennial agriculture into diverse farming systems on the ground and establish a conducive policy environment.

Get it on the Ground. Within the context of the evolving Sustainable Development Goals, a commitment can be made to target the integration of perenniality via perennial crops, trees, forages into 20 percent of annual cropping systems by 2030.

Support Smallholders and Family Farmers. Perennial systems can transform agriculture for smallholders and family farmers because perennial crops are more flexible and resilient to climate

Do we need to shift agriculture and transform cropping systems?

1. For decades, the sustainable agriculture community has called for diverse, innovative farming systems and landscapes that mimic nature and enhance resilience while providing food and nutritional security, livelihood and ecosystem service benefits. Today some 50 percent of the world's population is supported by largely intensive production on 35 percent of the global land area, which in large part is degraded. Agriculture needs to provide sufficient food and nutritional security to meet the demands of future generations in the context of unprecedented global environmental and socio-economic change.

2. The yields of annual crops, currently grown on 70 percent of the world's cropland area, vary widely based on stresses and availability of productive inputs (irrigation, nutrients, pest management, technical support, etc.). Although these yields have more than doubled over past decades, this has degraded fertile land, depleted groundwater provoked pest upsurges, eroded biodiversity and polluted air, soil and water.[i]

3. To reinvigorate agriculture in a sustainable and productive way while meeting multiple societal and environmental demands on a vast scale will take a significant shift and considerable investment. Fortunately a group of scientists, practitioners and investors have been working for several decades to develop perennial versions of currently annual staple crops. Their vision is that new perennialized crops can be integrated into agricultural systems along with perennial forages, shrubs and trees to provide increased food, feed, fodder and fuel per unit area while bringing the multiple benefits of perenniality.

What is perennial agriculture?

1 Perennial species (crops, forages, shrubs and trees) are those able to regrow and continue to reproduce grains, seeds, fruits, and biomass after a single harvest. They can be harvested numerous times for up to 10 years for crops and much longer for forages, shrubs and trees.

2 Building perenniality into agriculture systems is the intentional integration of perennialized crops (grains, oilseeds, legumes etc.), forages, shrubs and trees in diverse farming systems, landscapes and agro-ecosystems to:

- provide more consistent, abundant and affordable food, feed, fibre, and fuel;
- enhance the natural-resource base and environment that underpins productivity;
- make farming more financially viable; and
- contribute to the overall well-being of farmers, farm workers, and rural communities.

What are the benefits of "perennializing" agriculture?

4. **Ecological benefits.** Perennial species offer many advantages over annual species both above- and below-ground in terms of maintaining ecosystem functions. Perennials maintain the soil cover, soil structure and biota and have deeper root systems than annuals and thus provide soil stability and enhanced soil health. They can also tap available soil nutrients, enhance biodiversity, make more water available to plants, and capture and sequester carbon (See Table 1). In the breeding process, characteristics from wild relatives can be drawn upon to make crops more nutritious, more resistant to pests and with greater adaptation to the impacts of climate change, which can increase the capacity of agriculture to address food demands.

5. **Socio-economic benefits.** Perennials require reduced fertilizer and energy inputs and so less financial investment. This means farmers can re-direct such resources towards education and other livelihood enterprises while enhancing the flexibility and diversity of their farming systems. This is particularly true where a perennial crop offers multiple products such as dual purpose food, feed, fibre and biofuel. One example is perennial wheat which offers forage for feed early in the season, a grain crop for food and finally straw or hay for biofuel, which has been demonstrated in Australia. The flexibility and resilience of dual-purpose perennial crops makes them most attractive on soils or in situations where other cereal systems are considered marginal.

6. **Smallholder benefits. Farmers, pastoralists and forest dwellers** need multiple options to increase and maintain their livelihoods, especially in less favourable areas or fragile environments. Increasing the availability of perennial grains, oilseeds and legumes expands the opportunities to rotate perennial and annual crops and to grow multiple crops together in perennial intercropped or polyculture systems thus increasing biological and economic diversity and achieving additional ecosystem services and multiple goods.

