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Optimizing decision making in the global biofuel chain for sustainable development, by creating insight into trade-off between social, economic and environmental impacts, and how these affect actors in different locations and on different time scales.

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ABSTRACT:
Biofuels can provide a renewable and CO_2 neural fuel, however biofuels are contested as the land needed to cultivate biofuels threatens food security. The market pull created by the European Biofuel Directive, that targets at a 10% obligatory blending in transport fuels by 2020, threatens food production and biodiversity in other continents, as for instance Africa, since Europe does not have the required land area neither the suitable climate. Sustainability criteria are defined, however, evidence is still lacking, as this new sector is still in the learning phase and data and expertise on best practices are being gathered. Furthermore, different actors within this global cultivation, production and usage chain have different priorities. Europe is targeting at mitigation of climate change, while Africa's priorities are poverty reduction and conservation of soil fertility. Therefore it is important to operationalize the sustainability criteria in decision making by creating insight into the trade-off between the 3 dimension of sustainability; social (sustaining livelihoods in developing countries), economic (poverty reduction and profit making), and environmental (mitigation of climate change and conservation of soil fertility and biodiversity). Through mapping of the actor network and the distribution of costs and benefits (including externalities) in the entire chain, we will indicate where decisions can influenced. By combining this with the impact assessment we are creating insight into trade-offs and power relations for optimization of decision making. We will discuss the case of small holder jatropha farmers in Tanzania cultivating for export, based on years of research. Combined with our expertise on socio-economic modeling of the decision making processes, in this case strengthened with extensive literature research on jatropha biofuels as well as expert knowledge obtained through interviews, we will develop a decision support model for policy making in this global biofuel chain.

INTRODUCTION: Biofuels; sustainable innovation or gold rush?

Challenges in international biofuel chains are huge, as policies are set to scale up the shift to a bio-based economy and criteria are defined to do this sustainably. However, decision making includes a large number of diverse stakeholders and is untransparent as it is hard to quantify impacts on the different dimensions of sustainability (people, planet, profit). Through analysing the decision making process in a case study, by mapping the stakes and expectations, we want explore opportunities to optimise the governance of global biofuel chains towards sustainability.

Our case study, the jatropha outgrower model as practiced in Tanzania, is based on small holder farmers that grow jatropha in hedges around their food crops. This "inclusive business model" is favorable as it protects farmers' assets for food production and has potential to give farmers a voice in deciding how to share the rewards and risks of biofuel production (Balkema and Romijn 2012, FAO 2010, p.98, Figure 11, PISCES 2011, p.13, Vermeulen 2009). Furthermore, it should create enough economic development to lift farmers in arid areas out of absolute poverty (Portale 2012, p. 38). Through diversification of crops on existing arable land, environmental impacts as initial carbon debt, loss of soil fertility and loss of biodiversity are also low (Eijck et al 2010). However

realised yields are much lower than initially projected, as such shifting to alternative biofuels with higher oil yields need be considered (FAO BEFS 2010, p.7 and 131, Hultman et al. 2012 p.11, 14).

Small scale farmers indicated that yields have been unsatisfactory, only about half of them manages to eat 3 meals a day on regular basis (48%, Heijnen 2010, Figure 52). The majority (88%) answered to be interested to engage in jatropha cultivation for additional income generation (Heijnen 2010, Appendices p.73). Although living in marginal conditions, these farmers are willing to invest land and labour in experimental biofuel cultivation (Balkema et al 2011). In the perspective of the global chain these stakes may seem relatively small, however from the individual farmer perspective these are large, relative to their income and insecurity, and because of the high number of outgrowers involved (approximately 50.000 in 2011, expected to grow to over 100,000 in 2013 (H.A. Romijn field trip 2012).

TRADE-OFFS: Importing the baby with the bath water; biofuels, global justice and nutrients.

