Kramer or artisanal oil palm mill in Ghana's Eastern region
Photo credit: CIFOR-ICRAF

CHAPTER 4

Innovation in a systems perspective

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Highlights

- Innovation in tropical tree crop supply and value chains involves knowhow, markets, rights, environmental stewardship, institutions and intergenerational motivation,
- Innovations for recognizable phases of growth, saturation, collapse and reconfiguration of dominant systems imply time lags until windows of opportunity allow take-off,
- Innovations tend to have 'externalities' beyond what is addressed in existing norms and rules, and thus spark new social and ecological feedback responses and further innovation,
- Even though most innovations as such fail and don't recover the investments made, the wider social system gains from innovation and 'early adopter' entrepreneurs may gain most,
- Innovation policy can help in supporting and de-risking the innovation process, but should refrain from early picking of likely winners, due to low predictability of winners

1. Introduction

Without innovation there would be no life on Earth, no human societies, nor markets for African tree crop commodities. Innovation solves problems and creates new ones. The recent COVID-19 experience has shown the relevance of innovation in many ways (Duguma et al 2021). Innovations by a tiny virus with characteristic spikes allowed it to cross the species barrier and infect humans, triggering many innovations in response, that range from changes in human behaviour that reduce the infection rates, the development of vaccines, a cottage industry of mouth caps and protective gear production and marketing, public investments to reduce the economic impact of the pandemic, new ways of virtual interactions and personal

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adjustments to appreciate life in the much smaller spaces that remain after travel restrictions. Innovations get a chance when the status quo has become problematic, and they spark further innovations in response, including further innovations in the virus that increase its infectiveness. Cause-effect pathways in innovation can be complex, however. Most of the innovations are, at the specific level, unpredictable – making clear that any sense of 'Innovation Policy' should focus on creating boundary conditions for welcoming innovations, but not even try to guide what the innovations as such entail.

Between actions that emphasize the new ('innovation'), the existing ('development', 'adaptation') or the past ('rejuvenation', 'restoration'), similarities may exceed differences. To appreciate innovation, either as process or as set of 'new' ideas, one needs to know the past and have a sense (intuition?) of what the future may bring. Tree crop cultivation as currently found anywhere on the globe is the result of an accumulative process of innovation, transfer and exchange. Further innovation needs to build on existing foundations.

The four subsequent sections of this book will deal with four aspects of 'innovations', all directly related to the supply and value chains of tropical tree crop commodities produced in Africa (Figure 4.1):

a Climate, biodiversity, landscapes and environmental (cross-scale) impacts,

b Economic governance systems that link end-consumers to the supply and value chains.

c Production ecology and agro-technology,

d Social aspects of production systems and local livelihoods.

At the core of the figure is the body of the insect where it feeds, has its muscles, processes data and information and reproduces. However, the interactions of this body with the four wings of the butterfly are essential for its ability to fly., and that respond to concerns about product or process quality that consumers may have (or acquire). Innovations in either the body or any of the wings will only become mainstream if they improve the social-ecological system as a whole.

A certain tree crop may be new in a specific village but be well grounded in another. Although new, it comes with a huge amount of interconnected legacy. Accumulation ('legacy') can be found, for example, in

- the production ecological wing (A) such as, 1. the genetic codes in the germplasm, or 2) in the farmers' understanding of the crop interacting with above- and belowground environments (water, nutrients, pests and diseases),
- the social aspects wing (B), such as 3) in the technical guides for 'best management practice', or 4) in the grading rules for accessing different market segments,

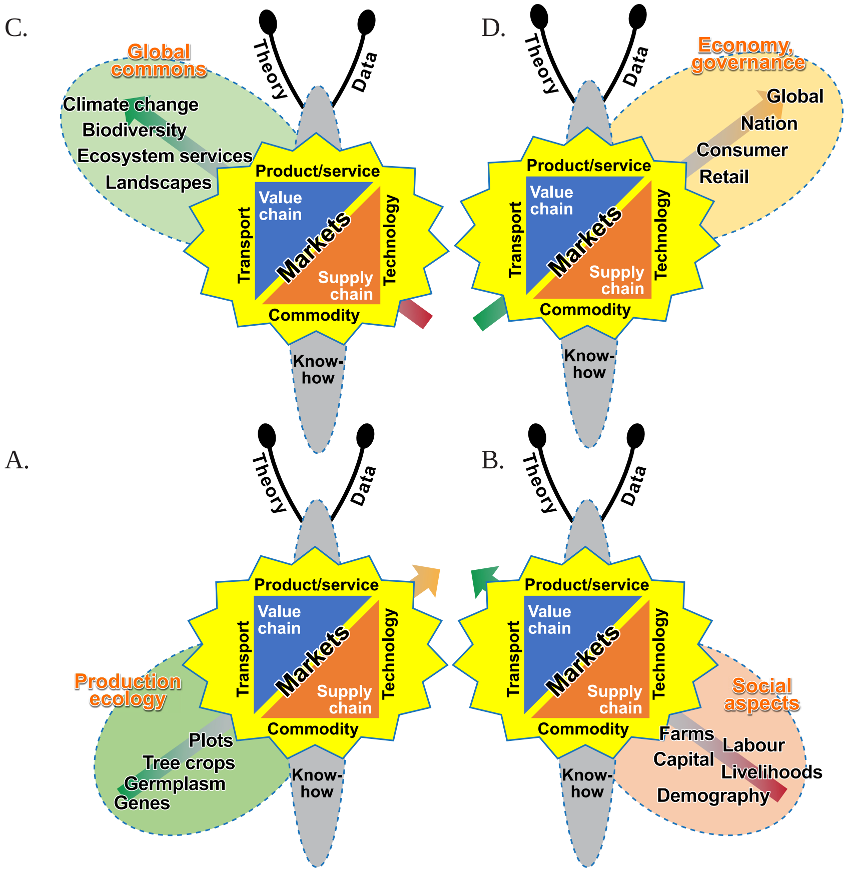

Figure 4.1: *Four subsystems in which innovation occurs in relation to the supply and value chain of tropical tree crop commodities: A. Production ecology, B. Social aspects of farming and local livelihoods, C. Global commons and environmental context, D. Economics and governance*

- the environmental impacts wing (C), such as 5) in the way the landscapes are organized and oriented around rivers or roads as primary transport infrastructure, 6) in the technology and infrastructure for transporting, storing and processing of the farmgate products, or
- the economics and governance wing (D), such as 7) in the array of end-products that match consumer expectations, 8) in these expectations themselves, 9) in the regulatory frameworks for reducing negative social and ecological side effects of production and further steps in the value chain, and 10) in the private and public (or voluntary and mandatory) governance systems that create, manage and (rarely) abolish such frameworks.

