Towards Agricultural Change?

A Planet for Life 2012 focuses on agriculture and its relation to development, food and the environment. At the end of the 2000s, a consensus has emerged and points to the urgent need for massive investment in the agricultural sector, which is (once again) viewed as one of the prime engines for development and food security, as well as for poverty reduction. But what exactly does this consensus cover? While the idea of investing in agriculture is gaining ground and although several countries or regions appear to be offering opportunities for investment in agricultural land, debates are going on as to which agricultural models to choose and how agricultural policies should be implemented.

A Planet for Life called on many highly specialized authors from different countries and perspectives, and invites the reader to discover the sector in all its complexity, upstream and downstream of agricultural production.

At the crossroads of the challenges posed by development, food security and the environment, the transformation of the agricultural sector is at the heart of the global stakes of sustainable development. To help steer these changes towards greater sustainability, this book makes us aware of how crucial it is to also change our representations of agriculture, change the visions that guide projects for change and the policies regulating this sector.

- Papers by leading international experts and scholars
- New perspectives from across the planet
- Multiple maps, charts, timelines and thematic focus essays
- A wealth of ideas for specialists and non-specialists alike (policy makers, administrators, concerned citizens, development professionals, entrepreneurs, journalists, students and others)
Traditionally, agriculture and forests represent competing land uses, with land as a fundamental and scarce production factor that can be utilized in several ways, including the preservation of forest ecosystems, the establishment of agricultural fields and urban expansion. In the tropics this competition is fiercer than ever as, while tropical deforestation is topping the international agenda, between 1980 and 2000, 83% of new cropland in the tropical zone came at the expense of forests (Gibbs et al., 2010).

The rapid disappearance of tropical forests has attracted a great deal of attention in the context of the negotiations under the Convention on Climate Change (UNFCCC), leading to an agreement in Cancun in 2010 to establish a funding mechanism to fight deforestation and degradation in developing countries (REDD+1).

Stakeholders have become progressively aware that the fate of tropical forests depends significantly on agricultural policies. Therefore agricultural development is analysed not only for its positive contribution to food security, but also for its negative impacts on forest ecosystems, particularly in developing countries. The compatibility between both objectives depends considerably on the strategies to be prioritised for the future of agriculture worldwide.

1. REDD+ stands for Reducing Emissions from Deforestation and Forest Degradation. The “+” refers to the inclusion of the increase in carbon stocks, for example through appropriate forestry practices or plantations. The principle is to pay developing and emerging countries by means of contributions from industrialised countries, either through a market or a fund.
Agricultural intensification is the most commonly proposed solution to combine both objectives, and is usually understood as a green revolution based on new crop varieties, more capital-intensive technologies and the use of chemical inputs. The Borlaug hypothesis (*land sparing*) provides the underlying theoretical framework for this solution, according to which increased productivity per hectare leads to smaller areas under cultivation as less land is required to produce the same amount of agricultural commodities. Yet other development pathways exist for agriculture, notably organic agriculture for the supply of local markets, or the support of agroforestry to provide ecosystem services.

In this chapter, we examine the theory of land sparing in light of results from its actual application (section 1). We present an Indonesian case study and analyse the green revolution that took place here to determine the nature of the agricultural strategy, the types of agricultural technologies promoted and whether there has been any evidence of land sparing (section 2). Indonesia provides a relevant example as it faces extremely rapid deforestation, is highly populated and largely dependent on agriculture for its development and poverty alleviation. There also exists, both presently and historically, a clear competition between standing forests and agriculture. Finally, the Indonesian REDD+ oil palm strategy is addressed to assess the expected contribution of agricultural intensification in policies and measures to ease the pressure on remaining forests (section 3).