Dauvergne and Neville (2010) clearly indicate that there is a trade-off between environmental and social aspects within the global industrialised biofuel chain, by stating that already vulnerable people and communities will bear a disproportionate share of of the costs of biofuel development, particularly for biofuels from crops already embedded in industrial production systems. The core reason being that emerging biofuel alliances are reinforcing processes, and structures that increase pressures on the ecological integrity of tropical forest and further wrest control of resources from subsistance farmers, indigenous people, and people with insecure land rights. Dauvergne and Neville (2010) focus on the framing of the debate over sustainable biofuels, arguing that it is both powerful and misleading. They extend the biofuel trilemma of food security, energy and biodiversity (as termed by Tilman et al 2009) to include forest-depended communities (Dauvergne and Neville (2010) p634). Dauvergne and Neville (2010 p643) anticipate that state strength is an important variable, as in the biofuel alliances multi-national companies play a dominant role, strong states will be able to benefit more from biofuels through taking advantage of international market opportunities and regulation of domestic production in the agriculture and forestry sector. Failure of some fair trade systems to protect the livelihoods of the most vulnerable people, as Nelson and Galvez (2000 in Dauvergne and Neville (2010) p653) document, raises concerns about the ability of sustainable initiatives in the biofuel sector to protect the social well-being and the environment.

Gasparatos et al. (2011) identified 2 major gaps in the current biofuel literature and practice, namely (1) lack of consistent language that can be used to put the biofuels' diverse trade-offs into perspective and frame the biofuel debate, and (2) lack of appropriate integrated tools or toolkits for assessing the sustainability of different biofuel practices during their full lifecycle (p112). Include figure 1 form page 113 showing Millennium Ecosystem Assessment Narrative, source Gasparatos et al. (2011 p113) and refer to same figure in GEO4 including location as well a time dimensions. Gasparatos et al. (2011 p113) claims that the concept of ecosystem services as in the Millennium Ecosystem Assessment is useful as it pictures interrelation and dynamics simplified by directly linking ecosystem impact to human wellbeing, which are the two key elements in the biofuel debate. Furthermore, this concept of ecosystem services have been accepted in academia as well as by policymakers. Gasparatos et al. (2011 p114) identified the following main impacts of biofuels on human well-being reported in scientific literature; (1) rural development , (2) energy security and access to energy, (3) food security and access to food, (4) health, (5) land tenure, (6) gender issues. Also insert figure 2 Linkages between biofuel production, ecosystem services and human wellbeing Gasparatos et al. (2011 p123).

Hein and Leemans (2012) argue that committing scarce P to biofuel production involves a trade-off between climate change mitigation and future food production. All first generation biofuels require phosphorus (P) fertilisation, as P is an essential plant nutrient, yet global reserves are finite.

It is doubtfull whether this will increase with the next generations of biofuels. Microalgae, for insatnce, have a higher fuel yield potential due to a higher photoconversion efficiency than traditional energy crops, and produce high concentrations of lipids interesting for the production of transport fuels including jet-fuel. Theoretical microalgae could produce between 10 an 100-fold more oil per acre (Rosch et al. 2012). To realise these high yields large quantities of nutrients (N and P) are needed, nitrogen can be obtained from the air but this is a highly energy demanding process. World phosphate reserves are dwindling in amount and quality and the phosphate rock production will peak in around 50 to 100 years and then decrease as reserves are depleted (Cordell et al 2009 in Rosch et al 2012). Present global phosphorus fertiliser use is estimated to be around 16, 5 million ton per year (Bouwman 2012 p4). Most likely this will increase further, especially in Africa were population increase is projected to be highest will artificial fertiliser sis still limited, while yield in Africa need to increase for local food security (Bouwman 2012, p9). At the same time algal blooms occur in surface water around the world due to eutrophication as excess of fertiliser runs off to surface water (Bouwman 2012 p10).

