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Tree cover transitions and food security in Southeast Asia

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ABSTRACT

Trees are sources of food, especially fruits, critical for healthy diets. Trees also modify microclimate, water and nutrient flows for crops and livestock, and are a source of income, allowing forest-edge communities to be food-sufficient through trade without cutting down forests. Opportunities for ecological intensification, utilizing trees in agricultural landscapes, vary along stages of a tree cover transition of forest alteration and deforestation followed by agroforestation. The nonlinear forest transition curve can provide both a theory of change (similarity of processes) and a theory of place (configuration of state variables). We reviewed local perspectives on food security for four configurations of the forest and landscape transition in Southeast Asia, with local human population densities ranging from less than 10 to 900 km^{-2} to explore how current generic 'theories of change' on how to achieve global food security need more explicit 'theories of place' that take such differences into account.

1. Introduction

Food security, forests, poverty and sustainable development are terms that have relevance across all scales from local through national to global. Yet the meanings of these terms change significantly at different scales. In this article, we hope to disentangle the discussion on their interactions in the context of the elusive sustainable development goals for 'a future we want,' as agreed by world leaders in the Rio+20 meeting (http://www.uncsd2012.org/). Maslow (1943) suggested that multiple needs of individuals can be represented as a pyramid, with physical security as basis and identity and self-articulation at the top. Food relates to all levels of this pyramid, from basic needs to identity. Recently, van Noordwijk et al. (2014a) suggested that a similar pyramid applies at the scale of a national government, which sees territorial integrity, physical security, caloric food and water security as basic needs, but also articulates identity in food terms.

Trees provide resins and fruits, some of which are caloric staple foods and many are important dietary sources of vitamins (Jamnadass et al., 2013). Siegel et al. (2014) compared availability of fruits and vegetables with what is considered necessary for a healthy diet and found a global deficit of 22%, with 58% in low-income and −2% in high-income countries. This deficit in (tree-based) fruit and vegetable supply coexists with oversupply (relative to a healthy diet) of protein sources and caloric staple foods that are more easily stored and traded over long distances. Trees and forests also support local livelihoods, agricultural production and food security as they are major providers of environmental services (here interpreted as ecosystem services minus the provisioning services, following van Noordwijk et al. (2012a)). Food security, in all its aspects, in a world at risk of exceeding planetary boundaries through its human appropriation and modification of vegetation, climate, water and nutrient cycles (Rockström et al., 2009) implies a focus on quality and diversity of food, beyond calorific quantity, and on explicit choices to adjust desirable to affordable diets for the expected population size and welfare targets. On the supply side it requires the closing of both yield and efficiency gaps (van Noordwijk and Brussaard, 2014; Bommarco et al., 2013). Yield gaps are defined as the difference between actual and potential yield – acknowledging that there are many ways to define the latter in operational terms (van Ittersum et al., 2013). Efficiency gaps are similarly defined as the difference between actual and potential resource use efficiency, with similar challenges in defining 'potential' operationally. As technically inefficient ways of closing yield gaps can be economically rational for farmers in the absence of internalized environmental costs, policies to increase food security by reducing input prices have downside risks for the provision of environmental services. Yet, the Borlaug hypothesis that has been popular for the past two decades expects that by reducing

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yield gaps, agricultural intensification contributes to reduced pressure ('land sparing') on the remaining forests (Tomich et al., 2005; Lusiana et al., 2012). There thus may be a trade-off between the local environmental costs of intensification versus the opportunities it provides to conserve forests elsewhere. As first approximation, agroforestry is used as a term that indicates a combination of agriculture and forestry as land use sectors, but also as a way of combining functions and objectives (Mbow et al., 2014).

Forest-edge communities typically employ a dual economy where primary staples are self-produced and trade is focused on non-food items (Dove, 2011). The term intensification is widely used for changes in agricultural practice, but its definition as a change in a state variable 'intensity' often remains implicit, with notable exceptions (Giller et al., 1997; Tscharntke et al., 2005). Where land use intensity is commonly quantified on the basis of outputs or the magnitude of the yield gap (difference between actual and potential yield), the need for intensification to meet increasing demand is a tautology. Van Noordwijk and Budidarsono (2008) extended the Ruthenberg index that indicates the fraction of time (and space) that land is cropped in a swidden-to-fallow-to-permanent cropping series, with additional terms in an index based on efforts to modify the water and nutrient cycles, controlling weeds, pests and diseases, substituting human labour by fossil energy-based mechanization and removing remnant refugia for biota from a landscape. These various aspects of intensification can be compared on their effectiveness in increasing yield as well as affecting environmental services allowing tradeoffs to be made between the farm-level decisions that jointly determine land use intensity. Various adjectives are used in combination with 'intensification,' with terms such as 'sustainable' and 'climate-smart' indicating goals rather than methods, and 'ecological' currently preferred for efforts to close yield and efficiency gaps simultaneously (van Noordwijk and Brussaard, 2014).