**AMBIVALENT LINKS BETWEEN AGRICULTURAL TECHNOLOGIES AND DEFORESTATION**

The outlook for tropical forests depends on public policies that are directed towards sectors of the economy indirectly linked to forestry (e.g. taxation that encourages extensive land use such as cattle ranching in Brazil). Agricultural land policies are one such example: they aim to modify agricultural practices, ownership and usage regimes. They entail changes to agricultural technologies; and agricultural intensification, typically implying green revolution, represents just one, rather restricted, interpretation of the range of possible technological changes.

**THEORETICAL FOUNDATIONS: THE BORLAUG HYPOTHESIS**

The principle of minimising the extension of land area under cultivation by increasing yields from existing cropland is known as the Borlaug hypothesis, taking its name from one of the fathers of the green revolution that took place in Mexico from the late 1960s and then later in Asia.

Although the hypothesis seems initially rather evident, it is actually based on the simplistic idea that food production will increase until the initial demand is met. This is not the case, however, as economic forces are in fact the key determinant: investment decisions are made by farmers – both small farmers typically working less than one hectare per household as well as entrepreneurs that provide capital and modern production techniques to cultivate large areas – in reaction to price signals, while taking into account their own needs, outlets and property rights.
From an economic perspective, the Borlaug hypothesis is thus reformulated as follows: an increase in yield leads to a fall in agricultural commodity prices due to excess supply over demand, and therefore a decrease in profit per hectare, ultimately generating a supply adjustment through smaller growth in cultivated areas.

There is an inherent complexity in the analysis of the decision-making process of farmers since numerous variables are involved (including food prices that depend on public intervention). This problem is best addressed by taking a simplified look at the two analysis levels for agricultural expansion according to yields: the micro- and the macroeconomic levels.

The microeconomic level refers to decisions on new agricultural land, which are made by agents who are supposedly rational and well-informed. When farmers have the possibility of selling surplus production, technological progress generally leads to more land being converted to cropland. This has always been the case during “commodity booms” for export markets, such as bananas in Ecuador (Wunder, 2001). Such a trend apparently runs counter to the Borlaug hypothesis. Arguably, however, this tendency towards expansion may be moderated by the imperfect nature of markets: shortage of production factors locally (labour or capital available), high transaction costs to adopt new technologies or the presence of risks that influence investment decisions.

The macroeconomic level involves the functioning of the overall system, which can be visualised at the country level and beyond. The significance here relates to the repercussions of the adoption of new agricultural technologies at the macro level, and not in the policies and measures that could either facilitate their adoption or influence their impacts (e.g. a specific fiscal regime, human migrations, land tenure changes, etc). These economic repercussions occur when new technologies and associated higher yields spread to the extent that greater supplies lead to lower prices and reduced profitability. Human migrations are also a key feature, as the Indonesian case study suggests.

At the macroeconomic level, the elasticity of demand can be critical. Indeed, the simple interpretation of the Borlaug hypothesis is based on a demand that is fixed at the outset. Accordingly, meeting this demand should in theory prevent new conversions to cropland, since surplus production has no outlets. In reality, the way in which this demand is met will determine its evolution. But other factors will also influence this evolution, such as the existence of a food deficit and the elasticity of demand (see figure 1). For example, if the initial level is reached through productivity gains and lower production costs per unit, the expected drop in prices may generate an automatic increase in demand. This is known as the “rebound effect” and it occurs...
when demand is elastic (e.g. fluctuates in response to prices), which is likely to be the case for non basic needs.

Another important factor is the diversification of production. Aside from the fact that agriculture also produces non-food goods (oil for cosmetics, cotton for textiles, etc.), food production may diversify considerably to the point of creating new demand. Not everything boils down to a question of protein or staple goods: “luxuries” – i.e. non-essential foods that are consumed in addition to daily requirements – may also significantly influence production. Figure 1 provides a schematic summary of the interactions between levels and factors.

**EMPIRICAL CONFIRMATION OF THEORETICAL HYPOTHESES UNDER VERY SPECIFIC CIRCUMSTANCES** Two papers on land sparing were published recently that the authors believe to be the most comprehensive to date. Of these, one is presented below in detail, while reference is made to the conclusions of the other.