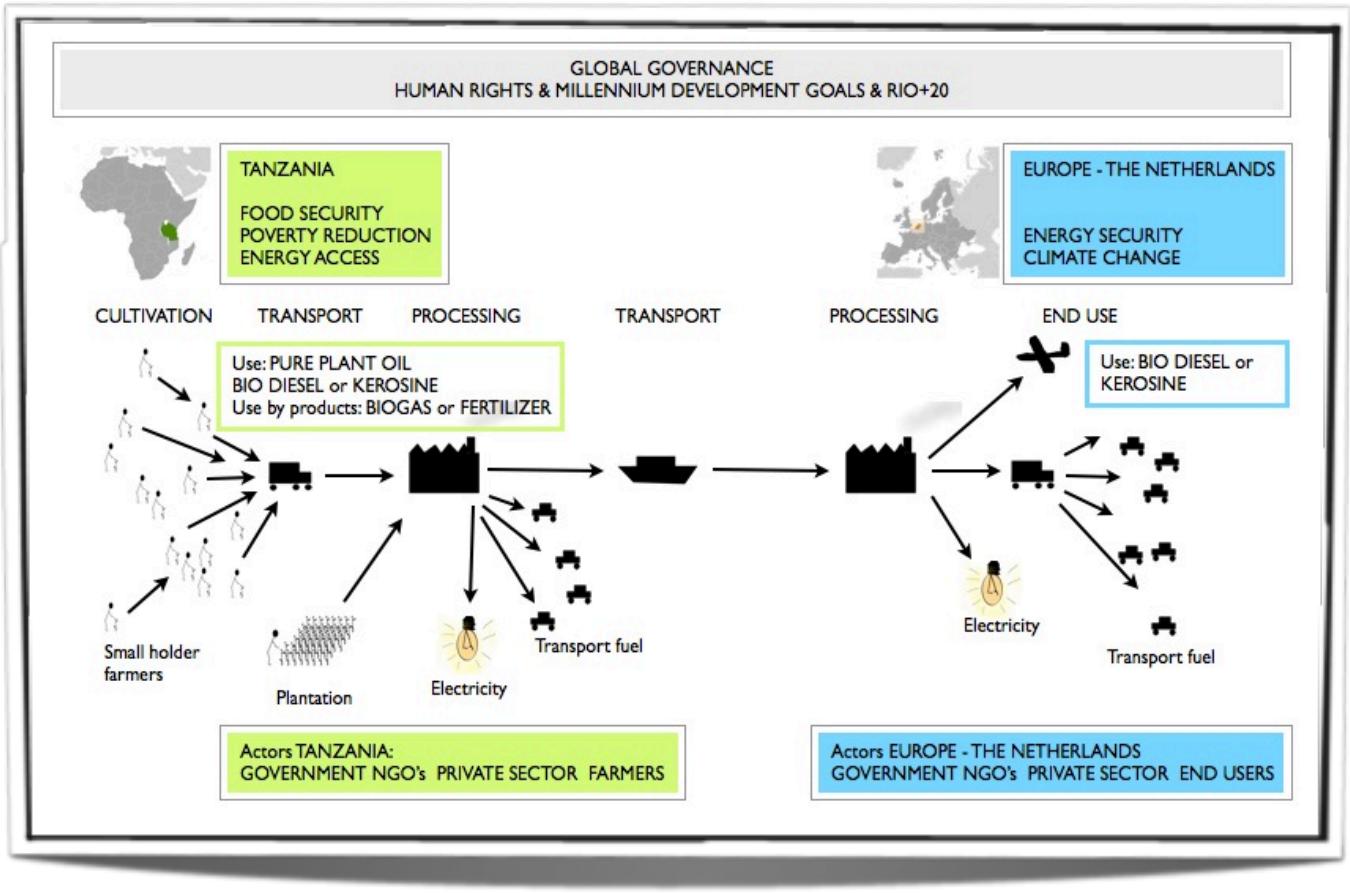


Figure 1: *Global jatropha biofuel chain, including different options for use of product and byproducts, based on jatropha cultivation in Tanzania either by small holder farmers or at a plantation.*

ACTOR ANALYSIS: Piece of cake? What's at stake for whom, where and when?

