Gliricidia known as ‘fencing plant’ in Zambia

In Zambia, Gliricidia commonly known as 'fencing plant' improving soil fertility and yields in addition to reducing soil erosion and control pollution.

Photo: World Agroforestry

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CHAPTER SIXTEEN

Agroforestry's role in an energy transformation for human and planetary health: bioenergy and climate change

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Highlights

- Sustainable and clean rural energy is essential for a coherent SDG portfolio on health, climate, food, jobs and terrestrial ecosystems
- Improved cooking stoves and policy support for charcoal production are still 'work in progress'
- Biodiesel derived from oil-rich seeds has created hope-hype-crash cycles and faces hurdles in accounting systems that include 'indirect land use change'
- Bio-ethanol production and large-scale wood-based energy focus on low-cost bulk production
- Rural evergreen electricity supply from coppiced fast-woods offers agroforestry synergy and prospects of integrated solutions at multiple scales

16.1 Climate change, energy transitions and agroforestry

When agroforestry was ten years old as formal term, the Brundtland report[1] on Sustainable Development reviewed many of the aspects that are still part of the current discussions – but it did not have the 'global climate change' issue on its agenda yet. Energy was amply discussed, however, and there the issue of carbon emissions was getting attention. Remarkably soon after that report, in 1992, the Rio conventions put climate change, biodiversity and desertification (land degradation) at the same level of priority and global commitments were made. It has taken the next 25 years to come to grips with implementation modalities and reframe the commitments as the 2030 Sustainable Development Goals (SDGs) of 2015, that presented access to energy, human health, climate change and integrity of terrestrial ecosystems at the same level as food, water, jobs and income (Figure 13.3).

Within the climate change discussions, the need for a decarbonization of the worlds' energy systems has been widely accepted, but its interactions with changes in terrestrial carbon stocks (including forests, mineral soils and peatlands) have been more contentious. Part of the problem is the different basis of accounting, at national scale, for energy-related greenhouse gas emissions at the 'demand' side of the equation, while changes in terrestrial C stocks are accounted at territorial or 'supply' level. With the connecting global trade outside accounting systems and the political interpretation of the agreed 'Common But Differentiated Responsibility'[2] controversial, there was no easy way to agree on effective measures. Initial resistance to seriously discuss 'Adaptation', as some had hopes that 'Mitigation' would be effective in curbing global climate change, was finally abandoned, but had led to firewalls between mitigation and adaptation at implementation and budget level (Fig. 16.1). Where agroforestry was already early on identified as relevant at the interface[3], there was little institutional space to follow through on synergies[4,5,6]. The focus on Reducing Emissions from Degradation and Deforestation (REDD+)[7] was on forests in their institutional definition and the concept of Reducing Emissions from All Land Uses (REALU) didn't get the early traction it might have deserved.

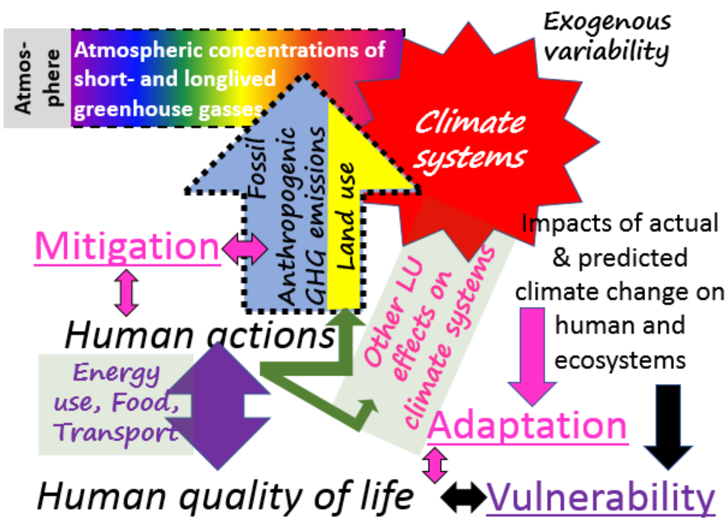


Figure 16.1 The logical loop of human actions aimed at increasing quality of human lives, but through use of fossil fuel and land cover change changing greenhouse gas (GJG) concentrations that change the global climate, with increased human vulnerability as a consequence; recognized intervention points are defined as emission reduction ('mitigation'), primarily through decarbonizing the economy, and dealing with the consequences ('adaptation'); direct effects of land cover on hydro-climate and temperature are discussed in Chapter 17; figure modified from[8]

Early surveys of farmer practice in relation to climate change[9,10] emphasized the relevance of trees and agroforestry. For farmers the association between 'trees' and 'climate' is obvious, as trees provide shade during the hottest part of the day, reduce windspeed and provide temporary shelter during rain. The effect of trees on climatic variables was so obvious that standard weather stations are operating at sufficient distance from trees to make their effects appear to be negligible. Yet, the 'microclimate' research that relates the actual conditions at the level of a plant, animal or human being to the vegetation and build-up structures was slow to connect with the global climate debates[11]. Global change as science had its origin in the data generated at synoptic weather stations and their change over time. Early criticism that part of the change in recorded data could be due to a changing context of the weather stations was seen as distraction – although stations that had obviously become part of 'urban heat islands' were taken out from the datasets studied. At the farmer level the microclimatic effects of trees are much more immediate and tangible than any role trees may have in global climate change – but the emergence of the 'climate smart agriculture' concept allowed local and global concerns to reconnect. At the interface of 'mitigation', 'adaptation' and 'vulnerability' the concept of 'climate smart agriculture' gained traction.

Beyond Mitigation and Adaptation, Agriculture and Forestry have to be jointly considered to link local solutions to global relevance[12], and in doing so their interactions with the 'energy transitions' agenda is at the heart of the matter.