Rudel et al. (2009) analysed the Borlaug hypothesis using historical data from 161 countries and 10 crops for the period between 1970 and 2005. They cite the existence of two contradictory forces resulting from intensification – higher profits per hectare and a fall in the sales price due to excess supply – and the need to test which was stronger historically. They remind us that “analysts working at the global scale have modeled the land-sparing effect rather than examining historical instances”.

Their econometric study initially focused on the global situation. The trends for the 1970-2005 period indicate that cultivated areas grow less rapidly than the population and the per capita income. An absolute reduction is also noted from 1980-85. However, the study does not reveal a significant correlation between crop productivity and the global evolution of cultivated areas. Nevertheless, a negative correlation (which therefore agrees with the Borlaug hypothesis) exists in 34 countries considered individually from 1900-2005. It is interesting to note that correlations do emerge when crops are analysed separately, rather than by country or groups of countries. For example, the increase in yields for wheat and coffee seem to have resulted in a reduction in the area allocated to these crops.

The value of this study is that tests were conducted at different levels to enable the authors to identify areas that potentially confirm the Borlaug hypothesis, so that these areas could then be studied in detail to include factors not present at the econometric stage. It shows that substitute imports and national land conservation programmes have an important role. For example, conservation has taken root in China (the Grain for Green programme) and in the United States (the Conservation Reserve Program) since the 1990s, with strengthened impacts for wheat due to the possibility of imports. For other crops, aspects of international economics are
critical, for example when Cuba lost its Soviet sugar market there was a consequent reduction in the area dedicated to this crop; or the implementation of the North American Free Trade Agreement, which affected Mexican soybean, maize and wheat crops. All cases illustrate the crucial role of public policies, whether for the environment or trade, to limit agricultural expansion and hence conform with the Borlaug hypothesis. The Indonesian case is interesting in this respect as the authorities did not seriously consider such interventions and forest cover has declined despite a successful green revolution.

In the second of these major studies, Ewers et al. (2009) also conducted econometric studies for many countries and crops, concluding that the Borlaug hypothesis is confirmed to a certain extent. This study took agricultural diversification into account, with regards to the development of non-staple crops and biofuels, and also considered dietary changes, such as an increase in meat consumption, which threaten the positive effects of agricultural intensification.

The next section presents an Indonesian case study. This country provides a valuable example because it faces fierce deforestation pressures and, despite a green revolution several decades ago, food production remains a great challenge. It thus provides important insights into the land sparing debate.