The drastic quantitative increases in food production and associated human population size in the past 10,000 years since the start of agriculture (Miller, 2008), with variable effects on qualitative aspects of food security, has been obtained at substantial environmental cost, with the green revolution as recent manifestation of what agricultural technology can achieve (Fig. 1). Four overarching goals have been agreed for international agricultural research, with increased rural income, increased food production and enhanced food security as a group aimed at continuing current developmental trends, while goal four, improved natural resource management requiring an escape from the trade-off with the first group. From the current position at the origin of the coordinate system in Fig. 1, there is a range of trajectories: continuation of a traditional focus on

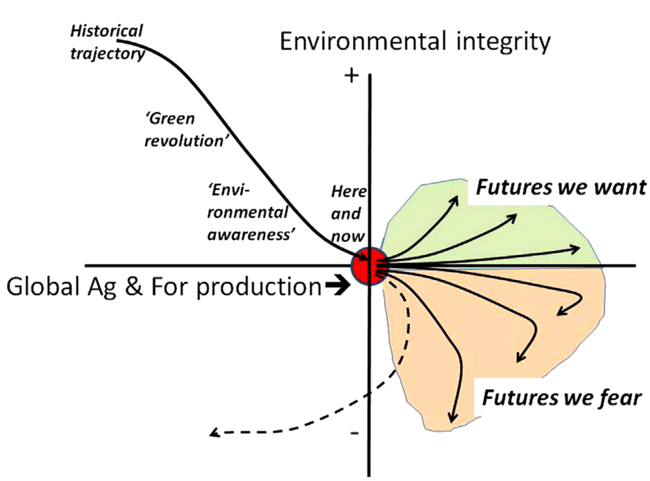

Fig. 1. Historical trajectory of humanity and its future options in the tradeoff between environmental services and agricultural and forest production that enhances income, food supply and food security.

supply alone may cross planetary boundaries and lead to a 'collapse' scenario. Simultaneous closing of yield and efficiency gaps may allow an escape into the desirable upper right quadrant of a recovery of environmental services alongside modest increases along the X-axis. The single goal of food security thus needs to be reframed as an imperative to navigate tradeoffs among two major axes, with yield and efficiency gaps as proxies. As yield and efficiency gap scale by different rules (van Noordwijk, 1999), the trade-off depends on scale (van Noordwijk and Brussaard, 2014).

With the 'theory of change' language becoming prominent in development circles, it is pertinent that 'forest transition theory' provides both a theory of (non-linear) change (similarity of processes, prominence of actors and agency, direction of change) and a theory of place (configuration of state variables) (van Noordwijk and Villamor, 2014). In this context a theory of change can be defined as 'Implementable, rational pathways, aligned with documented experience, to achieve change that is deemed desirable by funders and acceptable by gatekeepers.' A theory of place can be defined as a 'Framework for articulating, describing and analysing the spatial and contextual aspects of current livelihoods, the business-as-usual projection of ongoing change, and the identity and sense of belonging associated with these.'

We can recognize four configurations of forest, agroforestry and agriculture in the way landscapes relate to the four stated objectives (Fig. 2; van Noordwijk et al., 2015). These differ in actual land cover (fractions of various degrees of tree cover; spatial configuration), but also in institutional aspects of forest versus agricultural categories of land, and in the way livelihoods and food security are perceived (Carney, 1998; Jackson et al., 2010).

In configuration I swidden/fallow rotations (also known as shifting cultivation) are the major source of local livelihoods. As a land use system, swiddens are both forest and agriculture, as the swidden allows both crop production and a start of forest rejuvenation. The four objectives are addressed simultaneously.

In configuration II, institutional processes that segregate forest from village land associated with agriculture prevail and forest and agriculture become entities that are seen to complement each other in terms of human wellbeing. However, they also engage in an area trade-off: growth of agricultural area implies less forest, and forest conservation necessitates a more productive form of agriculture. The land sparing discourse that builds on the Borlaug hypothesis typically refers to this configuration.

Configuration III, which can develop out of the first if institutional pressures towards segregation are less strong, acknowledges an intermediate-tree-cover land use type, labelled as agroforestry. The agroforestry part of the landscape is intermediate between forest and agriculture in the functions and services it provides, and the theoretical framework for the resulting landscape transitions is one of land sharing (van Noordwijk et al., 2012b).

Finally, in configuration IV a distinct role of natural forest is recognized that supports landscapes in which an agriculture–agroforestry transition takes care of (nearly) all provisioning services (including food), with abundant use of trees on farm. The supporting and regulating role of forests allows the agriculture plus agroforestry parts of the landscape to provide for income, food supply and food security.

Where the four configurations currently coexist in Southeast Asia, we need to be aware that current change can be different from historical patterns elsewhere, with mutual influences in an increasingly connected world. The remainder of this contribution to the debate will review four case studies from Southeast Asia (Table 1) that represent the four configurations of Fig. 2. The four configurations are broadly aligned with the generic relationship between human population density and remaining forest cover (Köthke et al., 2013), with a major difference between the dominance of natural forest in configuration II and of agroforest in configuration III (Fig. 3).