In analysing opportunities for African farmers to engage in further expansion of tree crops with well-established (local, global) markets we can make use of perspectives derived from innovation in other systems (Klerkx et al 2012). A recent review of the Profit-Planet-People relations (van Noordwijk 2021) suggested that Adam Smith, Charles Darwin and Elinor Ostrom have been key innovators in the economic (efficiency), ecological (diversity) and social (fairness) aspects, in the 18th, 19th and 20th century, respectively. They all identified relatively simple rules that can account for complex, emergent system behaviour.

The specific 'innovations' that subsequent chapters will describe and discuss thus cover a broad range of aspects, and yet the effectiveness of each change can easily be limited by, or suddenly be boosted by, trends and changes in other subsystems. Rather than describing innovations in each subsystem in detail, this chapter will provide some concepts that can be used to understand innovations, what they have in common and how they are connected, across the subsectors (A-D). The following sections will build up a storyline of unavoidable system complexity, but hopefully give some conceptual tools that are not too complicated to apply. It will cover:

- Innovation and diversity as requirement for survival (Section 4.2)
- Efficiency and fairness as selection criteria (Section 4.3)
- Winners and losers across scales (Section 4.4)
- Windows of opportunity for adoption (Section 4.5)
- Dealing with externalities (Section 4.6)
- Turning externalities into assets (Section 4.7)
- Collective gain despite individual loss (Section 4.8)
- Concluding remarks (Section 4.9)

2. Innovation and diversity as requirement for survival

An understanding of innovation as a process in complex systems (and their subsystem components) can build on the ground rules that were articulated in the middle of the 19th century by Charles Darwin for the way plants and animal populations innovate, adapt and evolve as 'blind watchmaker' without 'design' but by retention of selfish genes embodied in 'emerging solutions' to an evolving fitness landscape (Dawkins 1996) through:

1. Persistence: Mechanisms for reproduction that retain essential characteristics of the parents,

2. Variation: A process that generates variation around what already existed,

3. Selection: An excess of individuals reproduced and selective survival to its own reproductive stage, reflecting at least some aspects of fitness in addressing the main challenges in the current environment.

Selection at the 'phenotype' level (step 3) leads to adaptive change at the 'genome' level, where the information referred to in point 1 is accumulated and passed on to subsequent generations, even if variation (step 2) is non-directional. Fitness (step 3) does not only depend on the way organisms deal with climate, soils and topography, but also on all the other organisms that are concurrently co-evolving. Thus, information gets also stored in 'niche' dimensions, habitats, patterns of vegetation succession dependent on functional traits of other organisms. This leads to an 'innovation ecosystems' perspective in which food chains, specialist/generalist interactions, energy flows and nutrient recycling can be traced back to the past and ongoing changes in all components.

Adding a human and social dimension to this system (Table 4.1) means that there are many other ways replication rules (step 1) accumulate (e.g. technology, markets, culture) and is exchanged, but retains the relevance of variation (step 2) and selection (step3).

Table 4.1: *Diversity in the way the three basic requirements for innovation (persistence, variation and selection) are embodied across four (interacting) systems of Figure 4.1 (X…XXX indicates an increasing level of importance)*

Emergent properties Innovation elements	**A. Biological organisms, production ecology**	**C. Ecological systems**	**B. Social systems, livelihoods**	**D. Economics, governance**
Persistence				
Genes and genomes	XXX	XX	X	X
Food and energy storage	X	X	XX	XX
Habitats and succession	X	XXX	X	X
Niche dimensions	X	XX	X	X
Cultural transmission	X	X	XX	XX
Infrastructure, connectivity		X	XX	XXX
Supply chains			X	XX
Gold, capital goods			X	XXX
Codified rights, norms			X	XX
Religion, discourses			XXX	XX
Information storage			X	XX
Technology			XX	XXX
Scientific theories			X	XX
Educative curricula			XX	XX
Global conventions, SDGs			X	XX
Variation				
Mutation	XX	X		
Sexual differentiation	XX	X	X	
Epigenetic effects	X	X		
Lateral gene transfer	X	X		
Dispersal, migration	XX	X	XX	
Biological invasions	X	XX	X	

Emergent properties Innovation elements	A. Biological organisms, production ecology	C. Ecological systems	B. Social systems, livelihoods	D. Economics, governance
Learning	X	X	XX	X
Personality	X	X	XX	X
Vegetation succession	X	XX	X	X
(Mis/myth)interpretation			XX	X
Gender, caste			XXX	XX
Language			XX	X
Art			X	XX
Technology			X	XXX
Travel			X	XX
Selection				
Survival of the fittest	XX			
'Black swan' disasters	X	X	X	X
Sexual reproduction	XX		X	XX
Intragroup territoriality	XX	X	X	XX
Cultural transfer	X	X	XX	XXX
Intergroup contests	X	X		
War-fare			X	XX
'Discovery'			X	XX
Options-in-context tests			X	XX
Elections			X	XX
Sport contests			XX	XX
Social media rankings			XX	XX
Climate change resilience			X	XX

3. Efficiency and fairness as selection criteria

Similar to the 'blind watchmaker' and 'selfish genes' of biological evolution, where complexity emerges from a non-directional process of variation through retention of what works, is the 'invisible hand' that Adam Smith first described as ways markets can be self-organizing systems (Rothschild 1994; van Noordwijk 2021). The self interest of both the 'buyer' and the 'seller' drive their negotiations over the quality, quantity and price of goods or services that one market party desires and the other can provide. If 'willingness to pay' exceeds 'willingness to accept' there is a profit margin that can be implicitly negotiated between the parties. Persistence, variation and selection are essential properties in this interaction, that shape buyer expectations of what will be bought and is worth its market price, help the seller deliver the expected quality at its existing price through cost-saving modes of production, and sort out where products or services no longer meet buyer expectations. Certification as an institutional innovation emerged as a way of adding 'persistence' of (voluntary) norms relevant to selection by consumers to give direction to, but not erase, innovation at the producer start of value chains

(Leimona et al 2018). The need for certification arises when chains get too long, and trust can no longer be based on personal relations.