GREEN REVOLUTION IN INDONESIA

POLICY DEBATES 1960 TO 2000: LIMITS OF INTENSIFICATION AND THE NEED FOR LAND OUTSIDE JAVA

Since the 1950s, policy debates in Indonesia have revolved around

BOX 1  **INDONESIAN AGRICULTURAL DEVELOPMENT**

During the first two decades of Indonesian independence (1949 onwards), agriculture dominated the economy (half of GDP, two-thirds of the labour force). In spite of a growth in mineral exports, including petroleum products, agricultural exports still accounted for around two-thirds of total export revenues, with rubber being the most important export crop. While some exports were grown on large estates, by the early 1960s smallholders were also producing large quantities of rubber and dominated the production of secondary export crops such as coffee, copra and pepper. The most important food crop was rice, but maize and cassava were widely consumed, especially in poor rural areas. The most densely settled island was Java which accounted for only 7% of the land area but 56% of the land under rice cultivation, and around three quarters of the land under maize and cassava cultivation. By 2008, agriculture only accounted for around 14% of GDP, and employed 40% of the labour force, although many of these workers were also engaged in other activities, including agricultural processing and trade. Exports of agricultural products, including processed rubber and palm oil, had fallen to less than 20% of total exports and palm oil had become the most important export, increasing from over one billion dollars in 2000 to 12.4 billion dollars in 2008. Rice production increased from an estimated 12.4 million tons of paddy rice in 1961-65 to 62.6 million tons in 2008. Much of this increase derived from higher yields, while in Java the area under rice probably fell, although data on this decline are contested. The area planted by large estates has increased to around five million hectares, which is entirely due to a very rapid growth in palm oil cultivation (4.1 million hectares in 2008). A further 526,000 hectares were under rubber. Most other cash crops are now grown largely by smallholders. In 2008, 14.45 million hectares are under smallholder cultivation for tree crops and seasonal crops such as tobacco.
three main crucial issues. The first was the perceived problem of rural overpopulation in the inner islands of Java and Bali, and the limits to agricultural intensification usually associated with the absorption of more labour, a process which had been ongoing in these islands since the late 19th century at least. More labour was used because of the introduction of double and triple cropping of irrigated rice land, more intensive use of dry land, and the cultivation of more labour intensive crops. But by the 1960s many agricultural experts thought that diminishing returns had set in and more labour could not be productively used in agriculture without new technologies which would raise yields per hectare. It was widely known that yields of rice in Indonesia were low compared with Taiwan and Japan, and agricultural economists argued for the development of higher yielding varieties and the greater application of chemical fertilisers.

A second focus for policy debate was the potential for large-scale land settlement outside the densely-populated regions of Java, Bali and Nusantara. One solution,
started by the Dutch colonial government in the early 20th century, was transmigration, i.e. the movement of rural households to areas with lower population densities and more land of arable potential. This policy was continued, albeit spasmodically, after 1950.

The third area for policy debate concerned the potential to increase production of smallholder cash crops which had been grown in Sumatra, Kalimantan, Sulawesi and Maluku for decades. Comparisons with neighbouring Malaysia showed that smallholder rubber yields were much lower; the question was how to extend knowledge about new varieties and better cultivation practices to millions of farmers scattered over vast areas.

When Suharto took power in 1966, he recruited a team of mostly Berkeley-educated technocrats, known as the “Berkeley Mafia”, to advise him on economic policy. They had a different approach to the Chicago-oriented economists that were influential in Latin America in the 1970s and 1980s, advocating cautious pragmatism and a strong role for government in guiding policy. They argued that agricultural development should be the top priority for government expenditure, and the first five-year plan (1969-74) allocated considerable funds to the rehabilitation and development of rural infrastructure, including roads and irrigation systems (22% of the plan’s expenditure went on agriculture and irrigation projects (Department of Information, 1974)). Although subsequent five year plans during the Suharto era gave less prominence to agriculture, rural infrastructure remained a priority. Furthermore, the transmigration programme received additional funding especially in Suharto’s third plan (1979-84): over this period, around 366,000 families were moved to Sumatra, Kalimantan, Sulawesi and Irian Jaya as sponsored migrants, and a further 170,000 as spontaneous migrants (World Bank, 1988).

The transmigration programme involved bringing new land under cultivation. Inevitably there was some encroachment on forest areas, although the Directorate-General of Forestry often prevented families settling on land under its jurisdiction, whether forested or not. In addition, local populations grew outside Java and took more land for cultivation. Large estates, especially in the palm oil sector, also expanded at the expense of forests. However, it must be acknowledged that these degradations were concomitant with the acceleration of food crop yields, especially rice, in most parts of the archipelago.

GROWTH IN AGRICULTURAL OUTPUT AND EXTENSION OF CROPPED AREA Between 1960 and 2000, Indonesia’s growth in agricultural output was 3.5% per annum; between 1968 and 1992 it was 4.8% (Fuglie, 2004: Table 5). These growth rates were rapid by international standards, and Fuglie’s estimates suggest that at least half was due to total factor productivity growth, i.e. output growth not caused by increased inputs. Both labour and land productivity grew at over 2% per annum between 1968 and 1992. After 1992, agricultural growth slowed and productivity growth was negative. Fuglie suggested several reasons for this decline including the El Nino-induced drought of the late 1990s, concomitant to the severe macroeconomic
collapse in 1997/98. Furthermore, by the early 1990s, rice productivity gains due to the successful dissemination of International Rice Research Institute varieties had reached a maximum, and a general decline in government assistance to agriculture forestalled new R&D investment.

