# Beyond Boserup: The Role of Working Time in Agricultural Development

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**Abstract**

*This contribution investigates the role of working time in the course of agricultural development. In so doing, we revisit Ester Boserup's (1965, 1981) hypothesis of increasing land productivity at the expense of declining labour productivity as a consequence of agricultural intensification in subsistence communities. We introduce a theoretical framework that centres on human time as a 'limited' biophysical resource and compare the labour burden across gender and age of four subsistence communities, one each from India, Bolivia, Nicaragua, and Laos. While Boserup's claim applies to early stages of agricultural development, the dynamics change with the introduction of fossil fuel based inputs into agriculture, leading to a rise in labour productivity. Despite these improvements, we still find overall labour needs to increase with agricultural intensification. Since household labour remains largely constant during this development process, the labour burden is primarily borne by women.*

## 1. Introduction

Many of the world's poor still live in rural environments, where their livelihoods depend on smallholder agriculture, foraging or pastoralism[1]. Through regional and national development programmes, local communities increasingly aspire for modern lifestyles as they integrate their production systems into a global division of labour. In other words, the prevalent development model promotes the integration of remote communities into the market economy through industrial development approaches based on the use of fossil fuels, either directly (through the industrialization of agricultural production) or indirectly (through specialized machinery). This appears to be the only chance to escape from the poverty trap[2].

The ecological crisis of our current times cannot be understated. The crisis is global, 60% of our ecosystems are degraded (MEA 2005, Steffen et al. 2004) and in many respects we have exceeded the safe operating space of the planet. The distortion of the nitrogen cycle is primarily attributed to industrial agriculture and the use of fertilizers (Rockström et al. 2009). As we globally head towards the erosion of our own natural resource base, these current development trends run counter to the increasingly accepted common notion of sustainable development. A more sustainable global future requires therefore a broader search for pathways where short- and long-term benefits for the people come at the lowest possible environmental cost and the lowest possible burden and stress on the people in terms of working time (Haberl et al. 2004, 2011).

[1] According to the UNDP report (2007/8: 90), around three in every four people in the world living on less than US$1/day reside in rural areas.

[2] These strategies are also reflected in individual countries' Poverty Reduction Strategy Papers (PRSPs) funded and designed by the World Bank.

Guided by this focus on sustainable development, our main concern is to gain a better understanding of these transition processes 'at the periphery', and the transformative potential and impacts that are generated at the society-nature interface thereof. The conceptual framework of sociometabolic transitions (Fischer-Kowalski and Haberl 2007) is an attempt in this direction. In this context, local rural subsistence communities have been empirically investigated to understand the systemic interrelations between the food production system and environmental pressures as a consequence. Comparing and contrasting these cases in terms of their demographic, sociometabolic and agro-ecological profile has helped to model development trajectories for larger regions. A variable that is often left out from such analysis is 'time use' and its link to sociometabolic transitions. While we have elsewhere illustrated our findings on the environmental pressures triggered by the specific material, energy and land use activities in the different communities (see Fischer-Kowalski et al. 2011), the focus in this chapter will be the social pressure on people in terms of working time and how the burden of labour changes with agricultural development.

To this end, we revisit Boserup's (1965, 1981) theory of agricultural change in subsistence systems, in particular her hypothesis on rising area productivity at the expense of declining labour productivity in consequence of technological intensification in traditional farming systems. This provides us with a bridge to comparing the burden of labour of four contemporary subsistence communities in the global south that are in different stages of agricultural development.

We will first provide a brief overview of Boserup's hypothesis, followed by our sociometabolic concept on human time as a (limited) biophysical resource. What follows is a brief description of the four case studies and methods used in data collection. We then present the main findings and conclude with a brief reassessment of our hypothesis.

## 2. Theoretical assumptions, concepts and methods

### 2.1. Returning to Boserup and introducing sociometabolic concepts

Boserup's 'anti-Malthusian' argument says that even in traditional agriculture, population growth does not fully translate into increasing land demand for food production. Instead, a learning process and technical improvements take place that allow for increasing food production on existing land. In effect, population density rises and growing population numbers can be sustained from the same area, land use is intensified and returns upon unit area increase, at the expense of rising labour input into this land. Boserup envisages a progressive series of fallow reductions driven by the pressure of population. Across the progression of intensification - that is from long fallow systems to multiple cropping– there occurs a reduction in agricultural output per man hour but a vast increase in total output per area. So, the higher the outputs per area, the more hours the farmer must work for the same amount of produce. In other words: As the benefits of fallowing are sacrificed, workloads tend to rise (due to labour intensive tasks such as weeding, fertilizing and irrigating), leading to a decline in the efficiency of labour productivity[3].

[3]Stone (2001) maintains that the key to Boserupian intensification is that the labour costs of intensification are both necessary and sufficient to raise production concentration. They are necessary since higher production requires proportionately more work, and sufficient since the proportionate increase in work succeeds in raising output.

Boserup's hypothesis has also come to be one of the core elements of the theory of sociometabolic regimes. Developed by Sieferle (1997, 2001) and other authors since (Fischer-Kowalski et al. 1997), the theory claims that certain modes of human production and subsistence can be broadly distinguished that share, at whatever point in time and independent of biogeographical conditions, certain fundamental systemic characteristics derived from the way humans interact with nature. These subsistence modes or *sociometabolic regimes* differ by the source of energy used and the main technologies of energy conversion. The theory makes a distinction between hunters & gatherers, the agrarian and the industrial regime[4]. These three different *sociometabolic regimes* exhibit substantially different *metabolic profiles* (i.e. the quantity of materials and energy used per capita and year) and a different use of land resources. The allocation of human time (as a limited biophysical resource contingent on demographic factors) has been integrated more recently in this theoretical framework. It seeks to establish a link between the intensification of land, energy, and material use and how this impacts on the need for increasing working time. To turn it around, having sufficient disposable time for engaging in social and cultural activities is a measure of well-being.