An optimistic view on continued innovation through sustained agility ('sustainagility') (Jackson et al 2010) links human adaptive capacity with a conserved resource base that allows new practices to emerge. It complements the persistence aspects ('sustainability') of complex systems that can avoid or even reverse fragility (Taleb and Douady 2013). Is such optimism justified? The pessimistic one sees 'degradation' and 'resource over-use' and extrapolates to bleak projections for the future. The optimistic view is often associated with Boserup (1965) view on the economics of agrarian change under population pressure, arguing that increases in population (or land) pressure trigger the development or use of technologies and management strategies that allow production to match demand. Current understanding of 'induced innovation' (Ruttan and Hayami 1984) is that it helped create 'solution space' for averting disasters, but that the scale of current global resource over-use and trespassing of planetary boundaries (Rockström et al 2007) provides challenges not handled before.

In the social, political and global systems that humans (unknowingly, initially) created and then started to rationalise, the persistence dimension of institutions created a strong 'path dependency' and focus on the 'form' of textual representation, rather than 'function' of implied meaning in changing contexts. Agroforestry as an 'institution' was, over 40 years ago now, an innovative label for what farmers had learned to do, probably from the start of agriculture 10,000 years ago. However, such practices became lost between agriculture and forestry as separate domains (van Noordwijk 2019) with their own perspectives on natural resource use, rights, technology, knowledge, power, education, culture and participation in global value chains. Agro-ecology (HLPE, 2019) has become the new arena for contest of institutional change in the policy environment around land use. Institutions do matter but institutional innovation is particularly hard to achieve (North 1990). Testing new institutional arrangements, such as 'Payments for Ecosystem Services', may well lead to significant change in what 'payment' entails (Namirembe et al 2017), but it is hard to change the way the field is known and regularly reinjected in the world of development from a single-disciplinary academic perspective.

At the highest level of 'persistence' may be the theories used in economics about how people make decisions on the use of scarce resources. One of the first economists to address innovation was Schumpeter (1942), who saw 'creative destruction' as a framework for continued renewal. His work has inspired several further new ways of analysing the innovation, several of which were recognized with the Nobel prize for economics (Table 4.2).

Table 4.2: Selected winners of the Nobel prize in economics for new ideas on how economics as a profession can deal with innovations in social-ecological systems (adding pico, meso and giga layers to the conventional micro-and macro-economics; van Noordwijk et al 2012a

Year	Name and official rationale	Relevance for sustainable tree crops
2018	***William D. Nordhaus*** -- "for integrating climate change into long-run macroeconomic analysis"	*Giga* relevance of incorporating asymmetry of planetary boundaries in economic analysis:
2017	***Richard H Thaler*** -- "for his contributions to behavioural economics"	*Pico/micro:* making 'bounded rationality' manageable
2012	***Lloyd S. Shapley*** -- "for the theory of stable allocations and the practice of market design"	*Meso/macro*: Bargaining power is directly related to the influence on overall chain performance if one player opts out
2009	***Elinor Ostrom*** -- "for her analysis of economic governance, especially the commons"	*Meso:* The real tragedy of the commons is that local ways of governing them have been misrepresented and ignored
2005	***Robert J. Aumann*** -- "for having enhanced our understanding of conflict and cooperation through game-theory analysis"	*Micro/Meso:* showing relevance of trust between actors in decision-making
2002	***Daniel Kahneman*** -- "for having integrated insights from psychological research into economic science, especially concerning human judgement and decision-making under uncertainty"	*Pico:* The concept of 'bounded rationality' has helped economists move beyond micro-economic cost-benefit analysis and e.g. consider asymmetry in dealing with risk
1998	***Amartya Sen*** -- "for his contributions to welfare economics"	*Macro:* Tree crops can play a role in poverty alleviation policies, depending on wage rates that can be supported
1991	***Ronald H Coase*** -- "for his discovery and clarification of the significance of transaction costs and property rights for the institutional structure and functioning of the economy"	*Meso:* Transaction costs, beyond direct production costs, are a main part of a political economy with 'vested interests' protecting status quo
1969	***Jan Tinbergen*** -- "for having developed and applied dynamic models for the analysis of economic processes"	*Macro* economic models need to include time-lags and feedbacks in allocating land, labour, capital flows

Among the biggest challenges that currently requires innovation is the concept of 'growth' itself. Just as individual organisms grow until they grow up and thrive, economies should be redesigned to thrive rather than to keep growing, as planetary boundaries put limits to ever-continuing growth, but not to substantial improvements of human well-being compared to the current situation (Raworth, 2017, 2021). This means that a "take-make-use-loose" flow perspective on material goods, as is commonly described for supply chains, needs to re-link use to make by being part of nutrient cycles, and restoration for technical materials, abolishing the concept of 'waste'. Technical innovation towards cyclic and regenerative production systems, need to link up with distributive rather than centralized social networks in order to respect the planet and people, while putting bounds to the profit perspective that appears to be the current driver that rules all. This is a radical agenda – but can only be realized if many small innovative steps are made, and are appreciated for the direction they allow change to take.

4. Winners and losers across scales

Many innovations follow S-shaped curves (grow, grow-up) over time in their expansion dynamics. Initial growth of new entities is slow, as there are 'teething problems' of settling in, followed by a more rapid exponential growth phase when positive feedback starts to dominate, and a gradual approach to a saturation level (growing up) where positive and negative feedbacks balance out (Figure 4.2A).