16.2 Energy transitions

Cooking has been one of the biggest leaps forward in human history, and as trees often provide the fuel required, a close association between crops and trees to make sure there's something in the cooking pot and something to heat it (in other words: forms of agroforestry) has been as old as agriculture. When crop fields were scattered in a vegetation of recovering fallow plots, one didn't have to walk far to find firewood, but when cropped fields became contiguous and fallow periods short, maintaining firewood supply required specific efforts. In parts of the world hedgerows developed that combined functions in keeping straying animals from cropped fields, with microclimate effects and provision of wood for farm implements and as fuel. Traditional European agroforestry had strong rationale in wood energy security[13], an aspect recently gaining attention through emission accounting rules[14].

Energy is used for many aspects of modern lives, with cooking probably as oldest invention, requiring control over fire and its fuel. Energy can also be classified by its source, with solar energy driving many processes on Planet Earth, with nuclear transformations as driver of geothermal energy the main other source. However, much of the solar energy currently used has been stored in fossil fuels and can only be used by releasing CO_2. A tentative two-way classification of energy use (Fig. 16.2) can help to trace many of the historical energy transitions, and discus the way forward.

The steam engine was the first alternative to strongly location-bound hydropower as source of looms, and led to a drastic shift of the economic geography of textile industries. When steam engines were put on rails and became mobile a shift from woody biomass to fossil fuels of higher energy density was a step forward. The discovery of electricity and practical means to get it under control, led to a preference for coal as cheapest fossil fuel for electricity generation, and oil as basis for mobile engines. Woody biomass retained a significant share in the total mix only in countries of low population density. Average per capita energy use has only quadrupled from 1820 to 2010[15], but its energy source has shifted and (the 20 GJ p.p.p.y. in 1820 was nearly all from biofuels, the 80 GJ GJ p.p.p.y. in 2010 only for one-third), and the human population increased eightfold. Substitutions of biofuel involved coal, oil and natural gas, with a slow rise of hydroelectricity and a small role overall for nuclear energy sources.

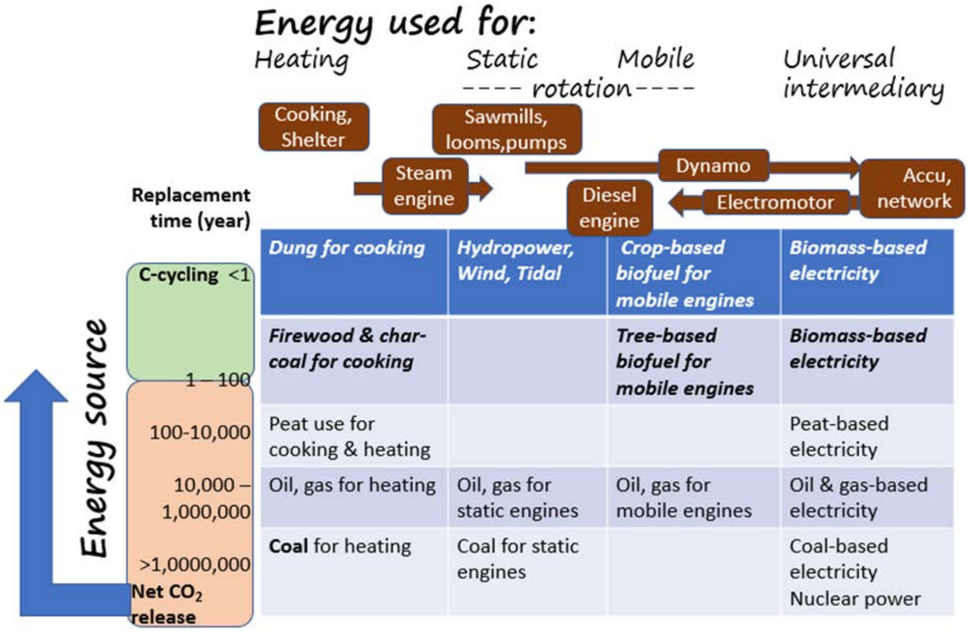


Figure 16.2 Historical energy transitions have involved both a shift in the types of energy used and the replacement times of the energy sources (linked to sustainability and net C emissions to the atmosphere)

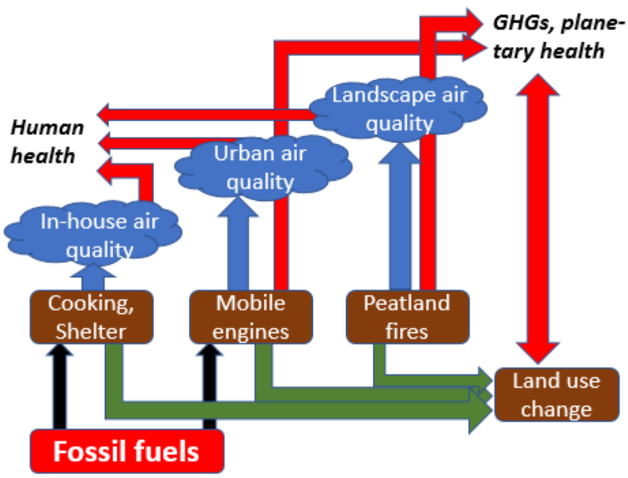


Figure 16.3 Relations between planetary health, human health effects of fuelwood use in closed kitchens, fossil fuel engines in urban areas and landscape level effects of peat fires

The search for emission-saving energy sources initially focussed on the undisputed relevance of mobile engines and their need for high-density energy carriers. Biodiesel and bio-ethanol became the targets. However, this ran into a number of challenges:

- When mainstream crops (maize, soybean) were used as source of oil in biodiesel production, the actual energy yield per ha of crop land was low, and barely compensating for the emissions needed for agricultural inputs to maintain production,

- Yet, the increased use as biofuel interacted with a fragile supply-demand balance and led to increase in food prices; in response the emphasize shifted to non-food fuel sources, preferably those that can be grown on land not suitable for crops,
- The productivity of such crops, despite initial claims to the contrary was low and they became part of a hope-hype-bust cycle[16],
- The most economically viable current source of biodiesel, palm oil, expanded rapidly, but became associated with both social and environmental concerns; especially where the expansion shifted to tropical peat soils (relatively free of human conflict), the carbon emissions exceeded any possible emission saving from replacing fossil fuels.

