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Tobacco growers at the crossroads: Towards a comparison of diversification and ecosystem impacts

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ABSTRACT

An international Framework Convention on Tobacco Control has been in force since 2005, also aimed at regulating tobacco farming: FCTC article 17 on diversification, and FCTC article 18 on socio-ecological issues. Relating to the FCTC, information was gained and evaluated from tobacco farmers of growing areas sampled from major world regions (Rio Grande do Sul/Brazil, Tabora/Tanzania, Meinung/Taiwan, and Germany/Europe). A local farming survey was carried out in 2007, using a common data protocol, which covered, among others, questions on area and production development, energy used in curing, workforce, economic livelihood situation, and diversification opportunities. In addition to the survey, secondary (national-scale) statistics, public testimonies and other published data were explored. We analyzed these data using a portfolio approach, which combined statistical analysis, meta-analytical study and descriptive narratives. The projected trend of a global shift of tobacco cultivation into the developing world is confirmed, but also refined. Wood is used in Brazil and Tanzania for curing Virginia green leaf, thus contradicting the projected continuous reduction of this energy source. Child labour remains a major component of family farm tobacco operations in Brazil and Tanzania, while the cost and availability of seasonal labour turns into a bottleneck of production in Germany. More diversification opportunities exist than generally claimed, but no efforts are seen to address poor and vulnerable growers, in particular. German and Taiwanese tobacco growers can reasonably be predicted to discontinue farming in the near future, while tobacco cultivation in Brazil and Tanzania is seen to expand, mainly due to the political economy of low-cost production. Conclusions are drawn with respect to the work of the UN Study Group on Economically Sustainable Alternatives to Tobacco Growing (ESATG), effective since 2007.

Introduction

Land use, in general, is already a highly political activity, and tobacco, in particular, is one of the world's most controversial crops. This can chiefly be attributed to the synthesis of knowledge on the disease impact of smoking with concerted public action over the past decades. According to the World Bank, tobacco use is projected to claim a billion lives this century (Jha and Chaloupka, 1999), with smoking-related mortality responsible for half the diseases and deaths in developing countries (Beyer and Bridgen, 2003). Moreover, tobacco farming has been identified as a development issue with regard to environmental sustainability, especially in growing areas of the developing world (UNECOSOC, 2004; Ramin, 2006; FCA, 2007; WHO, 2004a, 2007a,b).

With almost 130 producer countries, the commercial smoking product species *N. tabacum* is the most widely grown non-food crop globally (FAO, 2008). Decades ago, it has been identified to pose "a particularly difficult dilemma for development" (Goodland et al., 1984, p. 51), because long-term impacts on ecosystems and the livelihoods of growers/workers appear substantially to outweigh the perceived short-term benefits such as income generation and employment effects (Baris et al., 2000; Clay, 2004). In 1995, several multilateral aid agencies, development banks, non-governmental organizations (NGOs) and United Nations (UN) authorities portrayed tobacco as "a major threat to sustainable and equitable development", concluding that "in the developing world, tobacco poses a major challenge, not just to health, but also to social and economic development and to environmental sustainability" (Bailey et al., 1995, p. 1109).

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A global convention went into force in February 2005 with a host of measures designed to not only reduce the health burden caused by tobacco use but also address the economic, social and environmental implications of tobacco as a crop. The Framework Convention on Tobacco Control (FCTC), negotiated under the auspices of the World Health Organization (WHO), provides the basic tools for countries to enact comprehensive tobacco control legislation, policies and programmes at the national level (WHO, 2005). Parties to the convention – as of 30 April 2008, 168 signatories and 154 ratifying parties – are required to promote and facilitate the exchange of information regarding, among others, the cultivation of tobacco and related practices of the tobacco industry in the respective growing countries (article 20). The treaty further addresses key agricultural issues in two articles of part IV (measures relating to the reduction of the supply of tobacco) and part V (protection of the environment): article 17 asks for the "provision of support for economically viable alternative activities" for tobacco workers and growers (among others), and article 18 asks for "due regard to the protection of the environment and the health of persons in relation to the environment in respect of tobacco cultivation . . . within their respective territories" (WHO, 2005). The countries under study signed and ratified, respectively, the FCTC in 2003/2004 (Germany), 2003/2005 (Brazil) and 2004/2007 (Tanzania) (Taiwan is not a part of the UN system).

In contrast to other treaties, coalitions of non-state actors and new groups from developing countries were brought into the FCTC process such as environmental, human rights and women organizations. Described to be vocal, spirited, and leading the charge for most of the progressive provisions including articles 17 and 18, these organizations often fought the "intense pressure from a handful of countries, particularly the USA, Japan, and Germany" (with traditionally strong connections to the cigarette manufacturing industry) (Hammond and Assunta, 2003, p. 241). These strategic actors, partly supported by groups of tobacco growers, have continued to submit public testimonies on the detrimental aspects of tobacco farming, thus putting the issue of crop diversification – either based on, or away from tobacco – high on the agenda of global land use policy (Keyser, 2007; WHO, 2007c,d). The costs of tobacco cultivation have been summarized by Lightwood et al. (2000, p. 70) to include, among others, environmental damage such as soil degradation, deforestation, and water pollution.

At the first session of the Conference of the Parties (COP) to the FCTC in February 2006, it was decided to establish an ad hoc study group on alternative crops, and the Government of Brazil (along with the WHO) hosted the first meeting of the study group in February 2007, promoting the inclusion of article 17 as a priority within the COP agenda. The major outcomes can be summarized as follows (WHO, 2007c): (i) the FCTC does not aim to phase out tobacco production in the short-term, but alternatives to tobacco crops need to be explored since eventual and long-term decreases in demand, caused by (public health) tobacco control, are assumed to exert an impact on production; and (ii) the human–environmental concerns associated with growing and curing tobacco continue to be debated, since extensive research and evidence is missing about the detailed socio-ecological costs of tobacco farming. In July 2007, the corresponding report was presented at the second session of the COP, which mandated the study group to continue its work as UN Study Group on Economically Sustainable Alternatives to Tobacco Growing (ESATG). At its second meeting in June 2008, the study group developed a report to the COP at its forthcoming third session in November 2008 that would address, in particular, the issue of scientific evidence and economically sustainable diversification measures as an alternative to tobacco, including possibilities of non-agrarian livelihoods (WHO, 2008). While some progress was noted in the area of ESATG, it was identified as necessary to implement data collection and monitoring mechanisms to keep records of tobacco-growing impacts, conversion measures, corporate practices (to undermine the promotion of ESATG), as well as of trends in indicators of human well-being as part of a national policy framework to promote alternative development. It was recommended that monitoring should be done at the household level and that information should be made available to farmers and to the public (WHO, 2008).

Many tobacco-farming studies are either based upon secondary statistics (e.g., FAO, 2003a,b) or crop budget analyses (e.g., Keyser, 2007). Except for few studies (e.g., Altman et al., 1996; Ramsey and Smit, 2002; Ochola and Kosura, 2007; Craig, 2008), there has been little scientific investigation of what tobacco growers actually think, especially about the issues raised in the FCTC. It is poorly understood as to "farmers' perception of the economic forces and policy alternatives that could affect their ability to sustain tobacco-farming enterprises" and "farmers' attitudes towards and experience with diversification" (Altman et al., 1996, p. 193). Against this background, the WHO has identified, among others, the following themes as part of a global agenda for tobacco control research: (i) cultivation and curing practices at the country and subnational level, and the relationship of tobacco production to the destruction of the ecosystem, particularly concerning deforestation; and (ii) opportunities for alternative crops and alternative livelihoods (WHO, 2004b). This study links to these critical themes by inquiring information directly from growers in four major tobacco-growing areas of the world and applying a common data protocol, in addition to the use of other sources of information. It aims at contributing to data-driven efforts to establish a global tobacco surveillance and monitoring system centred around the articles 17 and 18 of the FCTC, especially for developing countries and countries with economies in transition (Jategaonkar and Huber, 2007; WHO, 2008). In previous attempts to monitor tobacco development, household interviews were found to be "most expensive" (WHO, 1998, p. 87) so that a small sample of growers is used here to generate selected and preliminary results. While the small N/low-cost approach may create a limitation with view upon quantitative comparisons across countries and growing areas in this study, it is meant to be a first step towards a standardized international comparison, with a wider cohort study to be developed and with multiple sources to be exploited.

Material and methods

Description of the databases

The study compiled information from diverse materials and sources. Described as "portfolio approach" (Young et al., 2006), it integrated national-level secondary statistics, an analysis of local farming survey data, and a meta-analytical study of published literature and public testimonies.