As shown in Figure 1 our business model the cultivation of jatropha biofuel by small holder farmers in Tanzania for export to Europe as renewable transport fuel means that actors in the chain are spatially separated, living in different continents, governed by different countries, in different cultures and different socio-economic circumstances in different ecosystems. Furthermore overarching governance is difficult as global governance is still lacking. Therefore we need a actor analysis that includes more than we usually do map in innovation trajectories as shown in Figure 2, (mapping networks, expectations and learning), and in actor power matrices as shown in Figure 3. We want to map the actors, their role, stakes, strengths, vulnerability, influence, knowledge, capacity, learning, responsibility, connection to, and how the actor related to decision makers in the global value chain.

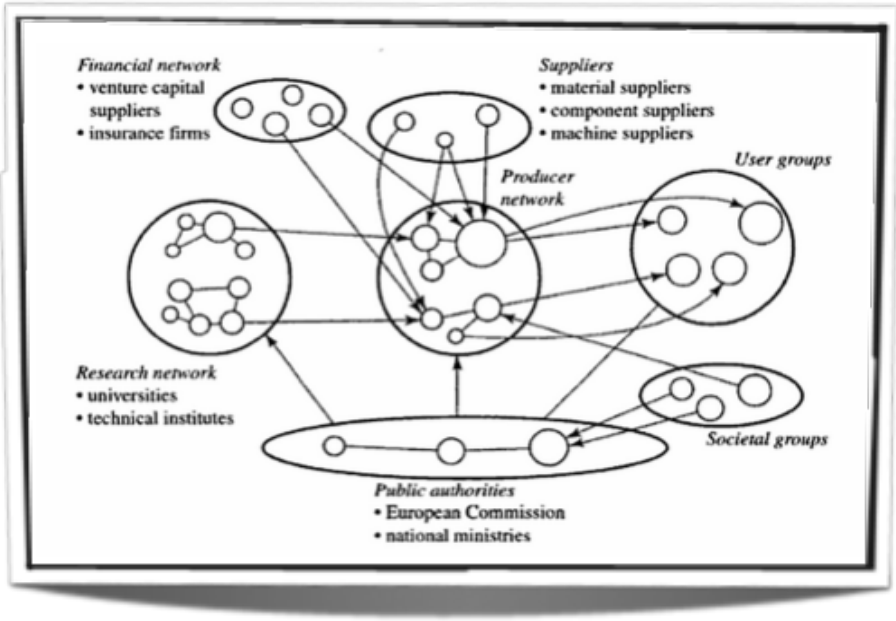


Figure 2: *Actor network in Strategic Niche Management (SNM)(Geels et al. 2004).*