Meanwhile, the substitution of coal or oil for electricity generation by wood pellets became one of the main ways advanced economies tried to meet their emission reduction commitments – with serious questions about the sustainability of such biofuels and the accounting rules that make them appear to be carbon neutral.

In seeking 'carbon neutrality' in energy sources there is agreement that sequestration and emission within a single year can be ignored, but of the time periods relevant for woody biomass (say 5, 30 or 100 years) only for the first (e.g. fast-wood plantations or coppiced woodlots) can a 'neutrality' assumption be justified within currently agreed accounting schemes. The current 'rediscovery' of the relevance of energy derived from current solar radiation (or that of the recent past), meets parts of the world where the main energy transition pursued is still substitution of 'traditional and dirty' by 'modern and clean' fuels. A major human health concern over smoky kitchens has indeed promoted fossil fuel sources as clean substitutes. Are improved cooking stoves able to connect traditional fuel sources with modern standards and lifestyles? Concerns over air quality in cities now pushes governments to declare the end of fuel-using cars and their substitution by electrical cars. Can the fossil fuel phase of development be shorted by a more direct transition to electricity generation from (woody) biomass? If so, how does this relate to current accountability at production and consumption level?

There are still optimistic voices: "Well-designed bioenergy systems can contribute to several objectives, such as mitigating climate change, increasing energy access, and alleviating rural poverty. With adequate technical assistance and land management, farm yields and income can be increased, food security strengthened, carbon sequestration improved, and pressure for land clearing reduced. There are, nonetheless, risks involved on bioenergy production and several initiatives worldwide have failed to achieve proposed positive outcomes. Overreliance on monoculture plantations, negative land-use change impacts, and use of cereal crops as feedstocks are among the main causes. Agroforestry systems and practices can address most of these risks and thus play an important role in sustainable production of several bioenergy outputs, including efficient solid biomass, biogas, liquid biofuels, and dendro power (*Gliricidia pyrolysis*)."[17]

In a nutshell, the Climate Change agenda requires an energy transition, weaning off current fossil fuel dependency. Biofuels can be an important part of the solution, but the direct use of fuelwood, the biodiesel and ethanol type 'biofuels' and the current use of wood pellets for large-scale energy generation all have issues and problems associated with them.

Can agroforestry (in its connections between field/farm level AF1, multifunctional landscape level AF2 and governance/policy level AF3) be of help here? It can conceivably operate between the 'mitigation' and 'adaptation' side of the existing UNFCCC (SDG 13) rules and seek synergy with public health (SDG 3) and food supply (SDG 2) concerns. In this chapter we will review four possible pathways:

- Improving traditional wood-based energy sourcing, securing local health benefits,
- Hydropower, addressing the land requirement and impacts on local land use,
- Biofuel (bioethanol, biodiesel), acknowledging the failed silver bullets of the past,
- Rural wood-based electrification,

interacting with the accountability and accounting rules that apply.

16.3 Fuelwood, charcoal and human health

The four-fold increase in per capita energy consumption as global average between 1820 and 2010 is surpassed by current differences between national averages. Declines in fuelwood with increasing HDI (Fig 16.4) are offset by increased consumption of forest fibre, while fossil energy use rises faster than fuelwood declines with mainstream progress in human development.

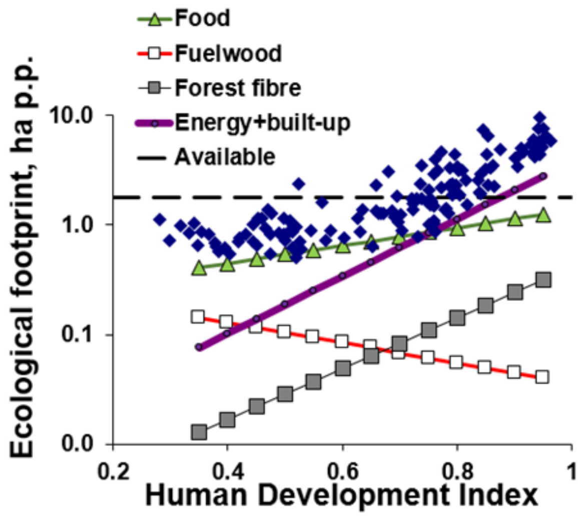


Figure 16.4 Ecological footprint (essentially the per capita area of forest supposedly able to re-absorb CO_2 emissions) of human consumption in relation to Human Development Index for countries of the world, with four main components: food production, use of fuelwood, use of forest fibre (timber, paper) and fossil energy use (plus cement) for a 'modern' economy (data for 2005)[18]

Woodfuel plays a critical role in energy provision in sub-Saharan Africa (SSA), and is predicted to remain dominant within the energy portfolio of the population in the coming decades[19]. Although current inefficient technologies of production and consumption are associated with negative socio-economic and environmental outcomes, projected charcoal intensive pathways along with urbanization may further accelerate pressures on tree covers[20].