First, tobacco growers were sampled from the leading tobacco-growing zone in four producer countries across the world, using lists of farmers available from grower associations. The areas are Santa Cruz do Sul in southern Brazil, the Urambo district in central Tanzania, Meinung in southern Taiwan, and Germany. The selected farmers were visited between August and October in 2007. A structured and standardized questionnaire was used to generate data on four broad categories with more than 30 questions in total (Table 1). In each area, 25 farmers were interviewed to obtain the same absolute (total number) and relative measures (proportion, %) ($N = 100$). Given their low total number, only German tobacco growers were sampled according to the relative weight of the farmers per growing district (*Erzeugergemeinschaft*, EZG), i.e., one farmer from EZG North (4%), 2 farmers from EZG Bavaria (8%), 4 from EZG Northeast (16%),

Table 1
Questions used in the formal interview.

1-**Grower's background information**
1. Age? <40/40–49/50–60/>60
2. Education level? Illiterate/<6 years of education/6–9/10–12/>12
3. Which type of tobacco currently? Flue (ha)/other to be specified (ha)
4. How many kilograms of all tobacco production last year? Flue/other
5. Generations (1/2/3/>3) and years in tobacco farming? <5/6–10/11–15/16–20/>20
6. Land ownership? Sole owner/joint owner/renter/mix of above
7. Have you abandoned tobacco farming during the past 10 years? Y (why?)/N
8. Will you consider switching from tobacco to another land use type? Y/N (reasons to be specified)
2-**Land, labour, livelihood**
9. Number and type of persons involved in farming? Family members (incl. children)/dependents/workers
10. Size of all landholding (ha)?
11. Which other crops (ha)?
12. Which type of fallow, if any (ha)?
13. Crop rotation back to 2000 for your biggest tobacco plot (2000/2001, etc.)?
14. Bottlenecks of production (land, labour, land rights)?
15. Tobacco income enough to cover household expenses? Enough/usually enough/not enough.
16. Enough capital to pay for the farming costs? Enough/usually enough/not enough.
17. Estimated share of tobacco in all household income back to 2000 (2000/2001, etc.)? All/half/<half
18. Income from other sources? Y (to be specified)/N
19. Any problems with the health of persons in respect of tobacco growing?
3-**Husbandry and curing practices**
20. Which energy is used to cure tobacco? Coal/wood/other
21. Sources of wood and types of trees (if so)?
22. How many kilograms (cubic meters) of wood/coal for all last year's cured (flue) production?
23. How many kilograms (cubic meters) of wood/coal for one curing charge (filled barn)?
24. How many curing charges for all last year's (flue) production?
25. How are curing and grading barns constructed? Brick/wood/others
26. Change in number of trees in your local area? Rise/fall/no change
27. Which type of trees on tobacco plot (if any)?
28. Which chemical inputs on plot (basal/top dressing) and seedbed? Fertilizer/pesticides/other
29. Soil problems and/or plant diseases?
4-**Credit, marketing and diversification**
30. Tobacco sold to which agencies/intermediate buyers?
31. Will children continue with tobacco farming?
32. Which major problems you expect when shifting away from tobacco?
33. Last season's credit situation? State/private lender/other

7 from EZG Southwest (28%), and 11 from EZG Baden-Württemberg (44%), with most of the interviews in Germany done by mailing or phone. Henceforth, country name represents the respective growing area.

The characteristics of tobacco growers participating in the survey vary considerably (Table 2). For example, it could be stated that Taiwanese tobacco farmers are considerably older and German tobacco farmers have many more years in formal education than growers in other countries, given the above-mentioned limitation.

Table 2
Characteristics of tobacco growers, number of years ($N = 100$).

	Brazil	Tanzania	Taiwan	Germany	Total
Age					
<40	2	8	2	7	19 (%)
40–49	14	7	2	8	31 (%)
50–60	8	6	1	5	20 (%)
>60	1	4	20	5	30 (%)
(Formal) Education					
None	0	0	1	0	1 (%)
<6	21	5	8	1	35 (%)
6–9	4	13	8	3	28 (%)
9–12	0	1	7	6	14 (%)
>12	0	3	1	15	19 (%)

Source: Own farming systems survey.

Second, national-level secondary statistics from several sources were evaluated. The statistical database (FAOSTAT) of the UN Food and Agriculture Organization (FAO) contains close to 230 countries and sovereign territories, dating from 1961 to 2006 (last available time point when the manuscript was completed) (FAO, 2008). But it provides no breakdown by tobacco varieties and the quality of reporting is as good as is the reporting of individual member states. The overseas reporting and monitoring system of the Foreign Agricultural Service (FAS) of the United States Department of Agriculture (USDA) includes raw tobacco by several varieties, covering nearly 150 countries. However, it contains reports from 1995 onwards only and, effective from January 2006, the *attaché* reports are available for historical purposes solely with no updates after 2005 (USDA, 2006). Other sources explored for secondary statistics are the world and national reports of transnational tobacco corporations on an annual or (bi)monthly basis (e.g., TLTC, 2005). Due to the highly dynamic business environment (e.g., frequent mergers), time series data are rare and most national reports are discontinued after 2005.

Third, given the paucity of research and evidence surrounding the agricultural issues raised in the FCTC, this study chose a matrix format to plot evidence on ecosystem damage (deforestation) by the type of (written) source and by the type of proximate activities reported in these sources. Basically, the method is a meta-analytical study (systematic literature review) adopting a rule from investigative journalism, i.e., information is considered reliable if confirmed by at least two independent sources. Both scientific articles published in international journals accredited by the ISI Web of Knowledge (http://wok.mimas.ac.uk) and other sources (books, book chapters, reports, public testimonies) were used. As a rule, testimonies from public hearings were expected to be confirmed in the published literature. The testimonies stem from two hearings of the WHO, with eligible submissions from tobacco farmers' and workers' associations, leaf companies, cigarette manufacturers, public/private organizations and NGOs. In October 2000, more than 400 written statements were submitted on the FCTC in general (WHO, 2000), and in February 2007 around 40 statements were submitted on agricultural diversification (WHO, 2007d).

Description of the study areas

Brazil

As the second largest producer country in the world (after mainland China), Brazil has consolidated its position as the world's largest exporter of leaf tobacco since 1993 (FAO, 2008). The south of Brazil accounts for about 95% of all national tobacco production. In the tobacco states of Rio Grande do Sul, Santa Catarina and Paraná, the cultivation of artificially cured (bright) Virginia for cigarette manufacture on 80% of all tobacco land dominates the cropping pattern over naturally cured Burley. Other growing areas are located in the northeastern states of Bahia, Sergipe and Alagoas, chiefly producing naturally cured, dark tobaccos for cigars and cigarillos.

The spatial pattern of tobacco cultivation has been dynamic for about 400 years, with apparently no limits to the further expansion of growing. Commercial cultivation began around 1640 and, by the early 18th century, the northeastern state of Bahia virtually monopolized the Brazilian tobacco trade (Barickman, 1998). After independence in 1822, and chiefly related to the "postcolonial colonisation" of Brazil's south by in-migrating middle peasants from continental Europe (Zündorf, 2001, p. 253), tobacco cultivation shifted into the south. Since the 1970s, tobacco companies operating in the region have adopted a strategy of moving into new

areas of Rio Grande do Sul, where yield and quality are similar to traditional tobacco producing regions in the south of Brazil (Vargas and Bonato, 2007).

Over the past decades, the number of tobacco-growing families has increased from 115,000 in the 1980s to 200,000 at present, equalling about 155,000 landholdings and not considering landless tenants (AFUBRA, 2007; CSCPF, 2007; SINDIFUMO, 2007). Over the past decade, the number of people employed in growing has also increased from about 500,000 to about 832,000 (Vargas and Bonato, 2007, p. 19). The farming survey for this study was carried out in the Rio Pardo Valley of Santa Cruz do Sul, a leading traditional tobacco-growing area in the state of Rio Grande do Sul holding about half of the tobacco land and output in the south. The sample (n = 25 farmers) represented less than 0.1% of the total tobacco-growing households.

Tanzania

Ranked among the top-20 growing countries in the world, Tanzania has consolidated its position as Africa's third largest producer (after Malawi and Zimbabwe) (FAO, 2008). Of seven major tobacco-growing areas in the country, Tabora in central Tanzania is the largest growing zone, with the cultivation of flue-cured Virginia for cigarette manufacture accounting for 80% of the national tobacco production (URT, 1998). Other flue-cured tobacco-growing areas include Kahama, Mpanda and Chunya in the south (Sauer and Abdallah, 2007). Dark, fire-cured tobacco is concentrated in the Songea district of Ruvuma region (URT, 1998). The national production of air-cured Burley is of minor importance. Except for pockets of land openings, the spatial pattern of tobacco growing in Tanzania has been more or less stable since commercial cultivation started in the 1930s (Songea), 1940s (Iringa), 1950s (Tabora), and 1960s (Chunya).