The rapid growth in food crop agriculture over the 1970s and 1980s, and especially the growth in rice production, can be seen as a partial vindication of the intensification argument. A considerable proportion of the growth was due to higher yields and to more intensive cropping of existing agricultural land, resulting from improved irrigation. As figure 2 shows, rice yields more than trebled from the 1960s to the 1990s, accompanied with a considerable increase in fertiliser use.

**TABLE 1. TRENDS IN INDONESIAN AGRICULTURE (ADAPTED FROM FUGLIE AND PIGGOT, 2006: TABLE 4.2 P 89)**

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<tbody>
<tr>
<td>Total cropland</td>
<td>17.6</td>
<td>18.9</td>
<td>26.0</td>
<td>32.2</td>
<td>39.3</td>
</tr>
<tr>
<td>(million hectares)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cropland Java and Madura</td>
<td>9.0</td>
<td>8.8</td>
<td>7.0</td>
<td>7.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Cropland other islands</td>
<td>8.6</td>
<td>10.0</td>
<td>19.6</td>
<td>25.1</td>
<td>32.2</td>
</tr>
<tr>
<td>Rice yields (kg/ha)</td>
<td>1,761</td>
<td>2,542</td>
<td>3,786</td>
<td>4,352</td>
<td>4,465</td>
</tr>
<tr>
<td>Rice outputs</td>
<td>12.4</td>
<td>21.2</td>
<td>35.8</td>
<td>47.5</td>
<td>51.3</td>
</tr>
<tr>
<td>(million tons of</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>paddy rice)</td>
<td></td>
<td></td>
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<tr>
<td>Fertiliser use</td>
<td>6.9</td>
<td>22.7</td>
<td>63.3</td>
<td>73.9</td>
<td>74.3</td>
</tr>
<tr>
<td>(kg/ha)</td>
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Total land under all forms of agriculture increased rapidly from 1961-65 to 1991-5. Most of this growth was outside Java and included growth in land under staple food crop cultivation (rice, corn, cassava, sweet potato, soybeans, sago, etc.). But there was also rapid growth in area under smallholder cultivation of cash crops such as cloves, coffee, palm oil, rubber and cocoa. Area under palm oil cultivation by large estates also increased (see box). All land area estimates in Indonesia must be treated with a certain scepticism and Fuglie’s estimates, based on national and FAO data, may be overstated. Meanwhile, cropland in Java has declined, especially since the 1980s.

The reason for this decline is the rapid growth in urban and peri-urban settlements which has meant that much cropland has been used for housing, industry and commerce. Outside Java, the expansion of cultivated land is due to population growth, leading to the use of more land for smallholder food crop and tree crop agriculture, land settlement schemes and the expansion of large estates. While the official transmigration programme has attracted considerable criticism from environmental organizations, it only accounted for a small part of the growth in area under food crops and tree crops. Most of the increase in food crop area has been due either to local populations cultivating more land, or to unofficial migrants settling on land without permission. The growth in tree crop hectarage is due to smallholders and commercial estates.

**IMPACT OF AGRICULTURAL POLICIES ON FOREST COVER** For most of the past century, Indonesian farmers have responded vigorously to national and international price
incentives, as well as to new technologies, and have increased the cultivation of many crops for different markets. Until the 1980s, the environmental costs of increased agricultural growth attracted little attention. Regarding food crops, the official view, supported by evidence, was that most production growth came from increased yields and the more intensive cultivation of existing land.