Contrary to Boserup's claim of incremental agricultural development progressing from long fallow systems to multiple cropping, the sociometabolic theory has a different view of 'transitions' between regimes: it sees the shift between energy regimes rather associated with a major transformation of society (such as the Neolithic and Industrial Revolution in the past). Sociometabolic regimes are not seen as something static either. Rather, they are constituted by a set of opportunities and constraints within which certain dynamics occur. But if the dynamics transcend or are pushed out of the boundary conditions of the regime by exogenous forces, turbulence will ensue with an unpredictable outcome anywhere between collapse of the social system (Tainter 1988, Leemans and Costanza 2005) and a transition into another sociometabolic regime (Fischer-Kowalski and Haberl 2007).

### 2.2. Human time as a biophysical resource

Within our theoretical framework, we consider human time to have the following metabolic characteristics. First, and in analogy to the other biophysical resources we are dealing with (materials, energy and land), human time is a limited resource. Each individual has 24 hours at his/her disposal. All human time has to be used somehow and preference for one activity over another is contingent on culturally prescribed means of self-maintenance and reproduction. In addition, each human lifetime hour, whether 'productive' or not, can only be sustained through a certain metabolic input (i.e. matter and energy), or else social conflict arises, people starve and die. Disposal over the use of time, one's own time as well as time of other people, is one major marker of freedom and power. How human time is used, therefore, is a crucial variable that determines as well as is determined by the system's social metabolism and its regime transitions. In some instances, societies have resisted transitions from hunting and gathering to agriculture since they were not prepared to invest the

[4]Traditional subsistence systems such as hunters & gatherers and the agrarian depend (almost) completely on solar energy. The difference though is while hunters & gatherers are 'passive' users of solar energy (that is they live on the resource base they have available in their territory), agrarian regimes mainly rely on an 'active' and controlled utilization of solar energy through the use of biotechnologies and mechanical devices. In other words, peasants try to channel solar energy onto a few plant species they wish to produce by changing the land cover, albeit at the cost of more human labour that further increases with agricultural intensification. The industrial sociometabolic regime, on the other hand, transcends the limitations inherent in relying on the current solar energy sources by utilizing fossil fuels.

increasing labour time required, while in others their will to do so paved the way for an agricultural transition (Carlstein 1982, Ellen1982).

### 2.2.1. Labour time studies revisited

Research on the allocation of human labour time has a long tradition in the social sciences, especially in sociology, anthropology and economics. An underlying assumption of all these studies is that human time is a limited resource that needs to be budgeted.

Early sociological time studies dealt predominantly with exploring the social conditions of the rising working class. In the early 1930s, a whole new era of work/leisure studies was launched. Among the range of emerging time diary literature, *Time Budgets of Human Behaviour* (Sorokin and Berger 1939) probably provided the most intriguing insights into sociological and psychological stimuli for daily time use. Since the 1950s, the effects of longer working hours have become increasingly analysed through the lens of comparative time use data. Probably the most ambitious multi-country time use study was the Multinational Time Use Study directed by Szalai (1972) in the mid-1960s or more recently, Gershuny's (2000) Multinational Time Budget Data Archive.

In contrast to the sociological tradition of quantifying time use, earlier anthropological studies have commonly relied more on qualitatively describing the 'daily round' of the communities studied (Malinowski 1935, Evans-Pritchard 1940). Generally more theory-led, notable attempts have been made to test two general theories related to time use. One is the role of 'leisure time' in cultural evolution. It is argued that development in arts and science is only possible once communities can move away from the drudgery of subsistence (Steward 1955). In contrast to this, Sahlins (1972), Lee (1979), and several others tried to show that leisure time is not a sufficient condition for the development of civilization. They showed hunters & gatherers to meet their needs with only about 1-3 hours of work each day, leaving plenty of time for leisure and idleness. This argument, highly debated by his critics (seeJohnson 1975, Bird-David 1998, Kaplan and Lancaster 2000), is neatly captured in Sahlins' classic text *Stone Age Economics,* where he dedicates the first chapter to the 'original affluent society'.The second theory that received considerable attention in anthropology is Boserup's (1965) thesis of declining labour productivity with agricultural intensification as discussed earlier.[5] While a large number of empirical studies tended to support Boserup's argument (Sahlins 1972, Grigg 1974, Netting 1977, 1993, Ellen 1982), some have rejected the 'decline thesis' (Harris 1971, Padochet al. 1985, Conelly 1992, Hunt 2000).

More recent anthropological publications on working time among horticultural societies include Johnson's (1975, 2003) account on the Matsigenka of Peru and Descola's (1996) study of the Achuar ethnic group in the Ecuadorian Amazon, both of which have substantially contributed to establishing a standard approach to time allocation studies[6]. Some of the questions they pose relate to time spent on acquiring protein from hunting and fishing,

[5]A different approach to labour productivity comes from the field of ecological anthropology. Rappaport's (1968) detailed monograph *Pigs for the Ancestors,* whilst striving to document the interdependence of cultural phenomena and biophysical variables, provides interesting data on energy expenditure during labour processes through the application of time-and-motion studies.

[6] Especially Allen Johnson (1975) is considered a pioneer in terms of activity coding and classification among non-market societies. His activity coding (1975) was taken as a base and adapted to our needs, restructuring, adding or eliminating some activities not considered of too much relevance for our own purposes. He later provided an overview of systematic observation methods (Johnson and Sackett 1998). Gross (1984), one of Johnson's students, did some interesting research on behavioural approaches in time allocation research and Baksh (1989, 1990) further refined the methodological approaches to instantaneous spot check sampling.

efficiency of hunting using traditional and modern weapons, assessing benefits from development assistance in terms of labour-saving devices, the economic importance of child labour in agrarian societies (see also Cain 1980), and women's contribution to domestic reproduction (Gross 1984, Antonopoulos and Hirway 2010).