In 1971, a programme supported by the World Bank spurred substantial increases in the number of tobacco growers and land under tobacco. The total number of tobacco smallholders in the country rose from 13,000 in 1967 to 47,700 in 1976 (Boesen and Mohele, 1979, p. 148). With the exception of half a dozen Greek estates in the Iringa highlands, flue-cured tobacco has been produced in schemes or "complexes" under close supervision (Scheffler, 1968). After a decline between the mid-1970s and the mid-1980s, the tobacco area has increased substantially since the late 1980s, supported again by the World Bank. The current number of people employed in growing tobacco is estimated to be about 180,000 in the country (Jacobs et al., 2000, p. 316). The farming survey for this study was carried out in the Urambo district of Tabora, the leading producer of flue-cured tobacco on a district level. The sample (n = 25) represented less than 0.1% of the district's total tobacco-farming households (45,000).

Taiwan

Taiwan is a minor producer country representing less than 0.2% of the global land under tobacco. Tobacco-growing areas, mainly Virginia for cigarette manufacture, are spread across the country.

Tobacco farming was introduced during the Japanese occupancy in 1895–1945. Historically, the tobacco monopoly of the Taiwan Tobacco and Wine Board (TTWB) negotiated land use agreements with farmers and maintained, among others, annual contracts for the production of tobacco cutfillers. In practice, this meant the protection of tobacco farming through a system of quotas guaranteeing purchase price and amounts of production. At present, the best quality domestic flue-cured tobacco is used to manufacture cigarettes, while a (minimal) rest is targeted for export. Scope for production (thus, price) increases is limited since crop quality is low due to stemmed/stripped tobacco (70%) and tobacco stems (30%). From an international perspective, domestic production is expensive (Perng and Trachtenberg, 2004).

The total number of tobacco farmers in Taiwan has been on a continuous decrease since about the late 1980s, with the growing sector employing about 20,000 people in the late 1990s (Jacobs et al., 2000, p. 316). The farming survey for this study included growers from Meinung, an area called the "kingdom of tobacco" (Hong, 1999). The sample (n = 25) represented less than an estimated 0.5% of the total national tobacco-farming households.

Germany

Germany is also a minor producer of tobacco, holding less than 0.2% of the global land under tobacco (FAO, 2008). Except for its northwestern part, the country has tobacco-growing areas across its territory, with two southern states – Rhineland-Palatinate (or EZG southwest) and (EZG) Baden-Württemberg – accounting for about three quarters of the land under tobacco. The cultivation of Virginia on 60% of all tobacco land dominates the cropping pattern over air-cured varieties such as Burley and Geudertheimer (Achilles, 2004).

Commercial cultivation began in the early 17th century, with a peak of mass production in the late 19th century. Since then, area and production have been on a continuous decline due to the import of tobacco from overseas (developing countries). Tobacco is now grown in most suitable areas due to climatic and soil reasons so that there is no scope for quality (thus, price) increases through investments in new growing areas (König, 2007).

The number of farmers decreased from about 200,000 in 1870 to 1000 in 2000, and it has been further reduced to an estimated 450 in 2007. The farming survey for this study included farmers from all tobacco-growing areas, with the sample (n = 25) representing 6% of the total national tobacco-farming population.

Results

Area and production development, including varieties

The global production of tobacco more than doubled from 3.6 million metric t (mill. t) in 1961 to a historical maximum of 9.0 mill. t in 1997. Then, it decreased to levels of the 1980s, i.e., 6.5 mill. t (FAO, 2008). From 2003 onwards, however, the pattern has reversed with an average annual increase of almost 4%. Global production of commercial tobacco falls into two different trends. The share of tobacco produced in the developing world (adopting here FAO's definition) increased from 57% in 1961 to 86% in 2006. When the FCTC went into force in 2005, tobacco production in the developing world had increased by 180% since 1961, and a further increase of 2% occurred in 2005–2006 (FAO, 2008). Far above these average values, Brazil has seen an increase of 439% and Tanzania an increase of 1825% since 1961. In contrast to the developing world, commercial tobacco production in the developed world decreased from 1.5 mill. t in 1961 to 0.9 mill. t in 2005 (FAO, 2008). An ongoing increase, however, has been observed with a 3% increase in 2005–2006, mainly due to productivity increases in the USA. In Germany, tobacco production has fallen constantly, while it has decreased drastically in Taiwan in recent years.

Global land under tobacco increased steadily from 3.4 mill. ha in 1961 to a historical maximum of 5.4 mill. ha in the late 1990s. Then it decreased to levels of the mid-1960s/1970s, i.e., about 3.8 mill. ha. From 2003 onwards, there has been a gradual increase at an annual rate of about 1%. Parallel to the global production trend, area development falls into two different trends. The share of tobacco cultivated in the developing world increased from 70% in 1961 to 90% in 2006. The tobacco area harvested increased by

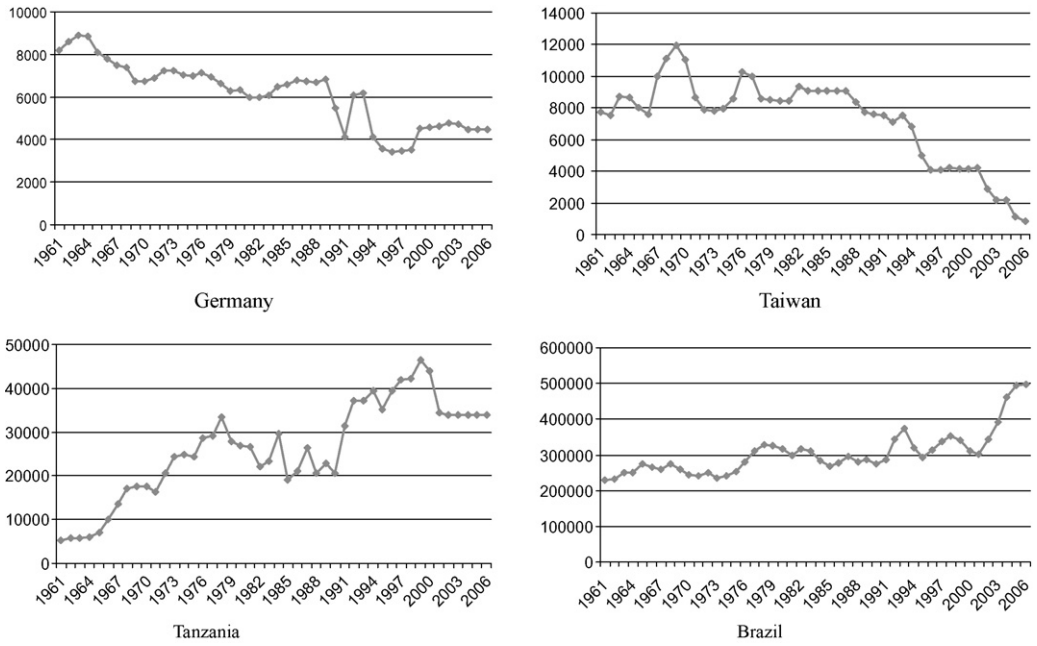

Fig. 1. Development of land under tobacco (ha), 1961–2006. Sources: FAO (2008), GoT (2007).

47% in 1961–2005 and 2% in 2005–2006 in the developing world (FAO, 2008). In Brazil, land under tobacco has more than doubled since 1961, while it has increased more than six-fold in Tanzania. In contrast, the area harvested for tobacco in the developed world decreased from 1.2 mill. ha in 1961 to 0.4 mill. ha in 2005, and has further decreased at about 4% in 2005–2006 (FAO, 2008). Tobacco land in Germany has decreased constantly, and it has decreased drastically in Taiwan, especially since 1995 (Fig. 1).

If a critical 20%-threshold value is applied over the past 25 years (Thun and Silva, 2003, p. 11), the four countries under study show either significant increases (Brazil 57%, Tanzania 26%) or decreases (Taiwan 90%, Germany 29%) of land under tobacco. Except for Tanzania, tobacco growers reported continuous farming activities over the past decade. Almost half of the Tanzanian growers (44%) intermittently stopped farming because of changing climate conditions, poor prices, health problems and/or lack of inputs.

The average tobacco landholding ranges from 1 to 22 ha, on average, and the share of tobacco in all landholding ranges from 22% in Brazil to 73% in Taiwan (Table 3). Table 3 also indicates high degrees of specialization in Germany and Taiwan, and less so in Brazil and Tanzania. In Brazil, the average land under tobacco per farm has remained more or less stable at 2.5 ha over the past half decade (AFUBRA, 2000, 2007). Land distribution ranges from 0 to more than 50 ha, with share croppers or tenants – i.e., 20% of the farming families working in land leasing arrangements – holding no land at all (AFUBRA, 2007). It has been reported that only 2% of tobacco growers own more than 50 ha in Brazil (Vargas and Bonato, 2007, p. 18). The average size of tobacco land among smallholders is 4.2 ha in Tanzania and 1.1 ha in Taiwan (ranging from 0.2 to 5.0 ha). In Germany, the average tobacco landholding increased from 6 to 9 ha in 2000 (Kappelmann and Tschmarke, 2005, pp. 17 and 19) to 14 ha in 2005 (Ruhm and Bokelmann, 2005, p. 27). It is 22 ha in this study.