What then was driving deforestation, which accelerated during the 1980s and 1990s? For many years it was thought that forest loss was due mainly to shifting cultivation, but this view was challenged as more sophisticated satellite imaging technology became available. It emerged that large plantation companies and forest conglomerates were the main actors driving deforestation. By the end of the century, there was much pressure on the Indonesian government to conserve pristine forests and to consider the consequences of non-food agricultural growth. Oil palm expansion by smallholders and large estates has driven such growth, but it is the latter that are considered responsible for the majority of forest loss. A World Bank report (2001) placed the blame for deforestation squarely on commercial developers, especially those involved in palm oil. Given that world demand for palm oil and other vegetable oils will continue to grow, is more forest loss inevitable? What about the 15 million hectares officially classified as temporarily unused arable land (Statistics Indonesia 2009: 92)? What must be done to turn this land to profitable agricultural use? These are the issues that will challenge policy makers over the next decade and beyond.

The Indonesian case study is not a straightforward validation of the Borlaug hypothesis because it exhibits many factors that blur the links between intensification and agricultural expansion. Certainly, yields have rapidly increased during the green revolution, however there has also been diversification with oil palm. The initial food deficit was filled (self-sufficiency in rice was achieved in 1984), while the population and economy have grown spectacularly, clearly impacting on agriculture. In this context it is difficult to ascertain whether higher yields have limited expansion. The case study illustrates perfectly the contradictory nature of certain policies from an environmental perspective: while intensification was supported, populations were simultaneously moved to forested areas where licenses for oil palm plantations were freely issued. Taking these complexities into account, the next section attempts to assess whether intensification can be used as a tool to combine higher productivity with forest conservation, addressing the burning question of oil palm expansion.

**BOX 3 REDD+ LETTER OF INTENT (LOI) BETWEEN NORWAY AND INDONESIA**

Signed in May 2010, the LoI established a partnership between Norway and Indonesia to contribute to the reduction of emissions from deforestation, forest degradation and peatland conversion. There are three phases: preparation (2010), transformation (2011-2013) and implementation (from 2014). At the time of writing, the following policies are in development: establishment of degraded land databases for economic development purposes, enforcement of existing laws against illegal logging and trade in timber and related forest crimes, elaboration and implementation of appropriate measures to address land tenure conflicts and compensation claims. The flagship of these measures is the two-year “moratorium” suspending all new licences for the conversion of peat and natural forest.
IMPLEMENTING REDD+ AGAINST DEFORESTATION: 
THE OIL PALM CASE

While several initiatives are currently underway in Indonesia in the framework of REDD+, we focus here on the deal with Norway that may have the greatest impact.

THE OIL PALM CHALLENGE Indonesia is the world’s largest palm oil producer, a position it aims to maintain by doubling its production level to 40 million tonnes by expanding its plantations to 16 million ha by 2020 and increasing productivity to approach Malaysian levels. Between 1990 and 2010, Indonesian production increased eight fold; while over the same period the area of oil palm cultivation grew from 1.1 million ha to 7.8 million ha. About 40% of oil palm plantations are managed by smallholders.

PLANNED ACTIVITIES Indonesian oil palm targets are, however, constrained by its commitments with Norway. Indeed, in May 2011 a presidential instruction, known as the “moratorium”, postponed the issue of new licenses for forestry and agriculture, notably oil palm plantations, on primary forests and peatlands for at least two years. Some NGOs have criticised the moratorium for failing to adequately address the threats to forests. Indeed, it has been shown that the presidential instruction can only protect 19% of the 45.3 million ha of total primary forests from further deforestation. The business sector has also criticised the moratorium. The Indonesian Oil Palm Producer Association estimates that the annual land expansion for oil palm will be reduced from 350,000 ha to less than 200,000 ha for the next two years.