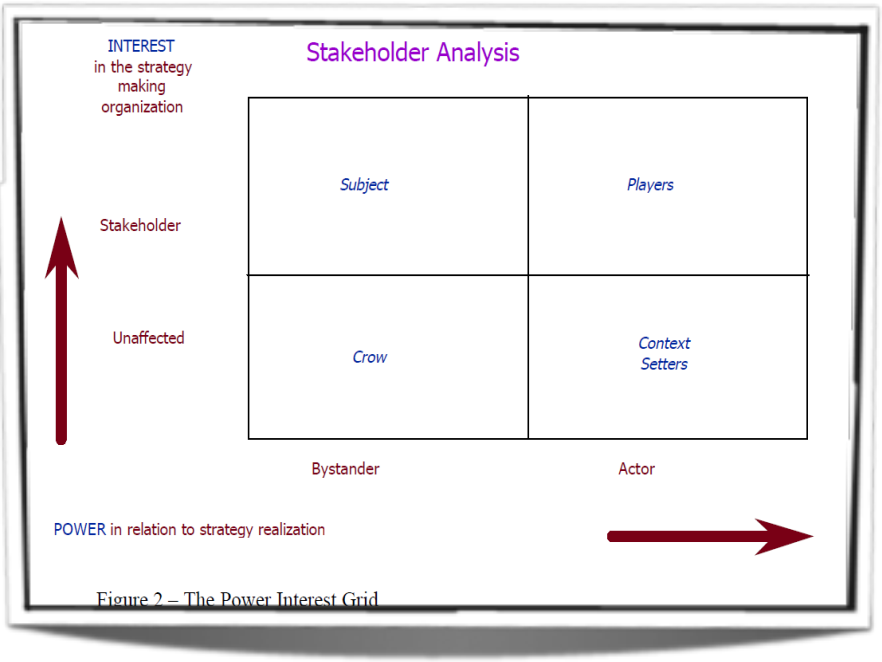
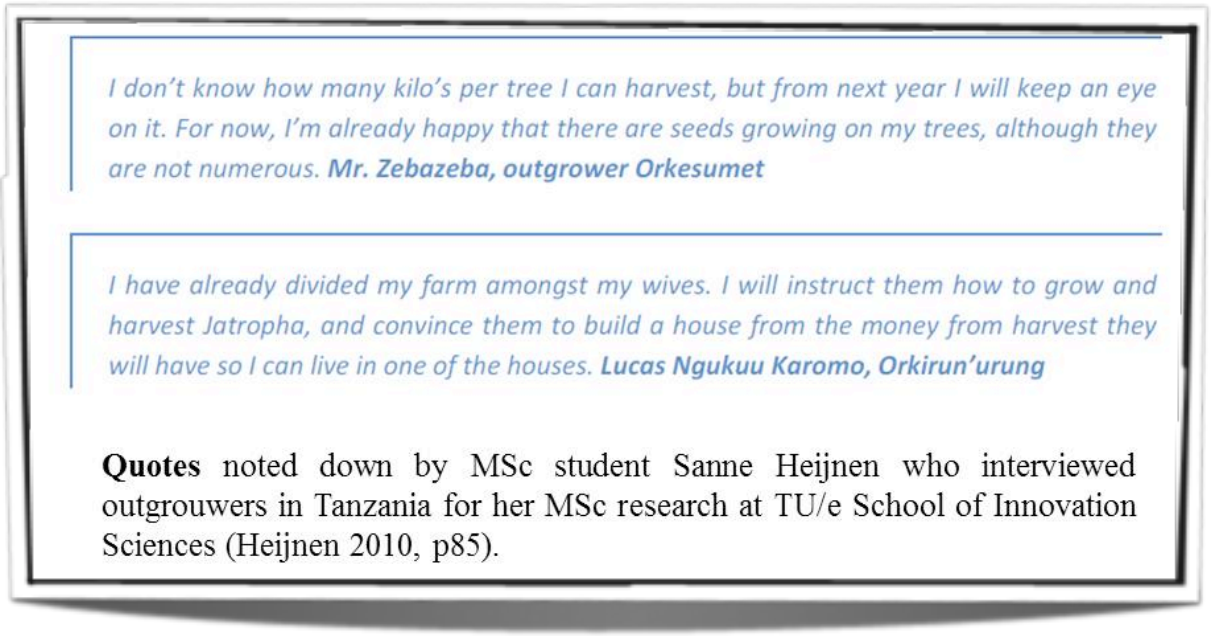