In rural areas firewood is used as such (and often not problematic, except nearby protected areas[21]), for transport to and use in urban centres, charcoal is preferred (for its higher energy density, cleaner and more easily controllable burning). Yet, charcoal is more controversial than firewood, being blamed for a rapidly expanding circle of deforestation around Africa's urban growth centres. In the debate five commonly held perspectives on charcoal have been identified as myths[22] that are perpetuated by different stakeholders and actors, namely, that: 1) charcoal is an energy source for the poor; 2) charcoal use is decreasing; 3) charcoal causes deforestation; 4) the charcoal sector is economically irrelevant, and; 5) improved charcoal cook stoves reduce deforestation and GHG emissions. For each myth there may be specific reasons that it is perpetuated against the existing evidence, leading to misguided policy responses and intervention approaches.

Indeed, analysis of the charcoal value chain in Kenya showed that most of the value urban consumers pay had to cover for transport and illegal levies along the way (or levies justified by the illegality of the transport, depending on perspective)[23]. Policy reform based on reliable data might create stronger incentives for sustainable production, as well as reliable supply to urban consumers[24]. A systematic review[25] assesses what's known on the status of the fuelwood sector in SSA and estimates the magnitude of impacts of increasing wood demand for charcoal production on tree cover, which will be obviously unsustainable under business-as-usual scenarios (Fig. 16.5).

Agroforestry through use of prunings harvested periodically from multipurposes trees such as those produced for timber is making farmers self-sufficient with firewood [26]. This practice reducecs women's drudgery in gathering firewood from forests and avoids soil nutrient mining from collection of dead wood. Agroforestry, if widely adopted as an integrated strategy together with improved kilns and stoves, can have a significant impact to reduce wood harvest pressures in forests through sustainably supplying trees on farm. Further integrating agroforestry with improved kiln and stove technologies could significantly reduce global warming potential from charcoal and firewood production and use[27]. A systematic approach is required to promote multi-purpose agroforestry systems compatible with farmers' needs under local farming systems and current dryland socio-economic contexts.[28]

Despite decades of attention of rural development and 'appropriate technology' projects, there is a widespread sense that results have been disappointing. For example, a large-scale randomized trial in India, on the benefits of a common, laboratory-validated stove with a four-year follow-up showed that smoke inhalation initially falls, but that this effect disappeared by year two. Households used the stoves irregularly and inappropriately, failed to maintain them, and usage declined over time[29].

Attention has shifted to gasifier cookstoves, and where livestock is held, biogas production as cleaner and sustainable rural energy sources[30].

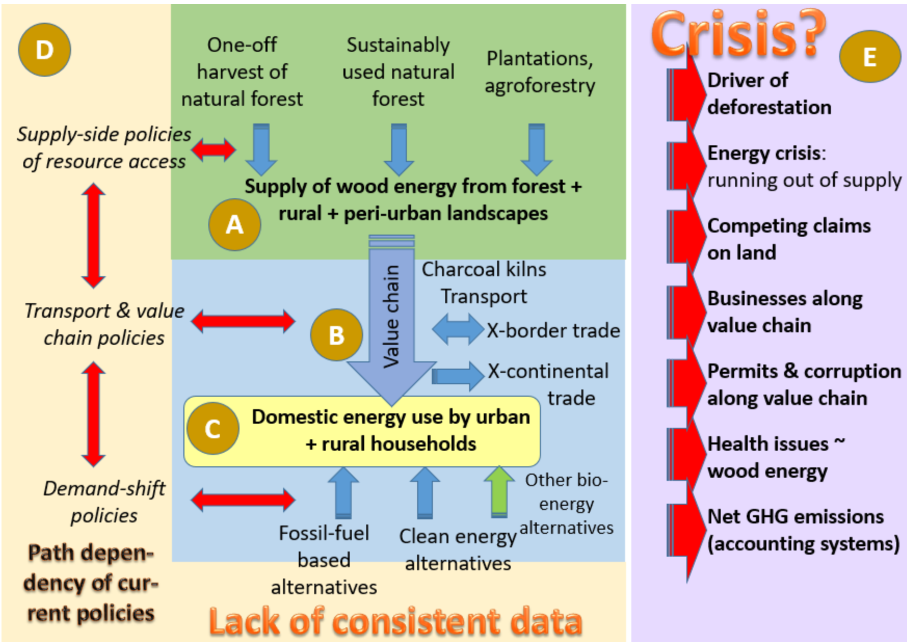


Figure 16.5 Conceptual diagram of the questions surrounding supply and demand of fuelwood and charcoal in the rural-urban continuum in relation to existing laws and regulations

16.5 Hydropower from healthy landscapes

Hydropower makes use of the global water cycle, driven by solar energy and modulated by vegetation. Watermills have existed for thousands of years, as evidenced by reconstructions of ancient mobile sawmills on the Tiber river in Rome. Some of the first active interventions in stream flows were to secure a stable supply of rotational energy, used for early industry, including looms for weaving.

After a phase of large reservoirs for combined generation of hydropower and regulated supply of irrigation water, the various environmental and social impacts led to a reconsideration and focus on smaller units, often with run-of-the-river designs. Still, such projects had major social impacts (compare Chapter 9), especially when conflicts over upstream land use erupted. Sedimentation, and hence reducing the economic life-time of the reservoir is the main issue in the large projects, while run-of-the-river with are highly dependent on flow regularity (compare Chapter 17). Plans for large interventions still exist for various parts of the world and remain controversial[31].

16.6 Liquid biofuels and biogas

Initial reports on the productivity of Jatropha curcas as source of oil-rich seeds, suitable for conversion to biodiesel sounded 'too good to be true'. And they were[32]. Interest in 'second generation', non-edible vegetable oils emerged around 2005, with Jatropha as its 'silver bullet' solution[33,34]. Technically these oils were ready for use[35], but the amount of policy support they received was out of balance with actual track records of productivity.

A number of authors have contributed to the 'post mortem' of the crash, focusing on technical shortcomings[36,37], or using a political ecology lens[38,39]. Existing knowledge of Jatropha productivity and constraints was not effectively used in the debate (Box 16.1). Others still see opportunities once research has resolved the low-productivity issue[40].