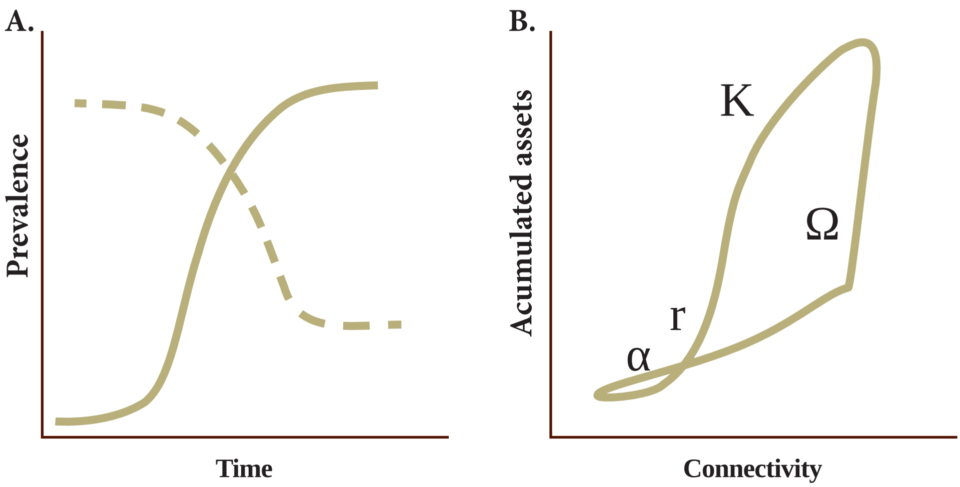

Figure 4.2: *A. Innovation systems perspective of interacting S-curves of individual innovations gaining or losing ground; B. Resilience alliance representation of system dynamics and four identifiable phases, with loss of accumulated assets and connectivity in Ω (collapse) and α (reconfiguration) phases typically faster than the exponential growth (r) and saturation (S) phases (modified from Holling 2001)*

An innovation systems perspective (Adner and Kapoor 2016) expands single S-curves to multiple, competing technologies that can coexist, each with their own S-curve, similar to the way biological species coexist. New technologies potentially replace existing ones if they are sufficiently fast in gaining initial traction and have a plateau value of adoption that exceeds that of others. Effects on others is not only by competition for 'growth resources', but also by modification of habitats and environmental pollution, shifting the selective pressures to which technologies have to respond. For example, turning 'waste' into a 'resource' creates 'niches' for new enterprises, but only while its raw materials remain available.

The term ‘innovation ecosystems’ (Nambisan and Baron 2013) has emerged as an important context for entrepreneurship, as ‘ecosystem entrepreneurs’ face a unique set of challenges associated with the need to balance the goals and priorities set, often by public governance, for the ecosystem with the private goals and priorities of new ventures. One of the challenges is that ecosystem entrepreneurs are commonly forced to operate as social entrepreneurs jeopardising profits levels without real compensation for the public goods they produce. In such a context innovation may face challenges to reach the exponential level of the S-curve if real compensation is not provided for the productions of public goods that come with adopting such practices. The innovation ecosystems concept was recently applied to analyse evolution within community forestry in Cameroon (Minang et al 2019). Major innovations were identified in the introduction of pre-emption rights, a ban on industrial logging, development of certification standards, and the introduction of the environmental notice in lieu of a full environmental impact assessment, as steps toward sustainable forest management. Little or no innovation was registered in areas related to forest enterprise (i.e., products and services value chains).

5. Windows of opportunity for adoption

While the S-shaped curves are a significant step beyond ideas of incremental (linear) technology adoption. The ideas of Holling (2001) were promoted by the ‘resilience alliance’, as a perspective on 8-shaped system dynamics (Figure 4.2B). This suggests that four phases of a cycle each form ‘windows of opportunity’ for benefitting from specific types of innovations (Holling 2001):

r-phase innovation focussed on the X-axis of Figure 4.2B by dissemination, connectivity and area expansion,

K-phase innovation focussed on the Y-axis of Figure 4.2B, accumulating stored capital, increasing (generally in small, incremental steps) resource use efficiency and carrying capacity to nudge the plateau to a higher level,

Ω-phase preparedness by diversification (hedging bets), insurance in social networks, investing in education of a younger generation for whom the current system may no longer be attractive,

α-phase reconfiguring systems with ‘agility’ based on accumulated experience and understanding of the new context – generally without enough time for real experimentation. This is where the main ‘out of the box’ innovation can be observed, but it relies on learning and networking during earlier phases.

Entrepreneurs literally are ‘go- betweens’ (prêner entre), acting as early adopters and innovate in r-phase adoption rather than α-phase generation of new ideas. The ‘information revolution’ that allows instantaneous communication around the globe by light pulses transmitted through fibre optics that can be decoded into understandable formats on the receiving end has altered all phases of the r-K-Ω-α cycle in marketing. In the r-phase social influencers help articulate increasing demand for new products or services, adding social desirability to objective properties that imply utility. In the K-phase Apps with daily ‘floor-price’ information on handphones now support farmer management and marketing decisions even in remote locations, but also lead to new forms of cheating and drive innovative ways of securing integrity of information flows. In the Ω phase, e.g. when a production process at a given location is undercut by emerging cheaper options elsewhere, the reputation and established network of trustworthy relations can sometimes be salvaged in ‘just-in-time’ innovative shifts (with a Finnish forest supply company that shifted from rubber boots to phones as a standard example in the business literature). The α phase may be the most dramatically changed by the information revolution as ever-more powerful ‘mechanical intelligence’ routines sift through a body of accessible information that faster than any single person can keep track of.

The tendency to stabilize buyer-seller relations into K-phase comfort zones may provide a false sense of security. Planned disturbance or tests of the relations (inducing a local Ω-α phase in Figure 4.2B) can take place through auctions in contract farming and through competitive procurement procedures that can keep a system in the r-to-K transition stage where ‘adaptation’ type (‘tinkering’) innovations function best. Adaptive responses have a context of persistence and standardized criteria to shield both sides of a transaction from too drastic change in performance. Planned disturbances of markets can be compared to ‘prescribed burning’ in savanna systems: regularly removing the deadwood fuel load can avoid bigger, devastating fires to emerge at longer intervals, while also providing fresh grazing opportunities.