Table 3
Tobacco landholdings (all varieties and systems of cultivation).

	Minimum	Maximum	Mean	Share in all
All operations				
Brazil	1.0	23.0	11.5	100%
Tanzania	5.5	75.0	18.6	100%
Taiwan	0.5	2.9	1.5	100%
Germany	0.3	260.0	56.5	100%
Tobacco operations				
Brazil	0	>50	2.5	22%[a]
Tanzania	1.0	6.0	4.2	23%
Taiwan	0.2	5.0	1.1	73%
Germany	0.3	212.0	22.1	39%

Source: Own farming systems survey; AFUBRA (2007); CSCPF (2007).
[a] 16% according to SINDIFUMO (2007) and 15% according to AFUBRA (2007).

With regard to various commercial tobaccos, artificially cured Virginia is grown in all four countries. Also called flue or Bright, Virginia is for use in American blend or straight Virginia cigarettes, accounting for 38–70% of all tobaccos inside the smoke product. Due to high sugar content, it has a good blending with other tobaccos. When chemically balanced with nicotine, it produces a smooth and flavourful smoke, and due to an easy control of the size of smoke particles, inhalation of nicotine is efficient (Fisher, 1999; Peedin, 1999). To a much lesser degree than Virginia, naturally cured Burley is also cultivated by German growers. Although Burley is grown as well in southern Brazil and Tabora/Tanzania to a small extent (URT, 1998; FAO, 2003b), none is reported among the surveyed farmers. Burley is a light, air-cured tobacco and the second most important constituent of an American blend cigarette (e.g., Marlboro). It accounts for less than 40% of all tobaccos inside the product, with the special ability to absorb about 600 additives such as casings and flavourings (accounting for more than 10% of the total weight of a cigarette) (Fisher, 1999; Palmer and Pearce, 1999). Other tobaccos in the survey include Geudertheimer, a dark, air-cured tobacco for use in cigars, mainly as filler. It is popular in dark French and Spanish cigarettes (e.g., Gauloise, Gitane), and it is also in demand of some local European industries such as in southwest Germany, apart from localities in Italy and France (Joossens and Raw, 1991).

Energy used in curing, including ecosystem effects

Farmers exclusively apply wood (Brazil, Tanzania) and oil (Taiwan, Germany) as artificial energy sources to cure green Virginia leaf. The other, less common tobacco varieties (Burley, Geudertheimer) use air/sun to transform green into dry (cured) leaves.

Wood in the form of poles and sticks is also used in the construction of curing barns regardless of which variety is cultivated.

In Brazil and Tanzania, all tobacco growers use fuelwood for curing Virginia in brick- or brick/wood-built barns. The farmers obtain 50% of the wood from their own lands and purchase another 50% (Brazil), or gather 30% of the wood from private and 70% from general lands and forest reserves (Tanzania). In both growing zones, about a dozen tree species are used. In Brazil, eucalyptus as an exotic species is the main type of wood, either used solely (44%) or in combination with native tree species such as *ovenho*, *ambotó*, *canela*, *angico*, *cavalho* and *gambotó* (66%). In Tanzania, indigenous tree species of the miombo woodlands (e.g., *Brachystegia speciformis*) are mainly preferred by tobacco growers.

The rates of wood consumption are similar in both growing zones (2.8 cubic m of fuelwood in Brazil and 3.4 cubic m per one curing charge in Tanzania), but total wood consumption on a farm level is higher in Tanzania (24 cubic m) than in Brazil (14 cubic m). The specific fuel consumption (SFC) for the flue-curing of Brazilian tobacco has decreased from about 6 to 10 kg of wood per kg of cured tobacco in the 1980s (Fraser, 1986, pp. 13–14) to 3 in this study. Also, the SFC in Tanzania has declined from about 50 to 60 in the 1960/70s (Temu, 1979), 25 to 40 in the 1970/80s (Boesen and Mohele, 1979; Mgeni, 1988; TRPDD, 1989), 12 to 26 in the 1990s (Waluye, 1994), to 13 in this study.

In Taiwan, all tobacco growers use fuel oil (heavy oil) for tobacco curing in brick-built barns, commonly in the form of 500 litres (l) of fuel oil for one curing charge (which can take in tobacco leaves from a field of about 0.3 ha). German farmers also use fuel oil for Virginia, with curing done in metal containers. Since containers are more efficient than brick barns, German farmers use less fuel oil (about 400 l) than Taiwanese farmers for one curing charge. Air-cured varieties such as Burley and Geudertheimer are dried in greenhouses or barns made of brick and/or wood, while the curing process is supported artificially, if needed.

Concerning changes in tree cover related to curing, tobacco growers in Taiwan and Germany report that the number of trees in their local area has not changed. In contrast, the numbers of trees have decreased remarkably in Tanzania and have increased in Brazil. Meta-analytical data from a range of sources, including evidence from published articles (Tanzania, not Brazil), confirm and also refine these trends in terms of the spatial dimensions and temporal scales involved—see Table 4 for broad categories as well as detailed references on tobacco-driven deforestation.

Dating back to the 1970s, the condition of forests in growing areas of southern Brazil was characterized as "deplorable" (Jungbluth, 1988, p. 15), mainly because forests once around the farms had been cut down for fuel to cure tobacco (Taylor, 1985). An estimated 12,000–15,000 ha of native forests were felled each year for curing (Crescenti, 1990), compared to the current level of about 6000 ha (Prado, 2000, p. 942). The aggregated impact in the tobacco-growing zones meant a reduction of native forest cover to only 2% of the original extent (Goldfarb, 2003, p. 39 citing Quesada et al., 1989). Still, some "destruction of native fauna and flora" is reported from the Rio Pardo Valley (Vargas and Bonato, 2007, p. 32). However, the general trend of losses in forest cover has been discontinued from the 1980s onwards, owing to legislative restrictions (all farms need to preserve 20% of their area as forest), the planting of exotic tree species (eucalyptus, pine) and improvements in curing technology (Jungbluth, 1988; Crescenti, 1990; FAO, 2003b; Frey and Wittmann, 2006; AFUBRA, 2007). The point has been made that, since trees planted by the farmers are mostly used in curing, some of the primary forest is left standing, "but reforestation does not really take place" (Christian Aid and DESER, 2002, p. 9).

In the northeastern tobacco-growing districts of Brazil, ongoing "destruction of native biodiversity" has been reported, and the claim has been made that negative consequences of tobacco farming are "clearly visible in the form of forest devastation, erosion and abnormally low water levels" (AGENDHA, 2007). However, the northeastern tobacco districts had already been described as "an area of open land with little forest cover" in the late 19th century (Barickman, 1998, p. 13).

In Tanzania, it has been reported that farmers complained about environmental degradation problems, specifically about "tobacco-growing areas turning into deserts due to land clearing for new farms each year and cutting trees for construction of tobacco barns and tobacco curing" (TTCF, 2007). As early as in the 1970s, this coupled process resulted in the rapid destruction of the woodlands (Temu, 1979), and in the 1980s it caused rapid deforestation (Mgeni, 1988) to the degree that "effects of desertification" around tobacco villages became visible in the early 1990s (Waluye, 1994, p. 252). Today, almost three quarters of the farmers in the Urambo district clear new forests and woodlands every season to improve their tobacco yields because they cannot afford the cost of heavy chemical pesticide application. Also, the district has an estimated 15% (42,738 ha) of arable land cleared each year to care for tobacco farming only (land for cultivation), which accounts for 3.5% of annual deforestation of the whole of forested land in Urambo. And clearing for curing purposes adds another 3% of annual deforestation (Mangora, 2005, p. 389).

Likewise, results from the Iringa area show that tobacco growers clear new land every 2 years, and that during the 1959–1999 period, "the causes of woodland degradation could be linked to tree cutting for tobacco curing and shifting cultivation for tobacco farming", with rates of deforestation ranging from 3.0 to 3.3% annually (Abdallah et al., 2007, p. 98). Already in the 1970s, fuelwood

Table 4
Evidence of deforestation by proximate activities and type of sources.