Table 1: Indicative advantages of integrating Perennials into agriculture

Perennial-integrated agriculture	Annual-based agriculture
Year round soil protection & lack of soil disturbance	Soil protected only during crop canopy time frame
Deep rooting systems, stable soil structure & soil health	Shallow rooting system, less organic material, reduced soil quality
Increased nutrient availability & efficiency with deeper roots	Nutrients tapped only in shallow depths
Yields not consistently high but consistent, but overall farm income is higher from diverse sources such as multi-purpose crops.	Yields consistent depending with consistent inputs
Increased water infiltration & more effective water cycle	Greater potential for water runoff & soil erosion
Greater potential to capture & store carbon	Greater potential for carbon loss through tillage & erosion
Typically greater biological diversity above and below ground	Often grown as mono-crop & loss of soil biota upon tillage
Reduced labour & reduced inputs	Increased labour & increased productive inputs
Offers flexibility to adopt novel farming systems which can increase diversity, reduce risk & redirect labour to livelihoods	Reduces system flexibility & increases risk to potential crop failures.

Perennial research: Status and needs

7. **Technologies for annual crops.** While there were once limits on perennial technologies, the breeding of perennial grains, oilseeds and legumes has recently undergone significant advances. Traditional breeding techniques such as the domestication and hybridization of annuals with perennial relatives can be combined with new technologies such as marker-assisted selection, genomic *in situ* hybridization, transgenic technologies and embryo rescue. Traditional and new breeding technologies are now being applied to many important crop species including sorghum, wheat, rice, maize, rye, flax, oats, pigeon pea, and sunflowers - as well as indigenous tree products and forages – individually or together to serve multiple purposes to achieve perennial, resilient agricultural systems.

8. **Breeding and boosting existing perennial species – forages and trees.** There are a number of opportunities to improve agroforestry systems as part of a perennial agriculture system to enhance food security. An example is *Faidherbia albida* systems in Africa, where crops grown underneath the trees benefit from nitrogen provided by leaf fall prior to the growing season and subsequent water infiltration. Yields are reported to have improved by as much as 3 to 10 fold. Another example is that the diversity of indigenous fruit and nut trees is being lost due to deforestation and land conversion. Such trees could be utilized or further domesticated as they offer an opportunity to increase diversity on farms, providing nutrition, diet diversity and health, as well as increasing livelihoods through cottage industries and new businesses. A few examples of these include *Irvinga gabonensis*, *Dacryodes edulis, Chrysophyllum albidum*, and *Allenblackia.*

9. Many perennial systems based on agro-ecological management practices rely on forage perennial species like alfalfa which have been grown for millennia to feed livestock and horses. Alfalfa is cultivated today over more than 30 million ha but many more forage legumes and grasses exist, waiting for the attention of science and policy makers to boost their role in novel farming systems. Natural grasslands cover 26 percent of global land area and 70 percent of the world agricultural area and provide livelihoods for about 1 billion of the world's poorest people and one third of global protein intake. The potential of perennials to restore and increase productivity and the multiple functions of the perennial grasslands is poorly understood and supported, but it holds a great potential that could be immediately used.

10. **A new generation of breeders and breeding programmes.** While there is an urgent need for more breeders and breeding, breeding must be done differently and in full collaboration with scientists from multiple disciplines through field trials and models within a systems approach. Research must be conducted holistically, addressing nutrition, taste, soil ecosystems, and climate change alongside traditional goals such as increased yield. Existing programs need to be developed and tested in developing countries. There is a great need to incorporate robust economic studies to better quantify the overall value of the contribution of perennials. Global networks of scientists and participatory approaches that fully engage farmers' platforms and priorities in these diverse contexts will be fundamental in successfully developing novel farming systems and perennial agriculture.

11. **Make research results available to the public**. Good research in support of perennials exists but is not currently reaching policy makers, the public or the farming media. There is a need to implement a systematic analysis to screen the highest potential crops, farming systems, and regions and socio-economic contexts in order to achieve short-term goals and early successes for maximum return on investment.