Within the field of economics, Becker (1965) emphasised the value of time at the household level, instigating the so-called 'New Household Economics'. His approach entails applying economic analysis to household behaviour and recognizes the importance of time in household production and consumption activities. In recent development literature, the concept of 'time poverty' or 'time stress' (see Hirway 2010: 26) refers to the burden of work on the poor, especially on women, that restricts the choice that is available to them in selecting activities[7]. In the wider context of sustainability, to look at human time as a key resource is still rather uncommon (among the few exceptions: Pastore et al. 1999, Giampietro 2003, Schandl and Grünbühel 2005, Ringhofer 2007, 2010, 2013).

In our theoretical approach, we consider human time as a *limited and fairly evenly distributed* resource, its availability depending on the number of people within a social system and their reproduction rates. In contrast to the previous time use traditions, we are mainly interested in human time as a resource on the social system level[8]. At the same time, we perceive the investment of human time as a means to reproduce certain sub-systems within a social system. These subsystems allow distinguishing between time invested for one's personal maintenance and development, from that of time invested for household or social reproduction. As such, to distinguish four time-relevant subsystems of the social system: the person system, the household system, the community system, and the economic system. We allocate the time spent on various activities to the respective functional subsystem that is being reproduced. Coding and classification does not differ much from what is commonly found in sociological and anthropological time use studies in order to increase comparability[9].

The *person system* functionally serves personal reproduction and includes all those activities that cannot be delegated or 'outsourced' to others. It holds all the physiologically necessary functions for a person's self-reproduction, such as sleeping and eating, and it encompasses functions for extended reproduction, such as studying, leisure activities or idling.

The *household system* serves as the organisational frame for biological reproduction and fulfils the function for basic day-to-day reproduction as a group (like child rearing and food preparation), and the functions that ensure the long-term maintenance of the household (like repair/maintenance work). The household system is typically organised as an exchange of unpaid labour according to the socio-cultural norms regulating age and gender roles in society.

The *community system* on the next higher functional level contributes to the reproduction of reciprocal relationships and shared beliefs, and political decision-making. In non-industrial societies, the community system may be regarded as a predecessor of several other more specialised systems, such as politics, religion or the judicial subsystem.

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[7] Within this concept, one important indicator of well-being is leisure, the time spent on rest and relaxation.

[8] Within ecological economics, Pastore et al. (1999) conducted a land-time budget (LTB) analysis for various villages in rural China, examining demographic variables, land availability and land use, time availability, and labour time use as well as cash flows. The LTB analysis is indeed one of the first approaches to treat land and time use as an opportunity or constraint at the social system level.

[9] The time use categories developed for statistical monitoring of the European Union (Eurostat 2001, 2007) have been largely followed in our five cases.

The *economic system* reaches beyond the household even if part of its function consists in supplying households and persons with life-sustaining commodities (with economic 'food provision' being sometimes hard to distinguish from the household's 'food preparation'); the economic system reproduces, in a division of labour and functional interdependence beyond the household, the society, and manages most of what we described as social metabolism above. Under modern conditions, it usually functions on the basis of paid labour. Under pre-modern conditions, economic activities may simply be an additional function of households or communities.

## 3. Description of the cases

### 3.1. Introducing Trinket, Campo Bello, Sabawas, and Nalang

In order to test Boserup's theory, we classify and position the four cases by – to use Boserup's term – their degree of 'agricultural intensification'. We do this by examining some basic demographic data and a few agro-ecological indicators on food production and consumption. If we consider population density as a certain indication of population pressure on land, Trinket stands out with by far the lowest density (0.11 cap/ha), along with the lowest rate of population growth. The other three communities, Campo Bello, Sabawas and Nalang, all have similar population densities (around 0.40 cap/ha) and fairly high population growth rates (2.5-4% annually). Information on the food system also allows an insight into the relative position of each of the cases. In terms of food production, we find a gradual increase from Campo Bello via Sabawas to Nalang, whereas Nalang also has the highest percentage of nutritional energy derived from agriculture. All communities gain a certain ratio of their food intakes from fishing and foraging; while these ranges between 7 and 16% in Campo Bello, Sabawas, and Nalang, Trinket derives almost 70% of its food energy from these activities. In terms of food production, therefore, Trinket stands out as a community predominantly based on a hunting and gathering mode of subsistence. From this analysis we have tentatively ranked the cases along a 'Boserupian axis' from Trinket to Nalang.

Trinket Island is located in the Nicobar archipelago (India) with 399 inhabitants in 2001. As it can only be accessed by canoe or diesel-engine boats during high tide, the island has remained quite isolated and people still live relatively traditional lifestyles.The local population mainly engages in fishing and gathering, the growing of coconuts and the bartering of *copra* (dehydrated coconuts) in exchange for market commodities. Some families also cultivate food gardens which they maintain with simple tools like sickles, axes, and spades. Despite low agricultural production – the area for staple food production accounts for only one third to one fifth of the area used in the other cases – fossil energy inputs are by far the highest in Trinket. This is a direct result of a state-induced subsidy programme for transport infrastructure which promotes the sale of cheap diesel and kerosene (Singh 2003, Singh et al. 2001,Singh and Grünbühel 2003, Singh and Schandl 2003).