	ISI-accredited journals	Other literature	Public testimonies
Brazil, south			
Land clearing	0	0	0
Fuelwood for curing	0	XXXXXX[a]	0
Polewood for barns	0	0	0
Broad specification	0	X[b]	0
Brazil, northeast			
Land clearing	0	0	0
Fuelwood for curing	0	0	0
Polewood for barns	0	0	0
Broad specification	0	0	X[c]
Tanzania, Tabora region			
Land clearing	X[d]	XXXX[e]	X[f]
Fuelwood for curing	X[d]	XXXXX[g]	X[f]
Polewood for barns	0	0	X[f]
Broad specification			
Tanzania, Iringa region			
Land clearing	XX[h]	X[i]	X[f]
Fuelwood for curing	XX[h]	XX[j]	X[f]
Polewood for barns	0	0	X[f]
Broad specification	0	0	0

[a] Taylor (1985), Jungbluth (1988), Crescenti (1990), Prado (2000), Christian Aid and DESER (2002), Goldfarb (2003) (citing Quesada et al. 1989).
[b] Vargas and Bonato (2007).
[c] AGENDHA (2007).
[d] Mangora (2005).
[e] Boesen and Mohele (1979), Temu (1979), Mgeni (1988), Waluye (1994).
[f] TTCF (2007).
[g] Boesen and Mohele (1979), Temu (1979), Mgeni (1988), Barry (1991), Waluye (1994).
[h] Abdallah et al. (2007), Sauer and Abdallah (2007).
[i] Mgeni (1988).
[j] Mgeni (1988), Barry (1991).

extraction for tobacco curing had nearly exhausted natural woodlands in the area (Temu, 1979). In more recent years, the excessive use of wood during curing as well as unsustainable cultivation practices (including uncontrolled land clearing) have become "crucial factors for deforestation and eventually desertification" (Sauer and Abdallah, 2007, p. 427). As in Tabora, smallholder tobacco farmers in Iringa identify local, native miombo woodland species as being normally used for curing.

Workforce and economic livelihood

Most tobacco growers run their operations on a full-time basis (76% on average): all farmers in Tanzania, about three quarters in Taiwan and Germany, and more than half in Brazil. With the exception of Tanzania, more than half of all farmers have more than 20 years of experience in growing the crop (Table 5). Tobacco farming is primarily a family operation in Brazil, Tanzania, and Taiwan, but less so in Germany.

In Brazil, household labour, including children and elderly, constitute the majority of workforce. About 3 or 4 out of 5 family members work in the field (AFUBRA, 2000) which form about 90% of the total workers involved in growing activities, with the remaining 10% provided from (occasional) assistance by part-time workers and neighbours (Vargas and Bonato, 2007). It has been reported that "family farmers are operating on such tight margins that frequently they must use their children as free labourers, especially during the harvest" (Christian Aid and DESER, 2002, p. 3).

In Tanzania, tobacco is cultivated by smallholders, except for the Iringa highlands where most of the crop is produced on half a dozen plantations (estates) run by Greek owners/managers. In the Urambo district, the mean labour force at farm level has increased from 6 persons in 1964/1965 (Scheffler, 1968, p. 84) to 17 at present, with children constituting the largest group (5 out of 17). The remaining labour is made up of adult family members, dependents and hired workers. It is normal for households to schedule harvesting work during weekends, when children do not have to go to school to benefit from their labour. The number of paid workers has increased slightly from 3 (Scheffler, 1968, p. 84) to 5 persons in this study. In the Tabora region, the share of tobacco-growing families in all households has increased from 10% in the mid-1960s (Boesen and Mohele, 1979, p. 31) to 75% at present (Mangora, 2005, p. 389).

In Taiwan, the composition of workforce is mainly family labour, but tobacco farmers increasingly hire seasonal workers during the harvesting time. Also, a traditional labour exchange system is practiced by the *Hakka* (guest people) in Meinung. The system organizes families into teams, with each team having 12–15 labourers, providing the pooled workforce for planting and harvesting tobacco (Hong, 1999).

In Germany, each farm has an average labour force of 20 persons, with 3 family members and 17 paid workers on average. Compared with the situation in 2000, when the ratio was 1:3–1:5 (Kappelmann and Tschmarke, 2005, p. 29), the share of seasonal workers has increased in this study. The cost share of seasonal workers in all tobacco operations has climbed to about 85%, with most workers coming from Poland, Czechia and Slowenia for a maximum of three months per season (Ruhm and Bokelmann, 2005, pp. 35 and 39). Since the work of housewives and children is usually not paid, only 10% of the labour force in tobacco farming is fully employed (Kappelmann and Tschmarke, 2005, p. 19).

Table 5
Experience in tobacco farming ($N = 100$).

	Brazil	Tanzania	Taiwan	Germany	Total
Full time	14	25	17	20	76 (%)
Part time	11	0	8	2[a]	21 (%)
Years					
<5	1	5	0	4	10 (%)
6–10	0	7	0	2	9 (%)
11–15	1	3	1	3	8 (%)
16–20	1	3	3	3	10 (%)
>20	20	7	21	13	61 (%)

Source: Own farming systems survey.
[a] No answer in 3 cases.

The share of income from tobacco operations in all household income, although it ranges considerably among grower households, can be summarized in two patterns. In both Brazil and Germany, tobacco accounts for more than half of all household income in next to all farming families, and only one fifth (Brazil) and one fourth (Germany) of the growers state that it is "not enough". In contrast, between two thirds and four fifths of all tobacco farmers in Tanzania and Taiwan report that the share of tobacco-generated income has decreased since 2000 from "all" to "less than half". Furthermore, the average real income among smallholders in Tabora has been declining since production started in the 1970s, then already "less than the minimum wage level for an unskilled worker" (Boesen and Mohele, 1979, p. 38), with the trend continuing into the late 1990s (Ponte, 1998), at least.

Almost all Tanzanian and Taiwanese growers dispose of income from other sources, and, to a lower extent (60%), a comparable livelihood strategy is reported from growers in Brazil and Germany. Compared with the situation in 2000, other and even more important sources of income among Tanzanian tobacco growers are the sales of food crops, petty commodity trade and other activities such as transport and construction. In Taiwan, most growers earn an additional and now major income from the cultivation of other crops, especially those grown in rotation with tobacco (e.g., rice, beans) as well as from non-agricultural activities including old-farmer (retirement) payments. In Brazil, other and minor sources of income stem from cattle ranching and related activities such as dairy production. In Germany, tobacco growers generate some additional income from the cultivation of cereals and legumes (but less so animal production) as well as from non-agricultural activities, again, including retirement payments.

Diversification: other crop cultivation, and beyond

In most cases, tobacco is grown as part of an already diversified cropping pattern, though at varying degrees of specialization and under different systems of cultivation. For example, the share of tobacco in all landholding ranges from 22% in Brazil to 73% in Taiwan (Table 3), and the share of tobacco farmers practicing fallow rotation ranges from half of all farmers in Germany to next to none in Brazil and Taiwan.

Brazil

Since the late 1990s, the share of tobacco in all landholding has increased from 10–15% (AFUBRA, 2000), to 15–16% (AFUBRA, 2007; SINDIFUMO, 2007), to 22% in this study. The cultivation of other crops includes maize and beans (black bean, soybean) together with a wide range of other varieties (rice, potato, onion, cassava, fruits, vegetables, etc.), which except for maize are grown on less than 1 ha, on average. The majority of farmers practice crop rotation in up to two seasons per year. Land devoted to pasture (beef, dairy cattle, poultry, pigs), ponds (fish farming), fallow and native as well as reforested woodlots often account for more than half of the landholding (SINDIFUMO, 2007). The mean area of fallow in the sample is 1 ha, but practiced by only one farmer. Other sources specify an average share of land under fallow at 11% (AFUBRA, 2007; SINDIFUMO, 2007).

Two thirds of the growers do not consider switching away from tobacco; and more than half of the farmers ($n = 16$) perceive not having enough money as a major problem, so that tobacco is looked upon as an attractive option. Almost all farmers ($n = 22$) rely on credits to run tobacco operations. On the other hand, next to all farmers ($n = 23$) do not think that their children will continue with tobacco farming.

Although a total of about 15 organizations are involved in trading tobacco in southern Brazil (Frey and Wittmann, 2006, p. 12), most of the crop is transacted through the subsidiaries of three global leaf companies (processing/export firms), namely Universal Leaf, Alliance One and Souza Cruz/British American Tobacco (BAT). In this study, half of the farmers sold their tobacco to Universal Leaf, one third of the farmers to Alliance One, and the rest to four local companies. The companies form part of a cluster or tobacco value (commodity) chain which creates perceived benefits for growers due to the provision of loans, inputs, and technical support together with a well-developed marketing system and close contacts with nearby cigarette manufacturers, mediated by support from government agencies (thus, keeping production costs low and ensuring high leaf quality standards).