6. Dealing with externalities

In the spread and adoption of tree crops farmers have used two contrasting starting points to integrate new tree crops into their existing land uses (compare Figure 3.1.4). The first makes minimal changes to existing vegetation, e.g. by underplanting coffee, cocoa or cardamom into existing (agro)forest or planting trees like rubber to compete with other pioneer vegetation in the fallows that alternate with open-field swiddens. These are essentially K-phase innovations, aimed at conserving existing vegetation and its functions, while using human labour efficiently (van Noordwijk 2019). The second involves large-scale plantations that adopted an r-phase concept of removing all that there was before, homogenizing landscape to the degree possible for an industrial scaling approach. This approach can only recover initial investments if subsequent yields are close to what is technically feasible (Woittiez et al 2017). The second type of expansion thus proved to have more ‘externalities’ (non-intended impacts that remained beyond the accounting context of planners), both socially and environmentally (e.g. deforestation, where the first of the two farmers’ approaches means forest modification), inducing protests, emergence of voluntary norms and standards for ‘certification’ or mandatory rules with compliance control.

Just as any national soccer team has as many coaches as there are inhabitants to the country who all know better than the one appointed to do the job, external observers of agricultural systems have a long tradition of better knowing than farmers where innovations can pay off. Proposed solutions tend to match the area of expertise of proponents (e.g. tree improvement, nursery management, soil management, spatial prioritization of development interventions, credit acquisition, extension methods, tenure reform). Many of the evaluations of expected benefits focus on only part of the S-curves that can in fact be expected, often emphasizing early gains rather than forecasted new equilibrium values. A recent review assessed 18 pathways for international agricultural research to contribute to rural poverty alleviation (Tomich et al 2019a), with mixed results for most (Tomich et al 2019b). Almost without exception, practice shows that as soon as one ‘limiting factor’ has been addressed, progress is limited by something of a different category. While many innovations start within a specific ‘theory of change’ (often needed to convince a financial investment), the experience shows that it is the flexibility to go beyond initial logical frameworks that differentiates the pathways to success on the ground from the ‘operation succeeded, patient passed away’ type projects that report that all that was planned was achieved, except for the overall goal.

Innovation can be seen through the innovation metaphor of buds and flowers (Kanter 1988). Among the six primary areas of attention shown in Figure 4.3 the five petals refer to Rights, Knowhow, Markets, Local ES issues and Teleconnections, covering the same ground as the four wings and body of the butterfly (Figure 4.1), but in a slightly different grouping. The heart of the flower is the local identity shaped by institutions, motivation, soft skills, intergenerational transfers and ‘bonding’ types of social capital (Meijer et al 2015). The five petals define five direct interactions with the outside world (with the national scale more prominent for some (e.g. rights) and others more directly global (e.g. markets and knowledge). When seen in pairs, they also interface with five arenas of national and international discourse: Options in context for technical innovations yielding marketable products, Coinvestment in green growth, environmental stewardship to respect planetary boundaries, Governance of the global commons. We see little space in the tropical tree crop agendas for the de-risking of innovation by Intellectual Property Rights (IPR) regimes, although much of the agrochemicals in use, as well as novel genetic improvement methods fall under such regimes internationally.

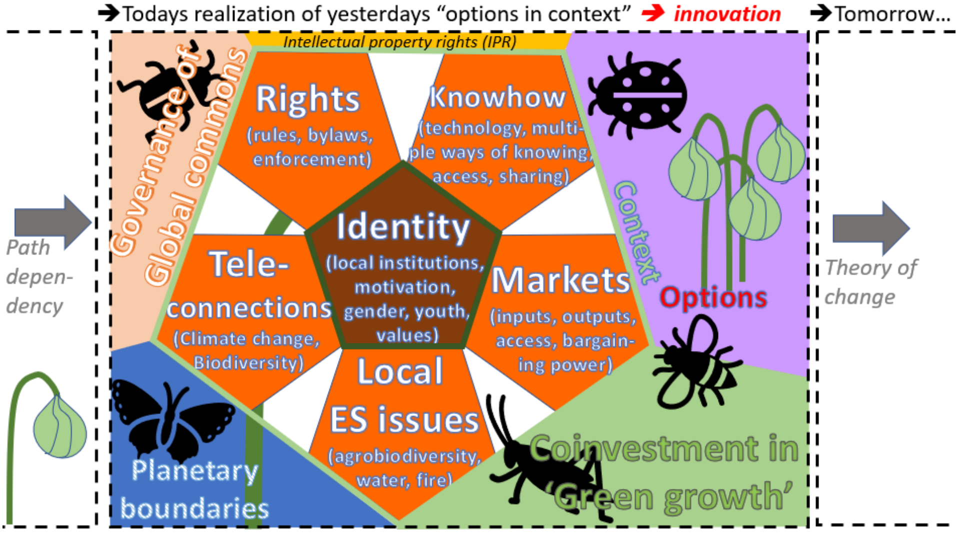

Figure 4.3: *A buds and flowers perspective on the way local identity interacts with global discourses in its stepwise process of change that connects its past to many possible futures and leads to nested innovation ecosystems (van Noordwijk et al 2020b)*

We see a snapshot of the history of any place, with today's flower yesterday's bud, and may have to expect a branching away (or another Ω crash out of the current system and α-steps to reconfiguration), rather than incremental approach to the current K yield plateau.