| | *Trinket* | *Campo Bello* | *Sabawas* | *Nalang* |
|---|---|---|---|---|
| | Forager-Horticulturalist | Shifting Cultivation (Short Fallows) | Shifting Cultivation (Short Fallows) | Intensive Rice Cultivation & Shifting Cultivation |
| **Demographic Data** | | | | |
| Population (cap) | 399 | 231 | 290 | 702 |
| Community Area (ha) | 3,626 | 615 | 652 | 1,630 |
| Population Density (cap/ha) | 0.11 | 0.38 | 0.44 | 0.43 |
| Population Growth (%/a) | 1.5 | 3.8 | 2.5 | 3.0 |
| Share of Population below Age 15 (%) | 39 | 61 | 55 | 45 |
| **Food Production and Consumption** | | | | |
| Food Production (GJ/a) | 2,820 | 1,840 | 2,792 | 3,752 |
| Food Consumption (GJ/a) | 1,752 | 940 | 1,383 | 3,320 |
| Nutritional Energy from Agriculture (%) | 30.7 | 84 | 84.5 | 92.6 |
| Nutritional Energy from F/H/G (%) | 69.3 | 16 | 15.5 | 7.4 |
| **Staple Food Production (SFP)** | | | | |
| Area for SFP, incl. Fallow (ha) | 29 | 200 | 238 | 139 |
| Share of Area for SFP (%) | 1 | 33 | 37 | 9 |
| Labour Hours for SFP (1000h/a) | 25 | 114 | 153 | 213 |
| Fossil Energy Input per Area (GJ/ha) | 0 | 0 | 0 | 1.2 |

*Table 1: Some basic demographic and food production data*

Note: Staple food is rice, cereals and tubers; in the case of Trinket it is copra. F/H/G stands for fishing, hunting and gathering.

The indigenous community of Campo Bello (Bolivia) is situated in the Bolivian Amazon plains and had 231 inhabitants in 2004. About one-third of the community's total area comprises the agricultural area for staple food production. People mainly grow rice, maize, and manioc with simple technology, using only machetes, sickles, hoes, and rice seeders for sowing rice. Much of the rice is sold on the market for cash immediately after the rice harvest, while plantains are generally marketed throughout the year. The local diet is complemented by protein sources from fishing and foraging that account for about one-fifth of total nutritional energy inputs into the system. Still largely secluded and self-contained, the village has witnessed a number of development projects introduced by the local administration and non-governmental agencies (Ringhofer 2007, 2010, 2013).

The remote indigenous community of Sabawas (Nicaragua) with a population of 290 people in 2008 is located in the officially titled Mayangna Sauni As territory. In the early1980s during the Contra War, the whole territory had to be abandoned and Sabawas remained uninhabited for almost 10 years until repatriation began in 1994. Almost 40% of the community's total area comprises the agricultural area for staple food production. This includes the farming of upland rice, plantains, banana, maize, and velvet beans with simple machetes, spades, hoes, and axes. Since the marketing of these crops is rather erratic due to the limited transport opportunities available, crop cultivation is largely for subsistence. The importance of farming is also reflected in the nutritional intake from agriculture indicator at almost 85%. The local diet is complemented by proteins from fishing and foraging that

account for the remainder of total nutritional energy inputs into the system (Ringhofer et al. 2010).

The multi-ethnic community of Nalang (Laos) with a population of 702 people in 2001 combines swidden agriculture with permanent paddy rice production. Despite a similar area size for staple food production, energetic returns in Nalang are twice as high as in Sabawas and almost three times higher than in Campo Bello. Part of the answer lies in the use of fossil fuel inputs in agriculture in the form of motor-ploughs, accounting for 1.2 GJ/ha. Greater ease of transport following the construction of a road in the 1980s has triggered increased market integration: First, the production of cucumber was introduced as an important cash crop during the dry season. Second, traditional buffalo rearing is gradually losing importance. While they are still reared, the arrival of the motor-plough in the mid-1990s has diminished the agricultural need for them. For meat production, buffaloes are gradually replaced by cattle, largely because their maturing times are shorter (Mayerhofer-Grünbühel 2004).

### 3.2. Methods of data collection on time use

Data collection methods vary between the case studies. Meanwhile, a more systematic methodology has been developed containing comparable time use indicators (Ringhofer 2010, Singh et al. 2010) and considerable efforts have been made to transform the time use data from earlier studies into the new scheme.

In the case of Trinket, we used 'time-frame' analysis focussing only on certain activities observed repeatedly (sample size 3-5 observations for each activity). Records were made how long they lasted and who (in terms of gender and age) participated in them. These activities were then weighted according to their annual frequency and thus the average daily hours could be calculated. For the household activities interviews were conducted. Time use for the person system was calculated as a residual. In the communities of Campo Bello and Sabawas, being the most recent empirical studies, the time use analysis was done most systematically, on the basis of observing people for days during their waking hours. In Campo Bello, the sample consisted of 12 male and 13 female days (containing 4 children between the ages of 6-15 each). Adding to these samples, a total of 112 spot checks were carried out, thereby obtaining two more person days. In Sabawas, the sample consisted of 13 male and 11 female days (including 3 children between 6 and 15 years and 2 adults above the age of 60) who were 'shadowed' at different times of the year, thus covering seasonal differences. Household interviews and direct observation were used for cross-checking. Average time use and standard deviations were done for all four sub-systems mentioned above. In the case of Nalang, a combination of both the above-mentioned methods was used. In this case, the sample size was 23 females and 23 males (among them 10 girls and 11 boys). In addition to observation, the context and meaning of activities performed was validated by interviews in all cases. In order to arrive at system level data, the frequency of these processes across the members of the community and the year was estimated and used for weighing.

## 4. Findings

How far does Boserup's (1965, 1981) claim still hold and aid our understanding of today's agricultural transitions? And what can we learn about the overall burden and stress in terms of working time across gender and age? Using the ranking of our cases along the'Boserupian axis' discussed in the previous sections, we organize the findings as follows: first, we examine land and labour productivity and seek to test Boserup's claim of the dynamics of agricultural intensification. Second, we present the labour investments in the economic and household system and the social distribution of the labour burden in the different communities as a consequence.