Tanzania

In a single rainy season, tobacco is cultivated together with maize, groundnuts, wheat and cassava, beans, rice and potato, which except for potato are grown on more than 1 ha, on average. Nearly all farmers practice crop rotation. The mean area of fallow is 2.2 ha, equalling 12% of all landholding. However, only a third of the farmers grow tobacco on the same piece of land for 2 or more consecutive years, which means a shortening of the fallow period to 4 years (while at least 20 years would be required for the restoration of natural fertility) (Mangora, 2005). This implies that a shift has occurred from slash-and-burn agriculture as practiced in the 1970s (Boesen and Mohele, 1979, p. 25) to a system of rotational and, partly even, permanent farming, notwithstanding the renewed land clearances for tobacco farming.

Tobacco growers are evenly split on the question of whether to switch to alternative crops. More than half of the farmers ($n = 14$) expect no reliable market for alternative crops, assuming low income due to poor prices or poor livelihood security. Other arguments include that farmers ($n = 13$) are not sure about alternative crops and worry about a stable source of loan for fertilizer. In contrast, farmers ($n = 12$) mention low prices, high input costs and poor grades as major reasons in favour of a shift. Likewise, tobacco growers are evenly split on the question of whether their children will continue with tobacco farming.

An obstacle in diversification is that all institutions have emphasized tobacco production at all levels and aimed at converting ever increasing numbers of peasants into tobacco growers (Boesen and Mohele, 1979). This applies to past situations (state tobacco monopoly), but also to the liberalized tobacco market in which private companies have operated since the 1990s. Transnational tobacco corporations such as Tanzania Leaf Tobacco Company (TLTC), a subsidiary of Universal Leaf, as well as Alliance One have contractual arrangements with smallholders, and all growers reportedly sold their tobacco to one of these companies (Alliance One 60%, TLTC 40%) from which they also borrowed inputs. No government incentives exist for crop substitution, but civil society groups and some farmers have been active (Kagruki, 2007; TTCF, 2007). Instead, both the Tobacco Board Act (1984) and the Tobacco Industry Act (2000) have established strict rules for contract farming (e.g., penalties for breaching the contract). Likewise, most research units in the country have their themes geared towards the search for improved varieties of tobacco (Abdallah et al., 2007).

Taiwan

In Taiwan, most tobacco growers cultivate crops such as banana, beans, rice, betel nut and taros in the course of altogether three seasons per year. One fourth of the farmers practice monocultural cropping of tobacco, and farmers with diversified crops practice rotational farming. In the combination of crops, most common rotational elements are tobacco–rice–rice, tobacco–rice–fallow (green manure) and tobacco–rice–other crops (beans, cassava, red pepper) combinations. The mean area of fallow is reported to be 1 ha.

A predominant number of tobacco growers (still) do not consider switching to other crops, given stable prices and incomes as well as familiarity with farming techniques ($n = 19$). On the other hand, even more farmers ($n = 23$) are convinced that their children will not continue with tobacco farming (the remainder have no children or have children too young to decide). Given their old age (Table 2), a considerable number of growers ($n = 11$) are already contemplating on retirement rather than worrying about shifting away from tobacco farming. Other growers ($n = 9$) expect a lack of capital as the major problem when shifting away from tobacco.

Dating back to the opening of the state-controlled cigarette market for transnational corporations in 1987, followed by Taiwan entering the World Trade Organization (WTO) in 2002, the relations between growers, tobacco companies and the state have changed considerably. The state-controlled TTWB was dismantled and set for privatization (still pending). Renamed Taiwan Tobacco and Liquor Corporation (TTL), the corporation currently re-negotiates land use agreements with local farmers in order to end the domestic production of tobacco due to comparative production advantages in other countries. In this study, all farmers sold their tobacco to TTL, which incrementally cuts back farming contracts and does no longer provide subsidies to cultivate the crop. With government programmes in work to help tobacco growers to switch to other crops, the already small area under tobacco will further decline and probably disappear within a few years (Perng and Trachtenberg, 2004; Wen et al., 2005).

Germany

In Germany, the share of tobacco in all crops cultivated on a farm has increased from 14–18% in 2000 (Kappelmann and Tschmarke, 2005, p. 20), to 33% in 2005 (Ruhm and Bokelmann, 2005, p. 29), to 39% in this study. Other crops include cereals such as maize, wheat and barley (40%), tuber crops (beetroot mainly) (6%), special cultivars such as horseradish, pumpkin, wine grape, rhubarb and carrots (4%), and legumes (rape) (2%). Non-arable farming such as fallow and pasture/meadows accounts for an average of 10% of all agricultural land per farm. The mean area of fallow is 3 ha (green manure, abandoned land), practiced by more than half of the growers. All farming is continuous cropping. Other studies confirm the relative share of individual crop covers in tobacco farming, further stressing that livestock activities are indeed rare (Kappelmann and Tschmarke, 2005; Ruhm and Bokelmann, 2005).

Farmers are evenly split on the question of whether children will continue with tobacco production (those farmers, who do not know, have no children or have children too young to decide). A minority of farmers plan to retire ($n = 2$), while others anticipate the loss of a lucrative income from tobacco ($n = 7$), an endangerment of continued farming ($n = 4$), and even the full collapse of all agricultural activities ($n = 8$). Other studies converge in the estimation that 10–30% of the tobacco growers will stop growing the crop in the 2006–2010 period (mainly due to old age), and that most of the remaining farmers will need to consider an exit from tobacco, if not from agricultural production until 2013 (due to financial reasons) (Kappelmann and Tschmarke, 2005; Ruhm and Bokelmann, 2005;

König, 2007). Most importantly, these studies suggest that, given the high degree of specialization, only few farms (5–10%) will survive on the basis of crop diversification as already practiced. These studies also agree that adjustment to the new situation will exert no impact on the overall agrarian structure, except for about ten villages in the southwest which hold more than 20% of land under tobacco in all communal land.

In 2003, tobacco farming became included in a routine reform of the Common Agricultural Policy (CAP) of the European Union (EU) (EC, 2003), with the aim to allow producers to adjust to a situation, where production support will be phased out (Gruijthuisen, 2007). Starting in 2006, premiums, which so far account for 70–75% of the final product price, will be reduced until 2010, thus factually ending the Common Market Organization (CMO) for tobacco. From 2009 onwards, 50% of the premium will be transferred into a flat-rate area subsidy, and another 50% will feed a structural reform fund to diversify away from tobacco. In 2013, tobacco support will be completely decoupled from production resulting in a reduction of individual farm support by 95% and forcing remaining (small) growers to abandon tobacco production. Currently, the government implements measures of adjustment, including tobacco exit and non-agrarian livelihoods, mainly based upon EU rural development policies. Different from Switzerland (Alber, 1998), cigarette manufacturers and global leaf traders such as Alliance One have no interest to compensate German tobacco growers in the form of increased product prices for lost premium shares (König, 2007). In this study, a considerable number of farmers ($n = 17$) sold their tobacco to Alliance One.

Discussion

Area and production development

Trends in tobacco land and production can be leading indices for transitions in the tobacco economy in particular countries, reflecting strategic initiatives by the transnational tobacco companies, in conjunction with national and local governments (Thun and Silva, 2003).

First, our results add support to the projected trend of "a continuing shift in the production of tobacco leaf from developed to the developing countries, and an increasing share of the developing countries in world tobacco leaf production" (FAO, 2003a, p. 55). Also, based on the observation of transactions which occur between global leaf companies, farmers and the state, at least partial evidence has been provided on the consolidation of tobacco industry activities in the developing world (Hammond, 1998; Yach and Bettcher, 2000; Cox, 2004; Collin, 2005). While production data alone show transitions as a result of both area development and changes in cropping intensity through agrotechnological developments (fertilizer, pesticides), if held against data on area development, it is obvious that the global shift of tobacco is linked to considerable land shifts, with potentially immediate ecological consequences for forest destruction and biodiversity losses, if not mitigated.

Second, data on land development further show that the global shift is more pronounced, but also less consistent than projected by FAO. Using a standard commodity framework and two modes of projections (based on the period 1970–2000), a share of tobacco land in the developing world projected for 2010 ranges between 86 and 87% (FAO, 2003, p. 42), which is already lower than the current trend. Also, individual country data and increases rather than decreases in global tobacco development suggest that the world tobacco market is less close to "saturation" or "stagnation" as claimed by FAO (2003a,b), a view supported by others (e.g., Keyser, 2007).

Third, most recent increases of tobacco production in the developed world (except Europe) point to productivity gains, which, again, need to be held against tobacco corporations' strategic initiatives. There is anecdotal evidence on the return of tobacco in the American farm belt (Etter, 2007), and the phenomenon needs to be better understood given the power of macroeconomic forces and public (tobacco control) policies in varying contexts of economically advanced societies, allegedly operating in the same direction (discontinuation of tobacco growing).