7. Turning externalities into assets

As an example of how externalities can be turned into assets, please consider the following. A major negative externality within the coffee value chain is water pollution from wastewater generated through wet coffee processing. There is growing demand for wet processed coffee since it is considered superior in quality compared to dry processed coffee; for example, in Ethiopia, there are more than 400 wet coffee processing installations, all of which are located at the vicinity of rivers. However, wet processed coffee generates a lot of wastewater thus yielding high environmental costs. On average, coffee processing results in effluent wastewater to an extent of about 3,000 litres per tonne of coffee processed and all the generated wastewater is directly released to downstream water bodies, and sometimes in disposal pits (Olani 2018). Wastewater directly discharged to the nearby water bodies results in high pollution concentration in the rivers causing severe health problems among the residents as well as loss of aquatic life in the water bodies. While evidence points to the fact that the wastewater yields huge environmental and health costs, there is no regulation in Africa's coffee producing countries that require these industries to treat the wastewater before discharging it to the water bodies. However, there is potential to produce bioethanol from the wastewater although this has not been explored in most of the coffee producing countries (Janissen and Huynh 2018). Feasibility studies (Woldesenbet et al 2016) conducted in Ethiopia show that bio-ethanol production from coffee wastewater is technically and financially feasible as an innovation, with a benefit cost ratio >1.05. Such an enterprise would present a win-win scenario since bioethanol can be utilized as an alternative energy production which reduces the environmental pollution and dependence on oil and petroleum in Ethiopia. It can also provide alternative energy solutions for small holders as well as a source of income and employment among the residents.

As a second example, cocoa producing countries have embarked on several programmes aimed at ameliorating their negative trade balance by adding value to cocoa through primary processing of cocoa beans to cocoa butter, cocoa paste and cocoa powder (Abbott 2013). These countries currently benefit from zero taxation on imports of cocoa beans to the EU, however, the efforts of these countries are confronted with tax escalation of processed cocoa products. Import duties for cocoa paste stands at 9.6%, 7.7% for cocoa butter and 8% for cocoa powder imports into the EU (Fairtrade Foundation 2017). Import duties for cocoa powder and butter are even higher towards Asian countries with China imposing 25% tax on these products (OFI 2018). The increasing tax rate as producing countries move-up the value pyramid is an incentive for export of cocoa beans and a disincentive to cocoa processing by producer countries. This indicates a classical situation of vested interests, with producer countries trying to draw more value from the chain to their local economies through domestic processing while developed (processing countries) have put in place measures to protect their domestic interests. Non-tariff barriers, such as certification requirements, are even more effective barriers for developing countries to export value added cocoa to the EU (Svenungsson 2016). Institutional negotiation, high level political discussions and partnerships on tariffs and non-tariffs barriers should be negotiated with vested interests of producer and processing countries mutually respected.

8. Collective gain despite individual loss

Innovation implies taking risk, as the majority of new ideas are not as good in practice as they appeared in theory – but a few may actually be better and can collectively pay for the investment in all those that failed. This brings up the social and societal mechanisms for 'de-risking' the innovators, often through use of public funding (Mazzucato 2018), as discussed below.

Large data sets on human 'culture' have suggested that there is major variation in a number of dimensions at (sub)national scales (Hofstede et al 2010, Minkov 2018) , including those that relate to 'uncertainty avoidance', 'collectivism-individualism' and 'power distance'. They jointly influence the way a bottom-up perspective (individualist, uncertainty embracing, non-hierarchical) on innovation interacts with a top-down one (collectivist, risk-averse, hierarchy-based). The latter emphasizes emphasises the persistence dimension, with the way markets provide the selection platform influenced by both. An example of how cultural context matters in innovative instruments of environmental policy can be seen in the way an American/ NW European concept of 'Payments for Ecosystem Services' morphed into 'Co-investment in Environmental Stewardship' for Asian and African contexts that are less individualistic (Leimona et al 2019).

A further dimension of societies is their degree of assertiveness, which influences how innovation is perceived and promoted, versus how it is a thoughtful process constrained by internal quality controls. This societal dimension tends to correlate with uncertainty avoidance but all high-low, low-high, low-low and high-high combinations of assertiveness and uncertainty avoidance exist, with consequences for the innovation cycles. Further aspects of gender differentiation in risk taking and collective benefits will be discussed in *Chapter 16* (Chiputwa et al 2021). Reversible rural-urban migration (also known as '*kota-desa*' networks) allow family members to explore new things (moving into town, moving back to rural areas to start new, urban-inspired, enterprises there). Complementing current interest in gender and youth aspects of social differentiation, investment by retirees and urban diaspora deserves further analysis in African rural development. An example of the complex policy interactions is provided in Box 4.1.

A term that may indicate the opposite of innovation has become a major element in current policy agendas: restoration. Yet, restoration generally requires innovation, rather than a simple return to the past. Commitments have been made to restore large areas using substantial public funding. It has thus become a major opportunity for promotion of agroforestry options for tree crops, that avoid the soil and environmental degradation involved in large-scale monocultures. The innovation first of all requires 'salesmanship', as farmer praxis already exists, but has not been associated with the new policy term (Miccolis et al 2016, van Noordwijk et al 2020a). Path dependency examples are provided in the analysis of rubber and oil palm adoption and transitions in SE Asia *chapter 24* (van Noordwijk et al 2021). The initial step that modified swidden/fallow cycles to become jungle rubber was relatively easy. Subsequent steps towards intensive monoculture rubber with 'improved' germplasm was remarkably slow and innovative planting materials matched internal rejuvenation (van Noordwijk et al 2012b) rather than rotational replanting. Further change from intensified rubber to intensive oil palm

Box 4.1

Reconciling policy goals in tree crop innovation

Governments responding to the various pressures they face may simultaneously (van Noordwijk et al 2018) seek three types of innovation in the main tree crop landscapes within their national borders:

I. Increasing production as basis for export and taxable national hard currency earnings in the face of ageing tree crop stands that lacked rejuvenation,

II. Encouraging young people to find new excitement and motivation in farming,

III. Anti-deforestation commitments to match global consumer expectations.

Without objective III the answer could be simple in countries that still have forest areas: stimulate area expansion for tree crops, by investing in new roads (e.g. financed by China's belt and road program) with incentive and credit schemes for young people. Effort to achieve all three simultaneously will have to rely on 'intensification' and support for intergenerational transfer – more challenging.