12. **A Centre for Perennial Grain Research**. Scientists and investors agree that an invaluable mechanism to advance perennial grains research would be to establish a Centre for Perennial Grain Research. Such a centre would provide a dedicated space for operationalizing principles and on-the-ground research on perennial grains. The centre could be attached to a university, CGIAR centre, or government agency that would serve a wider audience, allowing global collaboration for the integration and application to diverse farming systems and agro-ecosystems.

Next Steps: Getting perennial crops on the ground

13. **Integrate perennials into existing systems and dialogues.** It is imperative that perenniality is integrated within agriculture and natural systems in diverse environments. The concepts and benefits of perennial landscapes and perennial agriculture need to be brought more strongly into the local, national, regional and global discourse to contend with climate change, enhance biological diversity to attain safe and sustainable food and environmental security.

14. **Imbed perenniality into programs and projects.** Scientists, practitioners, donors and other investors have an opportunity to ensure that perenniality gets placed in different programs and projects (e.g. GEF, CGIAR and NARS) that are being designed to enhance progress toward sustainable development goals. Interesting crops that could be embedded into such programs are:

Rice: Perennial rice holds the potential to significantly reduce erosion in fragile upland environments from annual cultivation. h *O. longistaminata*, using the same genome, AA, as *O. sativa*, is the most promising donor of genes for rhizome expression.
Sorghum: Perennial sorghum has been developed and is now being tested in fragile environments such as Sub-Saharan Africa.

15. **Develop co-learning processes with farmers, community facilitators and advisory services.** There is an urgent need to recognize the shortcomings of mono-cropped farming and embrace efforts to integrate perennials in complex systems such as intercropping, rotational cropping, and multi-story systems and crop-livestock-tree systems. Increasing grain production is important, but there may be more value in terms of dual-purpose crops and the co-benefits of perennials for ecosystem and socio-economic services. Examples of perennial systems that are ready to be mainstreamed are:

Intercropping legumes with cereals: More than 10 000 farmers in Africa are now testing and growing different combinations of improved pigeon pea germplasm and integrated crop, soil and residue management with improvements seen in villages with respect to yield stability and child nutrition.
Agroforestry: Agroforestry can offer food, fodder, nutrients fuel and fibre. Examples are *Faidherbia albida* systems, where crops grown underneath the trees benefit from nitrogen and yields reported are improved by as much as three to tenfold.

Smallholders and Family Farmers

16. **The International Year of Family Farming (IYFF)** can be a starting point to help smallholders and family farms improve their livelihoods, as well as mitigate and adapt to climate change.

17. **Engage policy processes.** Perennialized agriculture needs to be brought to the attention of relevant policy makers and processes. These include Global Technical Committees such as COAG and CFS as well as the CBD, CCD, and UNFCCC Conventions. Evidence that perennial agriculture can meet sustainable development goals and can be of value to various national action plans must be clearly articulated. Policies must be reviewed for their support or inhibition of perennial agriculture. For example, access to land tenure may have implications for the adoption of perennial crops just as it does for existing perennials such as trees.

18. **Develop a campaign to adopt perennial agriculture.** Within agreements such as the Bonn Challenge and the Sustainable Development Goals, it may be possible to set a target to integrate perennial crops, trees and forages in 20 percent of annual cropping systems by 2030.

Summary

19. The integration of perennial species into farming systems, whether crops, forages, shrubs or trees can contribute to achieving multiple global development goals, including: increased food security and nutrition; the mitigation of and adaptation to climate change; and the enhancement of ecosystem services such as biological diversity, water, nutrients and land health.

A global strategy of policy engagement and research coupled with a coordinated development effort is needed to shift agriculture towards a sustainable path by setting a target to integrate perennial crops in a further 20 percent of farming systems by 2030.

[i] **FAO.** 2011. Save and Grow. A policymaker's guide to the sustainable intensification of smallholder crop production. Rome. (Available at http://www.fao.org/docrep/014/i2215e/i2215e.pdf).