### 4.1. Land and labour productivity

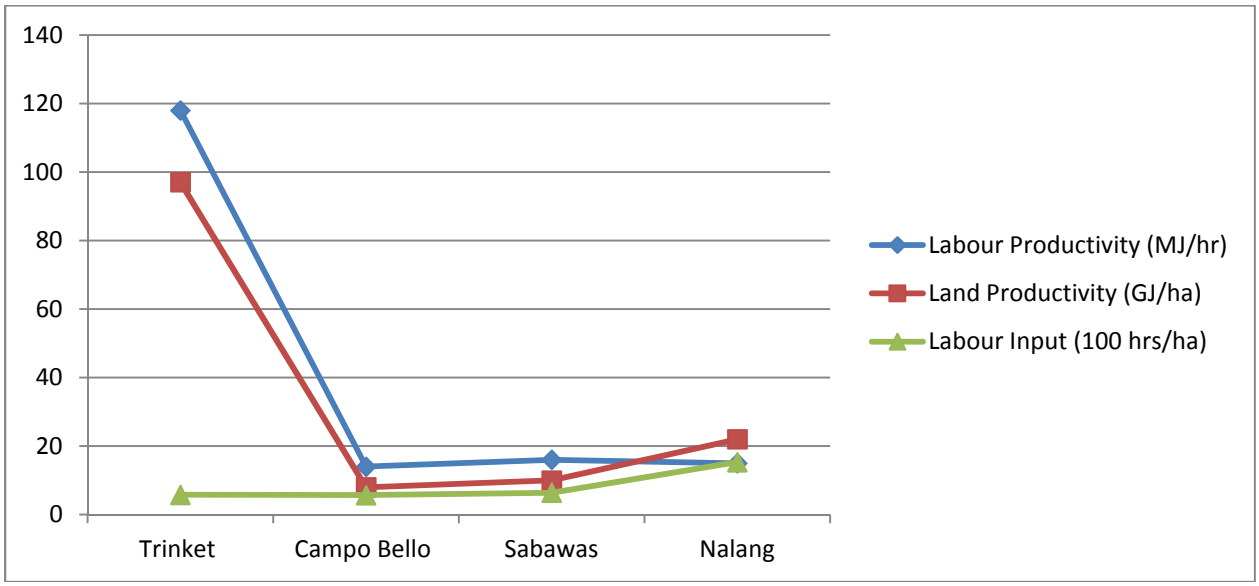


*Figure 1: Labour and land productivity in staple food production*

Judging from the results in *Figure 1*, our cases do not seem to comply with Boserup's claims of agricultural intensification. If we look at Trinket, it presents substantially more favourable conditions in terms of land and labour productivity. Both land productivity (in the sense of how much land is required to produce a certain amount of nutritional energy) and labour productivity (signifying how much work is required to realize this energy harvest) are far higher than in any of the other communities[10]. Looking at this from another perspective, it appears that no incremental evolutionary pathway of agricultural intensification would lead from a — however untypical — sociometabolic system of hunting and gathering like Trinket to anything like the other communities. With such high productivity levels it would seem totally irrational to change into a more intensive production mode in light of declining returns upon land and labour. Thus, a sociometabolic system like in Trinket will keep on or else collapse – but cannot gradually be transformed into an agrarian system like we see in the other cases. In effect, rather the hypothesis of distinct sociometabolic regimes is confirmed: communities like Trinket adhere to a sociometabolic regime of hunter & gatherers, however untypical, and there is no continuous, non-disruptive pathway leading from this regime to an

[10] The inhabitants of Trinket do not engage in agricultural tasks (except for some pig rearing) but rather grow coconut palms and exchange dried coconut flesh (copra) for rice on the market. This high land and labour productivity, therefore, is a result of the good exchange conditions from copra to rice.

agrarian regime. It takes a major transformation, a ‚transition'for a community to transcend this mode of subsistence (Fischer-Kowalski et al. 2011: 153-154).

We can see that Campo Bello and Sabawas are both ‚traditional' (Boserup 1981) production system in the sense of not using fossil fuel based inputs or even animal traction for any of their agricultural activities. Nalang, on the other hand, uses some fossil fuel input (1.2 GJ/ha), as motor-ploughs are applied for rice production. Taking into account fossil fuel use, the relation between the three communities would probably comply to the Boserupian hypothesis: with intensifying food production we indeed find increased yields per unit area, however, at the expense of increased labour input and declining labour productivity. Without fossil fuels, therefore, Nalang would probably have a much lower labour productivity than apparent in *Figure 1*. The use of fossil-fuelled and labour-saving technologies in agriculture, a fact that does not find consideration in Boserup's theory, reduces the need for human labour and makes human labour hours appear more productive.

### 4.2. Overall labour time investment in the different communities

How do these intensification dynamics relate to the overall distribution of working time in our communities? Or in other words, what can be said about the sharing of the labour burden across gender and age? To answer this, *Table 2* gives an overview of the daily hours invested in the individual subsystems, i.e. the person system, the household system, the economic system, and the community system.

While the person system draws by far the most time resources, with sleep taking the lion's share, overall time investments in the community system are rather low in all the four communities[11]. The time resources drawn by the economic system see a steady increase from the agrarian community of Campo Bello via Sabawas to Nalang. Trinket's labour requirements for the upkeep of the economic system, however, are much lower: they account for only a quarter as compared to Campo Bello and Sabawas and for about 1/5 of the time investments in Nalang. Trinket's daily working time of an average adult (16-60 years) thus amounts to little more than an hour, accounting for 434 hours annually. This is barely more than a quarter of the workload common in OECD countries. As for the 'traditional' agrarian cases, 4 to 6 hours are required daily by every adult for the upkeep of the economic system, which accounts for an annual (economic) working time ranging from 1,711 hours (Campo Bello), 1,733 hours (Sabawas) and 2,135 hours (Nalang) per adult. This compares to about 1,800 hours annually per economically active in the US and Japan and is above the averages for the European Union (Groningen database 2005)[12].

[11] What influences the time investment into the community system, and what differences (in terms of social integration and cohesion, for example) does the amount of time spent make? Unfortunately, our data on community time investment methodologically do not warrant such an analysis because of uncertainties in measurement and classification.