To illustrate the above, The Government of Cameroon (GOC, 2017) specifically recommends in its growth and employment strategy paper that Government action will aim at improving growth and regeneration of plantations and extension of surface area under cultivation. To operationalise the action, The GOC of developed a scheme to distribute about six million seedlings every year, corresponding to the establishment of 5 000 hectares of new modern cocoa farms each year. However other innovation schemes like that targeted in Cote d' Ivoire and consisting of rejuvenating cocoa farms may also contribute in realising Government policies of increasing production and productivity in tree cop plantations without necessarily leading to huge expansion of cultivated land.

was primarily limited by access to good planting materials and finance (as young palms are relatively expensive), with some attempts to use the levels of intercropping and diversity that worked well in rubber for the new crop.

9. Concluding remarks

There have been suggestions that we are approaching a world of equal opportunity where globalisation and telecommunications eradicate the importance of geographical distance—the so-called 'flat world' thesis. However, the contours of the world economy appear inherently and, enduringly, 'spiky'. Brown and Mason (2017) proposed a preliminary taxonomy of different archetypal innovation ecosystems and concluded that entrepreneurial ecosystems are a highly variegated, multi-actor and multi-scalar phenomenon, requiring finely tuned policy interventions. Tropical tree crops face a 'race to the bottom' of global competition for consumers in a flat world but have opportunities for institutional innovation by recreating controlled 'spikiness' through articulation, protection and management of 'niche' geographical identities.

Innovation policy can help in supporting early stages of testing of ideas that hold promise ('let all flowers bloom'), especially if this reduces 'externality' risks, by promoting a holistic (all 6 aspects of Figure 4.2) assessment. To be effective, any innovation policy should support and de-risk the innovation process, but refrain from early picking of likely winners, as management books are full of the examples of 'unpredictability' of winners and losers.

References

Abbott P. 2013. Cocoa and cotton commodity chains in West Africa: policy and institutional roles for smallholder market participation, In: A. Elbehri, ed. *Rebuilding West Africa's food potential*. Rome, Italy: FAO/IFAD.

Adner R, Kapoor R. 2016. Innovation ecosystems and the pace of substitution: Re-examining technology S-curves. *Strategic management journal* 37(4):625–648.

Boserup E. 1965. The conditions of agricultural growth: the economics of agrarian change under population pressure. London, UK: George Allen & Unwin. https://www.biw.kuleuven.be/aee/clo/idessa_files/boserup1965.pdf

Brown R, Mason C. 2017. Looking inside the spiky bits: a critical review and conceptualisation of entrepreneurial ecosystems. *Small Business Economics* 49(1):11–30.

Chiputwa B, Obeng Adomaa F, Ihli JH, Rusinamhodzi L. 2021. *Gender inclusion as a pathway to sustainable development of cocoa and coffee value chains in Africa*. In: Minang PA, Duguma LA, van Noordwijk M, eds. 2021. *Tree commodities and resilient green economies in Africa*. Nairobi, Kenya: World Agroforestry (ICRAF).

Dawkins R. 1996. *The blind watchmaker: why the evidence of evolution reveals a universe without design*. New York city, USA: WW Norton & Company.

Duguma LA, van Noordwijk M, Minang PA, Muthee K. 2021. COVID-19 pandemic and agroecosystem resilience: early insights for building better futures. *Sustainability* 13(3):1278.

Fairtrade Foundation. 2017. Brexit: let's change trade for good. https://www.fairtrade.org.uk/~/media/FairtradeUK/Get%20Involved/

Government of Cameroon (GOC). 2017. Growth and employment strategy paper. https://www.resourcedata.org/dataset/rgi-cameroon-s-growth-and-employment-strategy-paper/resource/319309ca-481c-4bc1-8e00-2c034303c6e1

[HLPE] High Level Panel of Experts. 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome. www.fao.org/cfs/cfs-hlpe.

Hofstede G, Hofstede GJ, Minkov M. 2010. *Cultures and organizations: software of the mind*. 3rd edition. New York: McGraw-Hill.

Holling CS. 2001. Understanding the complexity of economic, ecological, and social systems. *Ecosystems* 4(5):390–405.

Jackson L, van Noordwijk M, Bengtsson J, Foster W, Lipper L, Pulleman M, Said M, Snaddon J, Vodouhe R, 2010. Biodiversity and agricultural sustainagility: from assessment to adaptive management. *Curr Opin Environ Sustain* 2:80–87.

Janissen B, Huynh T. 2018. Chemical composition and value-adding applications of coffee industry by-products: A review. *Resources, Conservation and Recycling* 128:110–117.

Kanter RM, 1988. When a thousand flowers bloom: Structural, collective, and social conditions for innovation in organizations. *Knowledge Management and Organisational Design* 10:93–131.

Klerkx L, van Mierlo B, Leeuwis C. 2012. Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions. In: Darnhofer I, Gibbon D, Dedieu B, eds. 2012. *Farming systems research into the 21st century: the new dynamic.* Dordrecht: Springer. p.457–483.

Leimona B, van Noordwijk M, Mithöfer D, Cerutti PO. 2018. Environmentally and socially responsible global production and trade of timber and tree crop commodities: certification as a transient issue-attention cycle response to ecological and social issues. *International Journal of Biodiversity Science, Ecosystem Services & Management* 13(1):497–502.

Leimona B, van Noordwijk M, Kennedy S, Namirembe S, Minang PA. 2019. Synthesis and lessons on ecological, economic, social and governance propositions. In: Namirembe S, Leimona B, van Noordwijk M, Minang PA, eds. *Co -investment in ecosystem services: global lessons from payment and incentive schemes.* Nairobi, Kenya: World Agroforestry Centre (ICRAF), Chapter 38.

Mazzucato M. 2018. *The value of everything: Making and taking in the global economy*. UK: Hachette.

Meijer SS, Catacutan DC, Ajayi OC, Sileshi GW, Nieuwenhuis M. 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. *International Journal of Agricultural Sustainability* 13(1):40–54.

Miccolis A, Peneireiro FM, Marques HR, Vieira, DLM, Arcoverde MF, Hoffmann MR, Rehder T, Pereira AVB. 2016. Agroforestry systems for ecological restoration: how to reconcile conservation and production. Options for Brazil's cerrado and caatinga biomes. Brasília: Instituto Sociedade, População e Natureza – ISPN/World Agroforestry Centre (ICRAF), https://www.worldagroforestry.org/publication/agroforestry-systems-ecological-restoration-how-reconcile-conservation-and-production.