Environmental implications

The ecological implications of tobacco cultivation are part of the key agricultural provisions of the FCTC, but evidence remains "patchy" (Jha and Chaloupka, 1999, p. 32) and research poorly financed (WHO, 2004b). Therefore, new insights such as the ones generated in this study are considered to be urgently needed, both in terms of methodological considerations and empirical (though indicative) evidence.

Conceptually, it has been proposed to interpret curing-driven deforestation as a potential, but not necessary outcome of a complex, coupled human–environmental (land use) system, the analysis of which requires specific variables "that link natural and human components (e.g., fuelwood collection and use of ecosystem services)" (Liu et al., 2007, p. 1513). This has been achieved here in quantifying the type and intensity of wood consumption to dry green Virginia leaf, done together with an assessment of the related impacts on forest ecosystems in a comparative perspective. Previous work widely failed to couple the two components. For example, the industry-commissioned study of Fraser (1986) achieved the first, but failed on the latter, and Chapman (1994), in an edited special issue, compiled anecdotal evidence generated by journalists from talking to about half a dozen growers in Africa rather than comparing carefully researched studies using the same protocol across more than just African areas. In contrast to these studies, this work demonstrates that tobacco growers are at different stages of an energy transition with regard to curing technology so that varying impacts on ecosystem goods and services exist, thus requiring solutions tailored to particular situations. There are several implications of this argument.

First, a major claim of the tobacco control advocacy community that there is "massive deforestation" (Mackay et al., 2006, p. 48) due to tobacco needs to be modified in empirical terms. For example, China appears to have achieved an energy transition from wood- to coal-based curing technologies probably about two decades ago (Zhang, 1997), and the preliminary results from this study also prove that the massive deforestation statement applies especially if not exclusively to some growing areas (less so, countries) in the African miombo ecosystem zone (Saloojee, 2004). On the other hand, due to methodological improvements to measure the combined effects of deforestation through land clearance and curing-driven deforestation (Mangora, 2005), the extent of tobacco-related annual deforestation in these growing zones might be considerably higher than estimated in previous studies, which were based on energy needs in curing only (e.g., Geist, 1999). In sum, the usage of terms such as environmental "crisis" (WHO, 2004a, p. 2) or "desertification" (Waluye, 1994, p. 252), used to describe the particular and excessive impact of tobacco curing on native forest cover worldwide with hardly any differentiation made between different growing areas, very likely means an undue inflation of what the term actually implies (O'Connor, 1987).

Second, the "continuous reduction" of wood use in curing green leaf tobacco, as claimed in industry-commissioned works such as those of Fraser (1986) and Campbell (1995), can very likely not be substantiated given the preliminary results in this study. It has

been found that the current rate of wood consumption per curing charge in Tabora still matches what growers had consumed in traditional 12′ × 12′ × 16′ curing barns about 30 years ago (3.3 cubic m) (Temu, 1979, p. 13). If confirmed by other studies, this would reveal severe deficiencies in the improvement of curing technology and, thus, the provision of technical support by tobacco companies. In sharp contrast, the websites and reports of transnational trade and cigarette corporations praise their environmentally responsible corporate behaviour (Yach and Bettcher, 2000; Palazzo and Richter, 2005), while the agricultural lobby of the tobacco industry, notably the International Tobacco Growers' Association (ITGA), continues to challenge the environmental argument, claiming that tobacco promotes "the sustainable development of the region" (where it is grown) and that "it is less harsh on the environment than many other crops" (ITGA, 2007). However, so far only the historical tobacco belt in New England suggests a case for forests to be able to reclaim former tobacco land (Kauppi et al., 2006, p. 17578). Despite claims to the contrary (Crescenti, 1990; Frey and Wittmann, 2006), alleged "reforestation" in southern Brazil (FAO, 2003b, p. 24) appears to be less straightforward than stated.

Finally, a limit of our study is soil degradation and water pollution. In the absence of any direct measurements (which were beyond the scope of this study), there is indication only from Tanzanian growers, who report lost or impoverished soil fertility as a major soil and production problem. However, it is not clear why these farmers practice soil mining rather than restoring lost nutrients by fertilizer, especially since these are better-off farmers with tobacco holdings ranking far above the values specified in other studies for about the same area—e.g., 1.0 ha (Ramadhani et al., 2002, p. 230) and 1.3 ha (Mangora, 2005, p. 389). These ecosystem effects remain poorly researched and understood, and the situation is very likely to continue until direct measurements are done.

Barriers and opportunities for diversification

Preliminary results from this study indicate that, rather than carefully designed conversion projects, the generational aspects of farming are already crucial in potentially ending domestic tobacco cultivation on the level of individual farms, if not nationally. The case of Taiwan, in particular, confirms the rule that there is a "strong, negative linear trend between age and trying alternative enterprises" (Altman et al., 1996, p. 195). However, as the Tanzanian example shows, growers may opt to stop intermittently, diversify or discontinue tobacco farming, but new growers are recruited easily. So, it seems very likely that "the expansion of demand in the developing countries . . . drives the tobacco economy of the world", with the sound assumption that supply responds to demand and "is increasing in countries where production costs are low" (FAO, 2003a, p. 56). Nonetheless, preliminary results of this study tend to contribute to the growing body of literature which demonstrates "that many other commodities have the potential to rival and even surpass tobacco in terms of gross and net profits, returns to cash and returns to family labour" (Keyser, 2007, p. 43). Surveys among tobacco growers on diversification issues are rare, but early results from the flue-cured tobacco districts in the southeastern USA already revealed that half of the farmers had learned about on-farm alternatives to tobacco and found profitable alternatives (Altman et al., 1996). Likewise, specific efforts to diversify, for example, into soybean, poultry, hog, and cotton operations date back to the 1960s, at least (Hart and Chestang, 1996). In this study, the respective share of farmers, who are confident about conversion and diversification, is considerably lower. On the other hand, it is also apparent from this study that the base for diversification away from tobacco is set by an already highly diversified cropping pattern in which tobacco is integrated as one of many other crops (see also, Craig, 2008; Vargas and Bonato, 2007; Keyser, 2007; Hart and Chestang, 1996).

In developed countries with relatively large shares of industrial and service economy activities (Germany, Taiwan), diversification in the tobacco-farming sector is less of a problem. Put in neoliberal wording, "industry transitions can be difficult and may create social and political problems in the short-term, but economies go through many such transitions, and this one would not be exceptional" (Jha and Chaloupka, 1999, p. 69). In Germany, and with regard to Virginia only, climate alone can make the crop no longer competitive with the standards of flue tobacco produced, for example, in southern Brazil and southwest China. In addition, German tobacco has a low nicotine filler-type quality and is primarily consumed by the cigarette industry abroad, so that it can be easily substituted (Achilles, 2004). With the removal of tobacco subsidies and the rising costs of hired labour, it is obvious that the production of domestically grown tobacco is on a decline, and the situation appears to be similar in Taiwan. In both cases, social and political problems are limited to some communities with high degrees of specialization in tobacco growing, but transitions should be smooth due to policy changes of government agencies. In the EU and Taiwan, the best mid-term strategy for growers might therefore be to harvest tobacco revenues as a driver of new investments in other areas. One needs to acknowledge that tobacco production is "a small part of most economies" (Jha and Chaloupka, 1999, p. 68), and evidence exists from other growing areas that even in communities with a long history of cultivating the crop, "tobacco restructuring had not necessarily posed a livelihood shock" (Craig, 2008, p. 31).

The situation seems different in countries with heavy use of cheap labour and natural resources, forced to generate income from tobacco exports. Again, the guiding principles are that there is "little prospect of a sharp and sudden reduction in tobacco production" (Jha and Chaloupka, 1999, p. 71) and that "any successful transition from tobacco will almost certainly be a gradual process" (Keyser, 2007, p. 43). In the meantime, governments could be advised to meet the transition costs for their poorest tobacco growers, since farming is a major source of rural employment, and because grower associations can represent significant "emotional" political opposition to tobacco control (in terms of public health) (Warner, 2000). In Tanzania, a combination of agricultural policies and aid/development assistance would probably help poor tobacco growers switching to other crops. The case of Brazil is different, because tobacco farming is not a leading earner nationally. Also, with no subsidies provided by the government to tobacco growers (such as done in Turkey and India, for example), the tobacco industry has invested heavily in the production of the crop, so that there is little prospect for tobacco land to be switched to other uses (FAO, 2003a). In another study, however, the same organization (FAO) is more confident about the tobacco transition in southern Brazil, stating that there are "opportunities to diversify and move away from tobacco" (FAO, 2003b, p. 25). Our results speak out in favour of the latter view, which is also supported by the outcome from an earlier farming survey (Goldfarb, 2003, p. 41, citing Etges, 1989). The survey found that, given the environmental damage from tobacco (among others), 41% of tobacco producers said they would switch to another crop if certain economic conditions existed, including the availability of good credit and a market guarantee for the new crop. Landless sharecroppers and those renting land from landowners (constituting one fifth of all growers) would be the type of poor farmers to be targeted, because contractual arrangements in southern Brazil require all those farmers either to grow tobacco or to leave the farms (Keyser, 2007). In both cases (Brazil, Tanzania), solutions would need to fit the local context in which farmers operate, and bottom-up approaches would appear to be better suited than simply "refusing to lend money to nations for the purpose of

increasing tobacco farming" (Sugarman, 2001, p. 262). Appropriate action would very likely involve a mix of policies and different efforts such as "encouraging sound agricultural and trade policies, the provision of broad rural development programs, assistance with crop diversification, rural training, and other safety-net systems" (Jha and Chaloupka, 1999, p. 71).