[12] One should be aware of the difference between 'average per adult' (which is everybody above the age of 14), and an 'average per economically active', which in OECD countries is about half the adult population above 14 years. So these working hours in subsistence agriculture communities are really very high!

| | Average adult 16-60 (h/d) | | | |
|---|---|---|---|---|
| | *Trinket* | *Campo Bello* | *Sabawas* | *Nalang* |
| Total Population Size | 399 | 231 | 290 | 702 |
| Population Size 16-60 | 244 | 91 | 121 | 356 |
| **Person System (PS)** | **18.45** | **13.21** | **13.00** | **14.34** |
| **Household System (HS)** | **3.23** | **3.79** | **3.70** | **3.68** |
| Care forDependents | 0.00 | 1.59 | 1.50 | 0.46 |
| Food Preparation | 1.09 | 1.07 | 1.00 | 0.69 |
| House Building | 0.00 | 0.26 | 0.25 | 1.43 |
| Repair/Maintainance Work | 0.16 | 0.34 | 0.35 | 0.00 |
| Domestic Chores | 1.98 | 0.64 | 0.60 | 1.10 |
| **Economic System (ES)** | **1.19** | **4.69** | **4.75** | **5.85** |
| Agriculture/ Horticulture | 0.07 | 2.32 | 2.25 | 3.06 |
| Hunting | 0.00 | 0.46 | 0.45 | 0.00 |
| Fishing | 0.58 | 0.35 | 0.30 | 0.44 |
| Gathering | 0.00 | 0.17 | 0.20 | 0.15 |
| Trading | 0.39 | 0.43 | 0.45 | 0.00 |
| Wage Work | 0.00 | 0.27 | 0.25 | 1.46 |
| Housegarden | 0.02 | 0.21 | 0.25 | 0.00 |
| Handicraft | 0.00 | 0.41 | 0.40 | 0.13 |
| AnimalHusbandry | 0.14 | 0.02 | 0.20 | 0.61 |
| **Community System (CS)** | **1.13** | **2.32** | **2.55** | **0.12** |
| Annual Labour Time ES (h/a) | **434** | **1,711** | **1,733** | **2,135** |
| Daily Labour Time HS+ES (h/d) | **4.42** | **8.48** | **8.45** | **9.54** |

*Table 2: Daily time investment per adult in all four subsystems*

Hardly surprising, we find agro-horticultural activities taking the lion's share in the fairly similar agrarian communities Campo Bello, Sabawas and Nalang, accounting for about half of all the time resources invested in the economic system. Trinket's agricultural labour time, on the other hand, constitutes a mere 6% of total labour time inputs. Interestingly, despite Trinket's extremely low time investment in agriculture (agricultural labour requirements in Campo Bello and Sabawas show an approximate 30-fold increase as compared to Trinket, whereas Nalang's labour requirements show an even 40-fold increase), local nutritional energy returns from agriculture (see *Table 1*) account for a quite substantial 30%, which is roughly 1/3 of the agricultural energy harvests in the agrarian communities. Although Trinket and Nalang invest about the same daily time resources in fishing and gathering, Nalang receives less than one tenth of its nutritional energy from these sources, while Trinket's returns from these activities cover for almost 70% of their total nutritional requirements. Cash producing activities, i.e. wage work, trading and the production of saleable handicraft, require only about half as much time than agricultural activities in the agrarian cases, while Trinket's investment in trading is about four times higher than in agriculture. Wage work draws more than two hours of an adult's day in Nalang, while in the other agrarian communities it is far less significant than, for example, the production and sale of handicrafts as an additional source of income.

In terms of household labour, an interesting finding is that it remains at a similar level in all the cases, accounting for 3.2 to 3.7 hours per average adult[13]. Most time resources are invested in the day-to-day reproduction of the household, including child care, food preparation and all kinds of domestic chores. As we will find in the section below, this indicates a constantly higher labour burden for women throughout the development trajectory.