Figure 3: *Power Interest Grid.*

DECISION MAKING: Can't see the wood for trees? Making sense and taking responsibility!
Decision support tools examples for bioenergy sector named in Perimenis et al. (2011 p1784) are Vickman et al. 2004, Ayoub et al. 2007, Elighali et al. 2007, Muys et al 2003, Mitchell 2000, Arumugam et al. 1008. The decision support system developed by Perimenis et al (2011 p1785) uses a pathway breakdown including the following stages; (i) production, (ii) transport, (iii) conversion, (iv) distribution and (v) end-use. The following aspects are included in the decision support tool by Perimenis et al (2011 p1785); technical aspects (energy efficiency, feedstock conversion, complexity, development status), economic aspects (investment, operation & maintenance, overhead, revenues of main and by products), environmental aspects (LCA), social aspects (living standards, rural diversity, regional development, education, security of supply, regional trade balance, productivity, competitiveness, labour mobility, employment, income changes, reduces investment). In the multicriteria analysis the decision maker can set the weight factors according to local and actual priorities and based on the notion of public responsibility. This requires insight into the priorities of different actors and participation on future changes in priorities. Therefore the responsible decision making requires insight into the impacts of the decisions taken and how these affect different actor actors. A such overview of the actor network, and understanding of their priorities, as well as the understanding of the innovation trajectory, particularly the changing expectations and visions, learning and network forming is required.



CONCLUSIONS: The best for both worlds? Avoiding local optima!
Based on research so far, we conclude that within the global biofuel chain the perspectives on sustainability differ. For European societies climate change seems to be leading while the for Tanzania enhancing economic development for poverty alleviation is leading. Presently, decline in soil fertility is hampering the economic development in rural Tanzania. Therefore, biofuel innovations should be directed to export energy to Europe against a fair price to make poverty alleviate substantial and recycle and supplement nutrients and conserve ground water in the arid areas of Tanzania to improve soil fertility for increase in agricultural yields for food security.

Sub-conclusion on observations in Tanzania in last decade, we want to argue that in inclusive innovations we should govern learning trajectories to protect vulnerable groups in case of failure. As failure is not uncommon in this early stage of the innovation trajectory. Also in Tanzania

although it has the ideal geographic and climatic conditions for growing a wide range of bio-fuel crops, so far none of the jatropha processing companies have been profit making. Most activities are still heavily depending on subsidies and so far many initiatives failed (FAO 2010, p37 Table 3.2 lists 4 major jatropha investors in Tanzania of 3 have ceased their operation and the fourth is uncertain). It would be good to make the learning trajectory of innovation explicit and to set realistic time frames, although this is not straight forward.

DISCUSSION: Failure is the mother of success?

The interaction between expert and decision maker can be complicated, and understanding the different forms of this relationship is the first step towards the effective governance of expertise. The central message of The Honest Broker by Pielke (2007) is that we have choices in how experts relate to decision makers. These choices shape our ability to use expert advice well in particular situations, but also shape the legitimacy, authority, and sustainability of expertise itself. Whether we are taking our children to the doctor, or seeking to use military intelligence in a decision to go to war, or using science to inform climate policies, better decisions will be more likely if we pay attention to the role of expertise in decision making and the different forms that it can take (Pielke 2007). When reflecting on our business case of small holder farmers in Tanzania producing jatropha seeds that are collected and pressed by a company for export to Europe, we have to conclude the farmers risk their food security and that their additional income generated is still too low, the contribution to poverty alleviation has been too limited. Thus, unfortunately so far it has not been possible to fulfill both the social objective (local food security and poverty reduction), in combination with the environmental objectives (renewable transport fuels replacing fossil fuels without compromising on soil fertility and biodiversity) and economic objectives (profit making production of affordable bio-fuels) in the global jatropha biofuel chain. The role of scientists as honest broker has been doubtful, as scientists seem to be opportunistic and did not warn that costs of learning are high as well as the risk of failure in an early innovation trajectory. Furthermore, the role of policy makers can be criticized as well, especially international policy makers that defined unrealistic high targets in the EU biofuel directive without funds to ensure the social objectives and without strong alining policies on the reduction of energy use in the transport sector and incentives to realize this.

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