The economic potential of biofuel production from oilseed trees in small-scale agroforestry systems is often overestimated as profitability studies commonly ignore key methodological issues such as quantitative uncertainty analysis, full accounting for opportunity costs, and inclusion of all value chain actors[41].

Despite all this, still positive evaluations of Jatropha opportunities have been reported for Mali[42]. Elsewhere, attention has shifted to other oil-rich seeds[43], including those from the tree Pongamia (*Millettia pinnata), with greater attention to the production ecology, social-economic aspects*[44]*, pricing policies*[45]*, and basic requirements for farmer adoption.* Cross-sectional survey data on adoption of oilseed tree mixtures in smallholdings in Hassan district, South India, examined the impact of a biofuel extension program and farmer characteristics on adoption[46]. The findings revealed that tree cultivation is much more prevalent than oilseed collection, and that various activities of the biofuel extension program only stimulated the former. Low seed prices and high opportunity costs of labour are major factors impeding households to collect seeds from planted or wild oilseed species. The paper concluded that the program succeeds as an agroforestry program but not as a biofuel program.

A study in Tanzania[47] of income effects of agricultural biomass production for bioenergy purposes in comparison to firewood production found that the highest income effect for the poorest households derived from agroforestry, which households use as a source of firewood and fruits for sale or home consumption, followed by *Jatropha curcas*, sugarcane and finally cassava. Agroforestry in general has been also found to substantially release the pressure on public forest reserves.

A study for Indonesia[48] emphasized the relevance of geographical context: "The geographic focus for bioenergy development should take into account competitiveness with fuel and power generated from fossil fuels. Yet in areas where electricity is very expensive per kilowatt-hour and the fossil-fuel price is very high, which is typically the case in the outer islands, bioenergy is more likely to be competitive".

Multifunctionality of the specific plant or species options were taken into account as part of the context. Options prioritized here are nipa palm and 'nyamplung' (*Calophyllum inophyllum*) for coastal protection or restoration and for bioethanol and biodiesel production, respectively. Rice straw, rather than being burned as currently done, can be a feedstock for biogas. Albeit challenges, bamboo through biomass combustion or thermal mode, was a good potential for its abundance and being part of degraded land restoration approach.

Box 16.1 Jatropha hope-hype-crash[49]

Interest in jatropha as a biofuel crop has been driven by economic concerns over limited oil reserves and the global price of crude oil, by the global relevance of clean sources of renewable energy and by advantages Jatropha was claimed to offer from the national to individual household levels. Jatropha proponents further claimed that Jatropha production does not impact on food security due to its toxicity, whilst offering the added benefits of erosion control, soil enrichment, water infiltration and flood reduction, carbon storing, and the possibility of earning carbon credits. Many of the claims put forward were based on optimistic assumptions, especially regarding yield and the early warning signs and calls for caution were largely ignored, buried or overtaken by the wave of hype. Jatropha has been through multiple hype cycles dating back to 1945-50. The disappointment observed during the first hype could simply be attributed to a very specific need that was no longer relevant. The second and subsequent cycles share many similarities and resemble other 'miracle' crops. A combination of market pull (society, economy, environment and government mandates, subsidies, land allocation, and investors) and technology push factors were responsible for the disappointment. The push factors (oil processing and value adding) were not sufficiently well prepared or developed; they also were not implemented within the framework and guidelines necessary for realistic commercial development. Research in Indonesia highlighted the fact that many actors exploited the system for personal gain. Policies were often influenced by a network of powerful entrepreneurs who manipulated the process for personal gain. Companies and NGO's were able to access subsidies or bank loans and investment funds to develop large or smallholder jatropha plantations, while brokers successfully managed to get a piece of the subsidy cake. Researchers were able to access numerous research funds. While smallholders were often depicted as victims of land grab there were many who joined in the exploitation of jatropha. In hindsight it is easy to see why the jatropha hype ended in disappointment. From our review it is clear that jatropha was introduced without a comprehensive understanding of crop development and performance and market supply and demand.

It will be important that any strategies developed for similar crops be designed to foster energy development and improve socioeconomic conditions so as to instill the confidence necessary to once again adopt jatropha or any alternative crop. The biophysical results from this study highlight a need for high yielding jatropha varieties suitable for areas that do not compete with existing food crops. Production management systems that maximize commercial potential will also need to be developed, but not at the expense of the environment. Our jatropha – maize intercropping results showed that different management practices such as fertilizer, pruning, and planting density can reduce competition and/or enhance complementarity. Popular belief is that if the objective is to maximize jatropha yield, then maize yield suffers, and vice versa, although this may not be the full story. While intercropping with maize has been the study focus there may be other more suitable crops. In essence there is no single, generic or even correct solution so for growers to maximize plant growth and yield relative to their location and circumstances, they must understand that trade-offs are a necessary part of any multiple objective system. In reality for farmers it is simply yield and what combinations will provide the highest return on investment. The yield and social benefit uncertainties outlined in our study confirm that jatropha should not be promoted as a smallholder or plantation crop. Only when the underlying causes of the jatropha hype and disappointment have been addressed and satisfied will we see improved commercial performance and socioeconomic conditions and environmental concerns conducive to a successful biodiesel industry