### 4.2.1. Gender differences in labour time

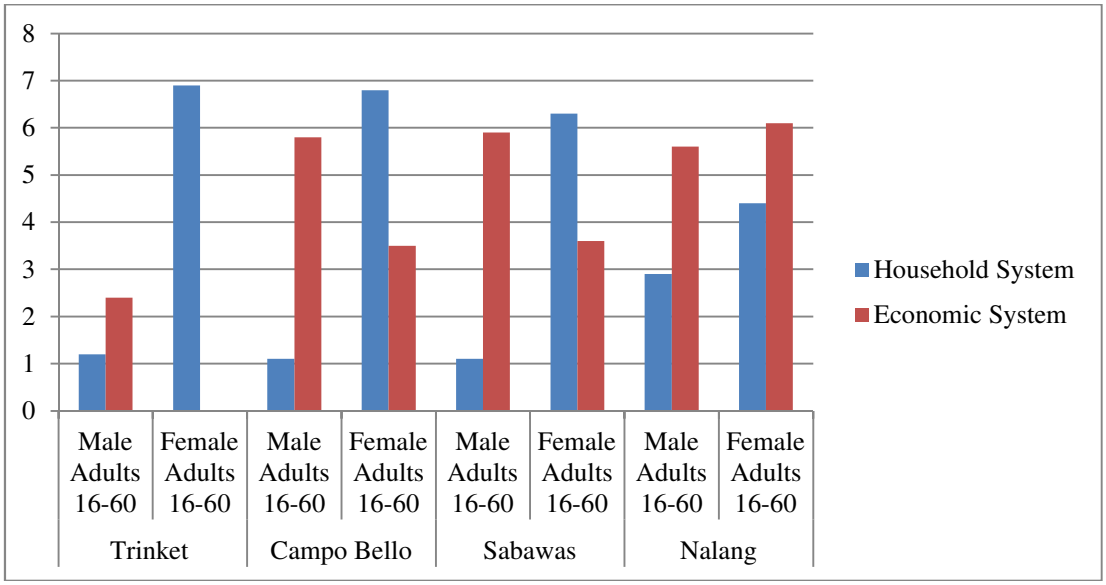


*Figure 2: Gender differences in labour time*

Through a gender lens, a tentative interpretation of our data shows that the upkeep of the household system predominantly remains in the hands of women throughout 'agrarian development'. In Trinket, Campo Bello, and Sabawas, household labour draws 6 to 7 hours from an adult woman's daily time resources, while male labour contribution to the household system accounts for only little more than an hour a day. Nalang's household labour, on the other hand, seems to be more evenly distributed among both sexes (*Figure 2*). In terms of the nature of tasks, we find a fairly similar division of labour chores between men and women. While female labour largely entails activities for the system's day-to-day reproduction, male labour tends to contribute to the long-term maintenance of the household (i.e. house-building, repair, maintenance work).

| | *Trinket* | | *Campo Bello* | | | | *Sabawas* | | | | *Nalang* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male Adults 16-60 | Female Adults 16-60 | Boys 6-15 | Girls 6-15 | Male Adults 16-60 | Female Adults 16-60 | Boys 6-15 | Girls 6-15 | Male Adults 16-60 | Female Adults 16-60 | Male Adults 16-60 | Female Adults 16-60 |
| Household System (HS) | 1.2 | 6.9 | 1.8 | 2.9 | 1.1 | 6.8 | 0.8 | 1.5 | 1.1 | 6.3 | 2.9 | 4.4 |
| Economic System (ES) | 2.4 | 0.0 | 2.6 | 2.6 | 5.8 | 3.5 | 2.7 | 2.4 | 5.9 | 3.6 | 5.6 | 6.1 |
| **Daily Labour Time HS+ES** | **3.6** | **6.9** | **4.4** | **5.5** | **6.9** | **10.3** | **3.5** | **3.9** | **7.0** | **9.9** | **8.5** | **10.5** |

*Table 3: Male and female daily labour time (h/d) in all four communities, incl. contribution of children in Campo Bello and Sabawas*

[13] More detailed data reveals a stagnant 2.1 daily hours per inhabitant.

As *Table 3* shows, overall labour in the economic system increases with 'agrarian development', and judging from our data, so does a woman's labour contribution. Except for Trinket, where women do not invest any labour in economic activities (and men's work is limited to little more 2 hours a day), we find a substantial almost 3-hour increase in a woman's workload from the fairly similar agrarian communities of Campo Bello and Sabawas to the more 'agriculturally intense' community of Nalang. Though male labour takes the lion share in agriculture in Campo Bello and Sabawas, a woman's role in agriculture is highly important and valued. For agro-horticultural tasks, women contribute about two thirds of their overall economic labour time. The small remainder is invested in subsistence fishing and gathering (hunting is solely ascribed to men in all the communities) and market involvement (through producing saleable handicraft, trading and wage work). As for Nalang, the only community that uses fossil fuel driven technology for agricultural production (i.e. motor-plough), a woman's share in daily economic labour time is slightly higher than that of her male counterparts. This finding illustrates that the labour-saving motor-plough may have alleviated a man's workload in rice production, while many other labour-intensive agricultural tasks still remain in the hands of women[14].

If we define the daily working time as the sum total of the time invested in the household and economic system, with 'agricultural intensification' we see a steady increase of working time for both sexes. In all these stages though, we find women to work longer hours than men. For men, the low daily work burden of 3.6 hours in Trinket cannot be sustained with agrarian production systems. In the more 'traditional' (Boserup 1981) production systems embodied by Campo Bello and Sabawas (in the sense of not using fossil fuel based inputs or animal traction), daily male labour requirements almost double. The use of agricultural technologies may relieve a man's economic work burden in Nalang; his contribution to the long-term maintenance of the household, however, increases. Similarly for women, a 7-hour workday (Trinket) cannot be sustained with increased agricultural production, when her contribution levels off at around ten hours a day. With women continuously working longer hours, they have less time available to spend for personal reproduction such as studying, leisure, or simply idling. Detailed data from Campo Bello shows that adult women even get less sleep than men. This, in the long, run may lead to illness and eventually premature death.

An interesting, however tentative, finding, is that even communities with a rather low labour burden per person (Trinket in our case) tend to display the same pattern of labour allocation by gender as more labour-intensive agrarian communities; however low the (economic) labour burden may be for men, a woman's share in (household) labour remains at a fairly similar level throughout 'agricultural development'.

[14] A similar situation was observed in Campo Bello, where the application of rice seeders as opposed to traditional rice planting saves up to 12 labour days in annual rice production. These technologies, however, are solely handled by men, while women still engage in laborious traditional planting, weeding and harvesting (Ringhofer 2010).

### 4.2.2. The contribution of children to labour time

| | *Trinket* | *Campo Bello* | *Sabawas* | *Nalang* |
|---|---|---|---|---|
| Population Size | 399 | 231 | 290 | 702 |
| Population Growth (cap/a) | 1,5 | 3,8 | 2,5 | 3 |
| Number of Children below 15 | 155 | 137 | 159 | 318 |
| Share of Population below 15 (%) | 39 | 59 | 55 | 45 |
| Children's Share in Communities total Labour Time Investment (%) | **39** | **61** | **51** | **45** |

*Table 4: Children's share in communities working time*

We finally examine the contribution of child labour in the different communities[15]. *Table 4* shows that the share of children in the communities' overall time budget varies between 61% in Campo Bello, 51% in Sabawas, 45% in Nalang to 39% in Trinket. Thus in terms of available 'live' hours, children below the age of 15 play a major role in all four communities.