Minang P, Duguma L, Bernard F, Foundjem-Tita D, Tchoundjeu Z. 2019. Evolution of community forestry in Cameroon: an innovation ecosystems perspective. *Ecology and Society* 24(1).

Minkov M. 2018. A revision of Hofstede's model of national culture: old evidence and new data from 56 countries. *Cross Cultural & Strategic Management* 25(2):231–256.

Nambisan S, Baron RA. 2013. Entrepreneurship in innovation ecosystems: Entrepreneurs' self–regulatory processes and their implications for new venture success. *Entrepreneurship theory and practice* 37(5):1071–1097.

Namirembe S, Leimona B, van Noordwijk M, Minang PA, eds. 2017. *Co -investment in ecosystem services: global lessons from payment and incentive schemes*. Nairobi, Kenya: World Agroforestry Centre (ICRAF).

North DC. 1990. *Institutions, institutional change and economic performance*. Cambridge: Cambridge University Press.

[OFI] Oil & Fats International. 2018. Cocoa oil, baked goods face US$60bn tariffs from China. https://www.ofimagazine.com/news/cocoa-oil-baked-goods-face-us60bn-tariffs-from-china (accessed 22/07/2021).

Olani DD. 2018. Valorization of coffee byproducts via biomass conversion technologies. (Doctoral dissertation, KU Leuven, Science, Engineering & Technology).

Raworth K. 2017. *Doughnut economics: seven ways to think like a 21st-century economist*. USA: Chelsea Green Publishing.

Raworth K. 2021. A healthy economy should be designed to thrive, not grow. https://www.oneearth.org/a-healthy-economy-should-be-designed-to-thrive-not-grow/ (accessed 15/12/2021).

Rockström J, Steffen WL, Noone K, Persson Å, Chapin FS, Lambin E, Lenton TM, Scheffer M, Folke C, Schellnhuber HJ, Nykvist B. 2009. Planetary boundaries: exploring the safe operating space for humanity. *Ecol Soc* 14(2):32.

Rothschild E. 1994. Adam Smith and the invisible hand. *The American Economic Review* 84(2):319–322.

Ruttan VW, Hayami Y. 1984. Toward a theory of induced institutional innovation. *The Journal of development studies* 20(4):203–223.

Schumpeter J. 1942. *Capitalism, socialism, and democracy*. New York: Harper & Bros.

Svenungsson G. 2016. *Trade barriers on EU's agricultural market: are farmers producing maize and the cocoa- & coffee industry in EU protected by tariffs?* MSc. Swedish University of Agricultural Sciences.

Taleb NN, Douady R. 2013. Mathematical definition, mapping, and detection of (anti) fragility. *Quantitative Finance* 13(11):1677–1689.

Tomich TP, Lidder P, Coley M, Gollin D, Meinzen-Dick R, Webb P, Carberry P. 2019a. Food and agricultural innovation pathways for prosperity. *Agricultural Systems* 172:1–15.

Tomich TP, Lidder P, Dijkman J, Coley M, Webb P, Gill M. 2019b. Agri-food systems in international research for development: ten theses regarding impact pathways, partnerships, program design, and priority-setting for rural prosperity. *Agricultural systems* 172:101–109.

van Noordwijk M, ed. 2019. *Sustainable development through trees on farms: agroforestry in its fifth decade*. Bogor, Indonesia: World Agroforestry (ICRAF).

van Noordwijk M. 2021. Agroforestry-based ecosystem services: reconciling values of humans and nature in sustainable development. *Land* 10(7):699.

van Noordwijk M, Leimona B, Jindal R, Villamor GB, Vardhan M, Namirembe S, Catacutan D, Kerr J, Minang PA, Tomich TP. 2012a. Payments for environmental services: evolution towards efficient and fair incentives for multifunctional landscapes. *Annu. Rev. Environ. Resour*. 37:389–420.

van Noordwijk M, Tata HL, Xu J, Dewi S, Minang PA. 2012b. Segregate or integrate for multifunctionality and sustained change through landscape agroforestry involving rubber in Indonesia and China. In: Nair PKR and Garrity DP, eds. *Agroforestry: the future of global land use*. The Netherlands: Springer. p.69–104.

van Noordwijk M, Duguma LA, Dewi S, Leimona B, Catacutan DM, Lusiana B, Öborn I, Hairiah K, Minang PA. 2018. SDG synergy between agriculture and forestry in the food, energy, water and income nexus: reinventing agroforestry? *Curr Opin Environ Sustain* 34:33–42.

van Noordwijk M, Ekadinata A, Leimona B, Catacutan D, Martini E, Tata HL, Öborn I, Hairiah K, Wangpakapattanawong P, Mulia R, Dewi S, Rahayu S, Zulkarnain T, 2020a. Agroforestry options for degraded landscapes in Southeast Asia. In: Dagar JC, Gupta SR, Teketay D, eds. *Agroforestry for degraded landscapes*. Singapore: Springer. p.307–347.

van Noordwijk M, Gitz V, Minang PA, Dewi S, Leimona B, Duguma L, Pingault N, Meybeck A. 2020b. People-centric nature-based land restoration through agroforestry: a typology. *Land* 9(8):251

van Noordwijk M, Khasanah N, Jelsma I, Dewi S, Leimona B, Suyanto. 2021. Rubber and oil-palm production and value addition in Asia: relevance for Africa. In: Minang PA, Duguma LA, van Noordwijk M, eds. 2021. *Tree commodities and resilient green economies in Africa*. Nairobi, Kenya: World Agroforestry (ICRAF).

Woittiez LS, van Wijk MT, Slingerland M, van Noordwijk M, Giller KE. 2017. Yield gaps in oil palm: A quantitative review of contributing factors. *European Journal of Agronomy* 83:57–77.

Woldesenbet AG, Woldeyes B, Chandravanshi BS. 2016. Bio-ethanol production from wet coffee processing waste in Ethiopia. *SpringerPlus* 5(1):1903.