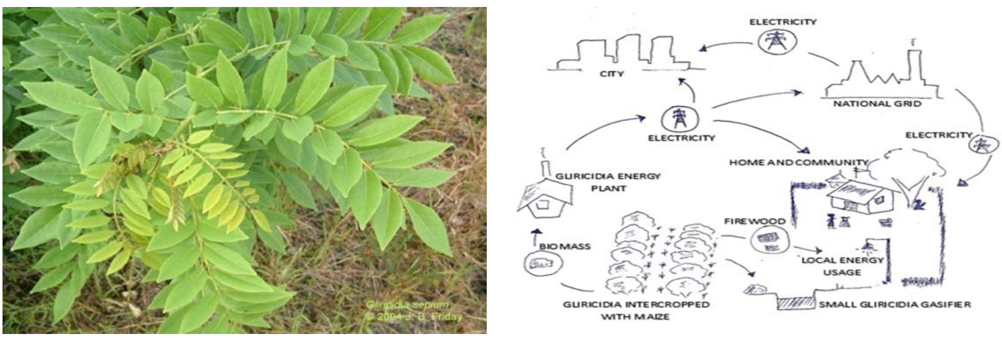
A study of factors affecting landowners' preferences for bioenergy production in Central Kalimantan[50] indicated that 76% of landowners preferred well-known species that have a readily available market, other than as source of bioenergy, such as sengon (*Albizia chinensis*) and rubber trees (*Hevea brasiliensis*) for restoration on degraded land. Only 8% of preferred nyamplung (*Calophyllum inophyllum* L.) for bioenergy production, as they had additional jobs and income, or had migrated from Java where nyamplung is prevalent.

Technically palm oil (*Eleais guineensis*) has been the main success story as feedstock for biodiesel, but the success has created problems of its own[51,52,53] and only partial success in self-regulation by the industry through standards and certification mechanisms[54]. We will come back to this in the section on accountability and accounting systems.

16.7 Bio-electricity for flexible uses

16.7.1 Creating EverGreen Food-Energy Systems for Rural Electrification

Prospects may be far better for small-scale electricity production for rural electrification. Six hundred million people, two-thirds of the population of sub-Saharan Africa, are still without electricity. In Malawi, for example, only 7% of the population has access to electrical power. This is an enormous drag on rural economic growth, and on improved outcomes in food production, health, and education. Ninety-percent of the sub-Saharan African population currently relies on firewood and charcoal as their primary source of energy for cooking, heating and other uses.



Local:	Industrial:	National grid:
• Small scale 4 KW and 9 KW Ankur gasifier systems operated by small holders and communities for their local power needs.	• Similar to 1 MW plant in Walapane, Sri Lanka. Private sector investment would build and operate the plants to supply local communities and local industry.	• Similar to 5 or 10 MW Tokyo Power projects. Large scale plants can be strategically placed to ensure feedstock and supply power to the national grid.

Figure 16.6 Opportunities at local scale, industrial areas and the national grid of a gliricidia-based electricity production

Experience now shows that tree-based systems can simultaneously provide electrical and bioenergy for the home and for industry, while also providing biofertilizers for crop production, and better-quality fodder for livestock production. These systems have the potential to transform livelihoods and food security, and enhance economic development while conserving the environment.

The approach overcomes concerns that growing crops for bioenergy might compete for resources with food production. On the contrary, through the concept of EverGreen Energy, fertilizer-fodder-fuel wood trees are incorporated into crop fields to provide the feedstock for power generation, while at the same time they directly increase crop yields, provide enhanced high-quality livestock fodder, improve vegetative soil cover year-round, increase soil fertility, and buffer crop production from drought and higher temperatures due to climate change. They also store much greater quantities of carbon in the soil and enhance biodiversity.

16.7.2 Gliricidia power generating systems in Sri Lanka

Similar to Africa, much of Sri Lanka's rural population is completely off-grid and without any electrical power. This situation has fostered a real innovation in the power sector. During the past 25 years, partners have worked to develop a dendro power industry, largely based on gliricidia as a feedstock. Gliricidia is so widely grown by Sri Lankan farmers that it is officially designated as the country's fourth plantation crop (along with coconut, tea and rubber). Lanka Transformers Limited (LTL) installed a 35 kW generator operating exclusively on gliricidia wood as a demonstration unit. Upon achieving operational success, LTL together with Ankur gasifier systems (Ankur Scientific Energy Technologies Pvt.Ltd) launched community-scale 4 KW and 9 KW systems using Gliricidia feedstock from smallholders for electricity generation.

Figure 16.7 A. Gliricidia intercropped with coconut in Sri Lanka. The trees are pruned every eight months to provide the biomass feedstock for electrical power generation; B. a 290 kW gliricidia fueled power plant in Sri Lanka, C. D. A 1.5 MW gliricidia fueled power plant in Sri Lanka

The Ceylon Tobacco Company (CTC) then established a commercial-type 1MW power plant in Walapane. This plant demonstrated all aspects of converting gliricidia to supply the national electricity grid. The success of this plant sparked the interest of the private sector. The Bio-Energy Association of Sri Lanka was formed, and through the Sri Lanka Sustainable Energy Authority, established the inclusion of dendro power to meet national energy demand.

In 2009, Tokyo Power constructed and commissioned a 10 MW gliricidia-fueled plant in Trincomalee, Sri Lanka. Following its success, the company recently commissioned a second plant of 5 MW capacity in Mahiyanganaya early in 2014. There is a 500 kW plant in Thirappane (Anuradhapura) and a 15 MW plant in Embilipitiya. It is reported that there are several more glircidia-based power plants now under development.

16.7.3 Gliricidia Systems in Southern Africa

Gliricidia is already widely distributed in farming systems throughout Africa, having been introduced four centuries ago. Research during the past three decades has demonstrated its value as a superb fast-growing nitrogen-fixing fertilizer tree. In Malawi, gliricidia is a major species underpinning the scaling-up of fertilizer trees for increasing crop yields in maize-based systems through the National Agroforestry Food Security Program. Practical systems for intercropping trees in maize farming have long been developed, and they are currently being extended to hundreds of thousands of farmers in Zambia and Malawi. They are being massively scaled-up in eastern Zambia, where 25 million trees were planted by smallholders during 2013 alone.