Preliminary insights from this study reveal two major concerns, which have been identified only recently in the ongoing discussion about diversification opportunities and barriers (WHO, 2008).

First, various modes of contract farming across tobacco-growing areas in the world have become the dominant social form of land use organization, which allows a small group of oligopolistic transnational tobacco corporations to establish direct contact with growers, thus producing tobacco at low-cost conditions, including the USA since 1999 (Craig, 2008). This actually poses a serious public policy issue in so far as government and civil society have hardly any means to alter the contractual arrangements between local farmers and global leaf companies. It has been early recognized that what is often lost in these discussions is that "the plight of tobacco farmers is affected more by tobacco company practices and worldwide economics than by tobacco control" (Altman et al., 1996, p. 192). In Brazil, for example, religious groups, ecology-minded organizations and some political leaders (representing family, small and landless farmers) have raised awareness about the need to diversify away from tobacco in the context of environmental damage, among others (Prado, 2000; Goldfarb, 2003; AGENDHA, 2007). Likewise, *Movimento dos Pequenos Agricultores* (MPA), a small farmer organization, has pointed to the "debt bondage on tobacco farms that are an immediate result of these companies' direct contract with farmers", also "preventing them from producing alternative crops, and obligating them to rely on their children's labor to help beat back the debt" (MPA, 2007).

Second, the high-labour intensity of the crop plays a surprisingly minor role in the discussion, but it actually links to issues such as child labour and the vulnerability of farming in certain political economy contexts. Preliminary results from this study show that labour issues can easily turn into severe bottlenecks of tobacco production, particularly in those countries, where paid labour becomes significant for tobacco operations. The recruitment, availability and high costs of seasonal labour already pose considerable problems among German farmers, and a similar bottleneck, though more often centred around labour right issues, is typical for farming operations in Brazil. In contrast, workforce is not a concern in Tanzania, and only some labour shortages may occur in Taiwan during harvesting and after natural disasters. Contrary to claims brought forward by the tobacco industry and its agricultural lobby on labour issues (e.g., in Brazil, "children and elderly members do not deal with tobacco" (AFUBRA, 2000)), this study has found that unpaid family workforce, notably child labour, is an important constituent of tobacco cultivation, not only in Brazil, but in other countries as well. Although this issue is not addressed explicitly in the FCTC, it could be turned into a strong argument with regard to tobacco land use policies in Tanzania (Masudi et al., 2001) as well as in probably many other growing countries. On the other hand, it needs to be acknowledged that corporate responsibility projects of the tobacco industry have been extremely successful in sidestepping tobacco labour exploitation, often done in combination with the deforestation issue (Otañez et al., 2006).

Theoretical considerations

Finally, in theoretical terms, this study proposes that a more subtle analysis be applied to global trends in tobacco growing, acknowledging that the livelihood of farmers can be affected more by corporate behaviour and macroeconomic forces than by tobacco control, as the collapse of tobacco growing in the Copán Valley of Honduras reveals (Loker, 2005). Apparent from the specific interactions between growers, leaf companies and the state (Zündorf, 2001), a political economy type of analysis of the agricultural sector is urgently needed. From the host of forces, which impact rural livelihoods and communities, the particular interplay between macroeconomic conditions and public policy has been highlighted as crucial (Ramsey and Smit, 2002). In a step further, which is beyond the scope of this study, farming surveys using common data protocols need to get linked with methods such as "political mapping" and "stakeholder analysis" (GAPT, 2000).

Further studies may adopt an actor-oriented approach centred around tobacco growers but also focus on transnational tobacco corporations and their strategies. Full business (value, supply, commodity) chains or networks need to be studied, evaluated and monitored. The strategic motivation to do so is that corporations are closely linked to the needs and perceptions of the investors concerning agricultural resources (raw tobacco), curing (nicotine generation), processing and manufacturing technologies (cigarette production), marketing (advertising, sales), and lobbying, especially the creation of "emotional" agricultural front groups of the cigarette industry. By leveraging this sensitivity to the perceptions of the investors, especially NGOs in a direct manner or through the Framework Convention Alliance (FCA), can seek to redirect the scope or direction of global tobacco corporations by focussing on demand in combination with (agricultural) supply-side aspects (Geist and Schulze, 2007).

Finally, the downward trend in Taiwan indicates that it might be too simple to portray divergent developments along the North–South divide and that South–South examples or structures are worthwhile to be explored in future. It further raises speculations about what could happen in mainland China which is the world's largest producer (and consumer) of tobacco. Can the trend in Taiwan be taken as a model for potential mainland developments, especially following China's entry to the WTO? If so, statements such as that the total area used for tobacco production is "projected to change little" (FAO, 2003a, p. 41) would again no longer be valid. Or will the Chinese tobacco monopoly become part of the neoliberalization of tobacco production? If so, this would add to the excess corporate power of global trade and/or manufacture corporations that already undermines tobacco growers' livelihoods and restricts possibilities for sustainable resource use and diversification. One must consider that land use systems follow an emergent rather than predictable pattern (Lambin et al., 2003), and that tobacco growing is probably no exemption.

Conclusions

As provisions of the FCTC take effect from 2005 onwards, the long-term future of *N. tabacum*, first time after the start of commercial cultivation about 400 years ago, "is uncertain and likely to decline" (Keyser, 2007, p. 3). The consumption of smoke products is expected to increase globally for at least the next 25 years, so that any land use transition, either based on or away from tobacco, will be gradual and smooth in most cases. Production exits at the level of individual farmers have already occurred in Taiwan and Germany, as it has been the case with another dozen countries since 1961 (e.g., New Zealand, Singapore), and as it will be the case with about half of the EU member states which grow tobacco at present (EC, 2003; FAO, 2008). The situation is different, however, in Tanzania and Brazil due to peculiar circumstances of the political economy of tobacco production in these countries. It can be reasonably assumed that due to low production costs, including poor law enforcement with regard to social and environmental standards, tobacco farming will continue to be a major compo-

nent of cropping in the respective areas of cultivation in these countries.

There is no one-size-fits-all approach to diversification, but local solutions will need to fit local conditions. However, contrary to claims raised by the tobacco industry and its agricultural lobby (notably ITGA), it has been shown that tobacco is best grown as part of an already diversified cropping pattern because high degrees of specialization mean high (economic) vulnerability. It has further been found that several crops, including those from organic farming, as well as non-agrarian livelihoods can be more profitable than tobacco, given that adjustments in agricultural supply chain processes, including a lessening of the power of global tobacco corporations, can be achieved and multiple value chains be created.

Still, extensive research and evidence is missing on the social and environmental costs of tobacco growing. A portfolio approach, including low-cost (small N) farming surveys, meta-analytical study and political economy analysis, is timely and necessary. For example, preliminary results reveal that tobacco growers in different countries apply variable diversification techniques and are at different stages of the energy/curing transition (e.g., serious degrees of contemporary deforestation in Tanzania but less so in southern Brazil). In some developed countries, local tobacco conversion projects have already been implemented or completed, contributing to increased forest cover, among others. However, negotiations between tobacco control advocacy groups, national governments and aid/development agencies are still at its infancy with regard to the large group of poor and most vulnerable smallholders in the developing world.

In this study, we did neither seek to provide an overview of all types of issues centred around the global tobacco transition, nor did we attempt to make specific conversion project recommendations. However, it is expected that a much larger cohort investigation into tobacco growers' activities and perceptions across growing areas in major world regions, supervised by an international network of supply-side tobacco (control) researchers, can better support the work of the UN Study Group ESATG (WHO, 2008). This would contribute to regularly collecting and disseminating information on tobacco production and the activities of the tobacco industry according to the FCTC article 20.4c (WHO, 2005). Since the COP to the convention obviously avoids data-driven efforts, the global surveillance of tobacco development will fall under civil society's responsibility "to develop a mechanism to monitor the implementation of this first international public health treaty" (Jategaonkar and Huber, 2007, p. 2).

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