Great confusion remains regarding the impact of the moratorium, especially when considering the conflicts with regional development initiatives. For example, in 2009 the Merauke Integrated Food and Energy Estate initiative was promoted in the Indonesian province of New Guinea island to secure food and energy resources. Initially, expectations were for the project to cover 2 million ha, supported by significant foreign and domestic investment. However, following public pressure over possible environmental and social damage, a reduced 1.2 million hectare plan was suggested, which is now obtaining a consensus. This draft regulation proposes the development of 420,000 ha of plantations during 2010-2014, a further 630,000 ha during 2015-2019 and finally an additional 230,000 ha of plantation during 2020-2030. These figures do not take commitments at the national level into account.

OIL PALM INTENSIFICATION ISSUES REGARDING PRODUCTION TARGETS The 2008 Indonesian Forest Climate Alliance report recommends a strategy which involves: consolidating policy and approval criteria for the release of convertible forests for oil palm development, reviewing of plans to optimize degraded land, intensification of oil palm estates, and zero burning for land preparation. None of these aims are easily implemented and, compared to other components, intensification has not been adequately addressed so far.

Two of the main challenges facing the oil palm sector are low productivity and limited access to capital. Large companies generally have their own R&D units which
produce high quality seedlings, whereas smallholders often have difficulty obtaining good seedlings and lack essential support (e.g. infrastructure and fertilizers). Collaboration between farmers and companies is often ineffective and there is much room for improvement.

To tackle these issues, the government has initiated a revitalization programme that is projected to help establish 730,000 ha of oil palm plantations by 2014. The programme enables plantation developers to access credit at preferential rates, as well as providing high-quality seeds and extension services on production methods and the optimisation of land resources.

CONCLUSION

The complexity involved in the transformation of agricultural production systems and the links to land availability highlight the necessity for public support policies to obtain the potential land sparing benefits. Indeed, an analysis of the deal between Indonesia and Norway suggests that the former does not prioritize intensification as a land sparing strategy or as a means to achieve REDD+ objectives.

Evidence shows that we cannot rely on spontaneous changes in technology to contribute to forest conservation. For example, Boserup (1965) showed that spontaneous innovation generally brings about an intensification of scarce resources. This means that farmers show a strong tendency to adopt extensive systems when land is abundant, to compensate for the scarcity of other production factors such as labour and capital. This holds true for both slash and burn farmers in Borneo and cattle farmers in Latin America. Accordingly, regarding deforestation in Indonesia, a reliance on spontaneous innovation and the adoption of new agricultural technologies to solve the problem would imply accepting an increase in forest clearing until the resource has almost disappeared, and then depending on farmers to implement conservation measures. A certain number of macro tools are therefore required, for example appropriate taxation on the agricultural sector or the creation of a network for technology dissemination.

One tool with great potential is the Payments for Environmental Services (PES) scheme, where beneficiaries (or intermediaries) of an environmental service establish voluntary contracts with the providers of this service and condition their rewards on the maintenance of the service. For Indonesia, a PES could consist of measures to support the adoption of sound agricultural technologies on the condition that forests on nearby land were left intact. Farmers and landowners would benefit from technologies capable of increasing their production and income, while the adverse consequences of forest clearance could be minimised. Ideally, a PES would secure the benefits (an increase in food production) while mitigating the adverse effects (expansion to the detriment of tropical forests).

Finally, it is critical that the “rebound effect” is tackled to avoid an increase in
consumption when food prices decrease. One suggestion is for action to be taken on diets throughout the world to bring demand per capita into line globally, for example by reducing the consumption of dairy products and meat. However, this is an extremely ambitious aim and the effectiveness of associated educational programmes is uncertain. Nevertheless, food transition studies enable different scenarios to be envisaged, for instance the implementation of alternative models in the agro-food industry (Paillard et al., 2010), or the establishment of systems to tax agricultural products based on their carbon content, similar to commitments made under the Climate Convention (Zaks et al., 2009).

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