The development of food-energy electrification projects would be a natural extension of the type of crop production systems practiced in these two countries. The species has also been widely tested and is well-adapted for such food-energy systems in Tanzania, Kenya, Ethiopia, and many other countries across the African continent.

16.7.4 Addressing a Perfect Storm of Challenges to Food Security

African agriculture must be transformed in the coming decades. With a population burgeoning to 2 billion people, at least twice as much food must be produced per year by 2050 to avoid widespread starvation. But food production per capita has been declining since the 1960s, and cereal crop yields have remained stagnant. In the face of this dire situation, observers are pointing to a perfect storm of further challenges.

EverGreen Agriculture is now emerging as an affordable and accessible science-based solution to regenerate the land on small-scale farms, and to increase family food production and cash income. EverGreen Agriculture is a form of more intensive farming that integrates trees into crop production systems at the field, farm, and landscape scales. The vision is sustaining a green cover on the land throughout the year.

The next step will be to foster South–South learning as a means to generate viable and successful development initiatives. We aim to facilitate the sharing of knowledge and experiences from Sri Lanka with interested parties across Eastern and Southern Africa (governments, communities, investors and power plant developers). In so doing, strong relationships across national and intercontinental borders will be fostered, allowing for ongoing cross-country sharing and co-learning to occur in the future beyond the life of the project.

Feasibility analyses and public-private partnerships will be developed to pave the way for attracting and harnessing substantive levels of commercial and public sector investment in the development of an agroforestry-based energy industry in Eastern and Southern Africa, with an emphasis on implementing new commercial-scale projects that can fully demonstrate the potential for wide expansion.

Box 16.2 A resource for firewood as seen by Evergreen Agriculture proponents

The gliricidia systems increase the on-farm production of firewood, a resource which is increasingly short supply in Africa smallholder agricultural systems. Farm production of adequate fuelwood saves the drudgery of women and children in travelling long distances to collect it, and this releases time and energy for other income-generating activities. It also reduces the destruction of natural forests by reducing the need to collect firewood from public lands. The increased supply of fuelwood that will be produced in association with the commercial production of glricidia for power generation will also ensure that the cooking and heating energy needs of the communities are amply met.

Our vision is a fully-fledged, integrated and sustainable tree-based food-energy system (EverGreen Energy) that is operating and providing benefits to numerous communities across Eastern and Southern Africa. We envision that the systems will be providing rural electrification benefits to 'powerless' communities, enhanced income generation from growing the feedstock, increased crop production with enhanced soil fertility, and greater wood-fuel availability in rural areas.

16.8 Accounting and accountability issues

While the earlier debate and policy formulation was mostly at the level of the plant species used for bioenergy production, subsequent analysis showed that footprints (emissi0ns caused per unit product) varied more widely within than between types of feedstock[55]. Palm oil was found to be both the best (most productive with low emissions when grown on mineral soils replacing low-C-stock vegetation) and the worst (when converted from forest on deeply drained peat soils)), within a range of tropical and temperate feedstock sources.

That defines a problem for the accounting. If the type of product is not a good predictor of the emissions savings, should rules apply at the national scale of a country of origin? A region within a country? A company that is transparent about all of its production? A specific, certified plantation? In the biofuel debate the issue of indirect land use change became specifically controversial (Box 16.3).

Box 16.3 Accounting challenges palm oil[56]

The public debate on oil palm heated up by the increasing options for use of palm oil as non-food product. Emerging demand for palm oil from European countries followed from policies to reduce their attributed CO_2 emissions through the use of biofuels, with associated carbon emissions outside their books. Based on earlier critiques, biofuels must (from 2018 onwards) lead to at least 60% emissions saving at global scale in order to be included in the EU policy, but the assessment of such emissions (at sector, national, company or plantation scale) is still debated.

Calculations of the palm oil carbon footprint for biofuel consider three phases of the production process and four types of emissions: (i) the initial conversion of preceding vegetation into an oil palm plantation, usually based on 'land clearing', leading to a 'carbon debt' defined as the difference between time-averaged C stock of the subsequent plantation and that of the preceding vegetation, (ii) the emissions due to production of external inputs, such as fertilizer, (iii) the growth cycle of the oil palms (typically around 25 years) and its management and fertilization practices that lead to the yield, direct fertilizer-related emissions and an aboveground and belowground time-averaged C stock of oil palm that influences the carbon debt and repay time, (iv) post-harvest processing including transportation until the product reach the end user.

Palm oil used for biofuel and produced in plantations derived from low (below 40 t C ha^{-1})[57] C stock land covers on mineral soils[58] and second-generation plantations (without attributable carbon debt) can achieve current targets for emissions saving when compared to the use of fossil fuel, when fertilizer levels are adjusted[59].

Based on the sampled companies with good agriculture practices, 25% of Indonesian palm oil production can meet the 60% emissions savings standards for net emission reduction when used as biofuel. This is more than what is currently exported to the EU for that purpose. When the EU threshold will increase to more than 70% in the near future further efficiency increases, including in the use of N fertilizer and in dealing with emissions at the mill will be needed.

The rationale for the “Indirect Land Use Change” ILUC debate is that even if the footprint of specific products used in biofuel matches the existing standards, its use as biofuel might displace current other uses of the same product (e.g. in the food industry) and lead to expansion of production elsewhere. As such, it is not informed by data of the types presented and discussed here. As ILUC calculations are generic, they don’t provide any incentives for or recognition of attempts to improve practice on the production side. Their primary target is the consumer/user side, nudging away from commodities with high ILUC tax (such as vegetable oils with current (or at least recent) expansion in high-carbon-stock density parts of the world) and towards those with low ILUC tax (such as vegetable oils grown in areas where conversion took place long ago). A major challenge of the ILUC concept, however, is that the choice of the level at which it is applied (commodities such as ‘palm oil’ with its global markets and expansion) appears to be arbitrary. One could equally argue that a generic ILUC tax should apply to all vegetable oils that are interchangeable for at least some of their uses.