We find the highest child labour ratio in Campo Bello (at 61%), which also has the highest population share of children below 15. More detailed data reveals that about one third of the community's total labour invested in the household system is contributed by children aged 6-15 years. This is in fact more than twice as much as compared to the children's contribution to household labour in Sabawas, where the share of population below 15 years is almost as high as in Campo Bello. It should be noted that in Campo Bello children of both sexes engage in reproductive household labour like child care and food preparation until about the age of around ten when they gradually become socialized into their gender-assigned roles. This pattern is less prevalent in Sabawas, where reproductive household tasks are mostly carried out by girls and female adults. Girls in Sabawas invest in fact twice as much time in the daily reproduction of the household system than boys (see *Table 5*).

The economic system draws similar time resources from boys and girls in both communities. Agricultural activities seem predominantly a male domain in both villages. In Campo Bello, a boy starts to cultivate his own fields round the age of 12, even if it seems more of an educational activity. In Sabawas, a boy's contribution to agriculture rather centres on assistant tasks such as the transport of plantains or the fetching of seeds (see Ringhofer 2010). Hunting and fishing is done in a more playful manner[16]. As for girls, fishing and gathering take the lion's share of their time investment in the economic system.

Clearly, children do lighter work, and they may do it less efficiently than adults. Still though, around one third of the total labour hours in both communities are contributed by children. Likewise in Campo Bello, as documented in Fischer-Kowalski et al. (2010), they invest about the same share of their day into working like an average inhabitant.

[15] Child labour in Trinket was observed, but not systematically registered. Therefore, the contribution from children in the labour processes is based on estimations. In light of this, the focus of this section lies on the cases of Campo Bello and Sabawas, where child labour contribution was most systematically observed.

[16] Play of children (e.g. play hunting or play food processing) in traditional subsistence societies has been documented widely (Bock 2002, Caro 1988, Fagen 1981) as a safe strategy that imparts more skills that will increase productivity in the future than would time spent in directly productive tasks.

| | *Campo Bello* | | *Sabawas* | |
|---|---|---|---|---|
| | Boys 6-15 | Girls 6-15 | Boys 6-15 | Girls 6-15 |
| **Household System (HS)** | **1.8** | **2.9** | **0.8** | **1.5** |
| Care for Dependents | 0.5 | 1.5 | 0.2 | 0.6 |
| Food Preparation | 0.2 | 0.5 | 0.0 | 0.3 |
| House Building | 0.0 | 0.0 | 0.1 | 0.0 |
| Repair/Maintainance Work | 0.2 | 0.2 | 0.2 | 0.2 |
| Domestic Chores | 0.9 | 0.7 | 0.3 | 0.4 |
| **Economic System (ES)** | **2.6** | **2.6** | **2.7** | **2.4** |
| Agriculture/ Horticulture | 0.8 | 0.2 | 0.8 | 0.3 |
| Hunting, Fishing and Gathering | 1.1 | 1.5 | 1.2 | 1.6 |
| Trading | 0.0 | 0.3 | 0.0 | 0.0 |
| Handicraft | 0.6 | 0.4 | 0.5 | 0.3 |
| Animal Husbandry | 0.1 | 0.2 | 0.2 | 0.2 |
| **Daily Labour Time HS+ES** | **4.4** | **5.5** | **3.5** | **3.9** |

*Table 5: Children's daily investment of household and economic labour in Campo Bello and Sabawas (h/d)*

Nalang and Trinket not only have a lower demographic share of children, they also seem to put less of a labour burden upon their shoulders. Due to their substantially lower share in household and economic work, they have the opportunity to spend the remainder of their day on their own person system – for studying and personal recreation.

These results, however selective, tend to support Cain's (1981) argument that agricultural communities with a high share of children also place a high labour burden on them. Or, to turn it around, communities where children are considered of high use value in terms of labour contribution (either for technological or cultural reasons) tend to have more children. We find that the community with the highest share of population below 15 (61%) also has the highest share in child labour (Campo Bello). Sabawas, the community with the second highest share in child population (55%), also puts a relatively high labour burden on their children. Nalang's children, on the other hand, are less burdened with labour, especially with household labour. Trinket finally displays the lowest demographic reproduction rate and the lowest share in child labour.

## 5. Conclusions

Rural development and poverty alleviation programmes world-wide have succumbed to the ideology of agricultural change through the deliverance of technology. While this has indeed served to maintain larger populations by boosting food production per area, this has not come without ecological and social costs. Boserup's claim of declining labour productivity does indeed hold true up to a certain point in agricultural development. As such, increasing workloads on rural communities in which women and children are subject to ever higher exploitation is evident. However, the dynamics change with the introduction of fossil-based technology, thereby setting limits to Boserup's linear claim. With the introduction of fossil technology a reverse trend of increasing labour productivity can be observed. This does not mean that the overall burden of work for the community is reduced or more evenly distributed across gender and age. Fossil fuel driven agricultural technology (such as tractors, tillers,

threshers etc.) remain in the hands of men and lessen their workload while several other labour intensive tasks (sowing, weeding, spreading manure, etc.) are still handled by women and children (see also Gooch, this volume).

We have seen that the change in the energy system causes a transition from one sociometabolic regime to another. This is evident not only in energy use per capita but also in overall working time of a community. Trinket's time investment in the economic system is only a quarter of the others. The leisure experienced by hunting & gathering modes of production is hardly comparable to the toil of the agrarian system with its severe consequences on the female and children populations. The difference in time use across our four cases indeed arises from the changing workload in the economic/subsistence sector, and this workload, like Boserup says, rises with agricultural intensification – up to the point where fossil fuels come into play. But the labour invested in household chores remains more or less constant across agricultural intensification and across sociometabolic regimes. Thus the cost of the additional burden is actually a trade-off on personal reproduction and care primarily borne by women (and to some extent also by children).

Development trajectories are not simply a matter of economic well-being. Ecological and social sustainability for present and future generations ought to include a broader view on the quality of life. To this end, we need to better understand the dynamic and systemic relationship between key biophysical resources of which time is indeed a crucial variable as is its equitable distribution across gender and age.

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