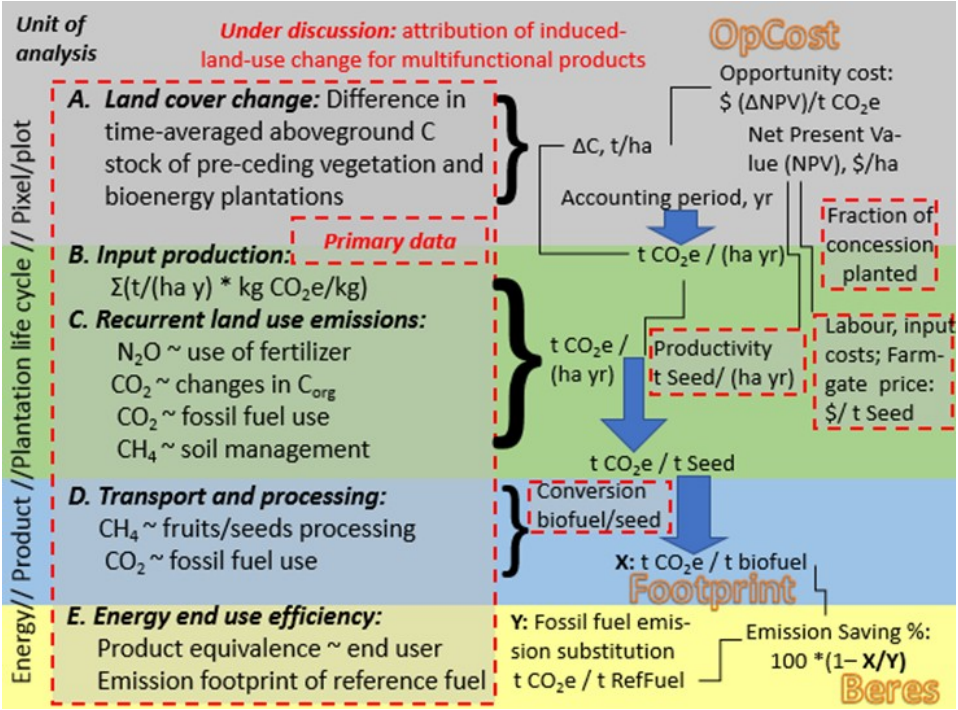


Figure 16.8 Biofuel Emission Reduction Estimation Scheme (BERES) as used for quantifying palm oil footprint in Indonesia

Oil palm as one of biofuel feedstock with relatively cheap price compared to other vegetable oils was found to be both the best (most productive with low emissions when grown on mineral soils replacing low-C-stock vegetation) and the worst (when converted from forest on deeply drained peat soils). Photo: World Agroforestry/Ni'matul Khasanah

While the BERES scheme (Figure 16.8) can be used for consistently comparing any biofuel source that has potential to substitute for fossil fuels, there are challenges where global trade is involved. Where carbon is sequestered in the country of production and released in the country of consumption, the emissions embodied in trade will have to be accounted for in a transparent overhaul of the current rules[60]. Currently well-intended actions by individual consumers in importuning countries ('individually determined contributions', such as a palm oil boycott) are not directly linked to area-based accounting and Nationally Determined Contributions in producing countries (Fig. 16.9).

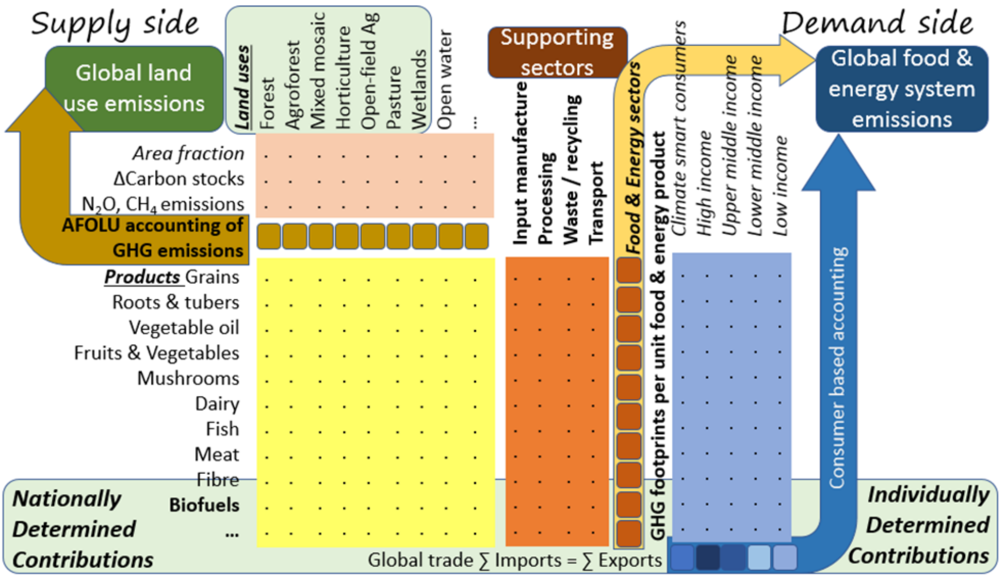


Figure 16.9 Accountability through the supply side of land use, interacting with that through the demand side of consumption, with challenges for coherent accounting of nationally and individually determined contributions to climate change mitigation, especially where global trade is involved (embedding emissions in tradable goods)[61]

Rural energy is clearly a key aspect of 'sustainable development' and conversion of biomass to electricity may offer the access to clean energy-demanding applications. But solutions need to be analysed in their regional 'green growth' context, as will be further explored in Chapter 21.

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