Figuring rural development : concepts and cases of land use, sustainability and integrative indicators

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Material Flows in a Social Context: a Vietnamese Case Study Combining the Material Flow Analysis and Action-in-Context Frameworks

Abstract

Material flow analysis (MFA) is one of the central achievements of industrial ecology. One direction in which one can move MFA beyond mere accounting is by putting the material flows in their social context. This "socially extended MFA" may be carried out at various levels of aggregation. In this chapter, specific material flows will be linked to concrete actors and mechanisms that cause these flows, using the Action-in-Context (AiC) framework that contains, inter alia, both proximate and indirect actors and factors. The case study site is of Tat hamlet in Vietnam, set in a landscape of paddy fields on valley floors surrounded by steep, previously forested slopes. Out of the aggregate MFA of Tat, the study focuses on material flows associated with basic needs and sustainability. The most important actors causing these material flows are farming households, politicians, traders, and agribusiness firms, of which local politicians turned out to be pivotal. The study shows the value of combining MFA with actor-based social analysis. MFA achieves the balanced quantification of the physical system, thus helping to pinpoint key processes. Actor-based analysis adds the causal understanding of what drives these key processes, leading to improved scenarios of the future and the effective identification of target groups and instruments for policy making.

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3.1 Introduction

Material flow analysis (MFA) constitutes a major approach for studying linkages between environment and society. This chapter addresses one limitation of industrial ecology (IE) and MFA, mentioned by Hinterberger and colleagues (2003) and worded by Duchin and Hertwich (2003: 9) as follows: "[IE and MFA] have until now not embraced a systematic approach to studying the economic, social and psychological aspects of decision-making."

Aggregate material flows studied in MFA can be linked to general economic system characteristics such as those of computable general equilibrium models (Ibenholt 2002), applied general equilibrium models (Kandelaars 1999), or simply gross domestic product (GDP). Kytzia and Nathani (2004) refer to this approach as the integration of material flows into a larger economic framework. Conversely, economic and other social elements may be added to models in which MFA stands central, giving rise to a family of approaches that could be called "socially extended MFA", of which the strictly economic version, discussed by Kytzia and Nathani and called by them "economically extended MFA", is one subset.

The integration of material flows into larger economic frameworks may generate relevant system-level descriptions such as dematerialization (material flows divided by GDP; Eurostat 2001). It does not, however, give causal insights, because causal agency (i.e. the decision making of actors) is not represented at the general system level. Socially extended MFAs may fare better in this respect, because they allow coming closer to concrete actors. One example of extended MFA with relatively lumpy material flows and actors is found in work by Kytzia and colleagues (2004), where flows of "food products" run between aggregate actors such as "agriculture" and "retailing". This level of aggregation can be used for scenarios such as simulating the effect of vegetarian diets on land use. Causal explanation as to *why* such things would happen requires a more truly actor-based approach that facilitates more insight into actors' decision making over concrete material flows, for example, farmers choosing between land-use options, food industries considering their options, or consumers deliberating on purchasing environmentally friendly goods. This level is also referred to by Fischhoff and Small (2000) when they say that for progress in IE, there is a need to connect IE models with models of human behavior. For a related discussion of the need to link integrate social scientific methods into industrial ecology, see the article by Andrews (2000) on microfoundations for industrial ecology.

The social sciences provide a wide variety of behavioral models that may be used for socially extended MFA. They may be grouped as micro-economic models, broader models of rational choice, and models that also include "non-rational" elements, such as social norms. All of these actor-based models link up closely with the design of policies. Roughly, the more comprehensive the model being used to explain why actors behave the way they do, the more comprehensive the policy that can be designed. Moreover, as we will exemplify here, actor-based analysis does not need to be confined to the actors that directly generate the material flows. Chains of indirect actors may be identified, too, as well as the causal mechanisms through which the actors are connected to each other. With that, the social structures of power that generate the material flows come within reach. All actors identified in the causal chains are potential target groups for policy making.

Binder and colleagues (2004) give an example of an actor-based socially extended MFA of regional wood flows. In the present chapter, we introduce an alternative actor-based approach. In comparison to the work by Binder and colleagues, the present study is based on more explicit views of the decision-making processes of actors and chains of actors that generate the material flows. This chapter does not, however, aim at comparing different approaches, but rather, at adding another example in this line of methodological development, and thereby preparing the ground for evaluating or integrating different approaches in the future.

Against this background, the aim of the present chapter is to elucidate and to illustrate the value of an explicit actor-based connection between material flows and their social driving forces (actions, actors, and mechanisms). For the illustration of this socially extended MFA we use data from a village study in Vietnam, gathered in the framework of the EU-funded project Southeast Asia in Transition.

The structure of the chapter is as follows. (1) We first establish an aggregate MFA of our Vietnamese location and then select a number of interesting concrete flows out of the aggregate. (2) These flows are connected to the proximate actors, and it is explained why the actors generate these flows. (3) The final analytical step is to link the decisions of these actors to those of other actors exerting power over them, such as government agents. (4) On that basis we look at the future, identify policy options, and conclude on the value of connecting MFA with an actor-based social-scientific approach. For steps (2) and (3) we will use the Action-in-Context (AiC) framework of De Groot (1992), which we found appropriate (without systematic comparison, and hence without any

claim of superiority) due to its explicit character, balance, and focus on multi-actor social causation.

3.2 Research area and fieldwork methods

Tat hamlet belongs to Tan Minh village, Hoa Binh Province, Vietnam. With a total territory of 740 hectares, it lies 140 km west of Hanoi. Most houses in the hamlet are found along the stretch of road that follows the river in the central valley, where 22 hectares of paddy fields have been developed. The valley lies at 300 meters elevation and is surrounded by mountains that reach up to 1,000 m, resulting in steep slopes, often of 45 to 60 degrees. On these slopes people practice swidden (shifting) cultivation,[12] covering an area of about 47 hectares. Tat is mainly inhabited by the Tay ethnic group. In 2001, the population consisted of 466 persons in 105 households.

Up until 1992, Tat relied almost completely on subsistence production. Especially since the improvement of the road in 1999, Tat has become deeply involved in the market economy, based on paddy (irrigated rice), swidden, livestock, and forest products. Vien (2003) and Rambo and Vien (2001) provide a detailed description of Tat's resource management system.

Researchers from Leiden University and Vietnam National University collected data in Tat from August to December 2001. A survey covering all households was conducted for basic socioeconomic and demographic data. A random sample of 29 households (i.e., a sampling factor of 3.83) then participated in a questionnaire to estimate their main material flows and stocks. Direct measurements and observations were carried out for buildings, waste flows, and food consumption. Household waste was measured for six different households during one week, for instance. To gain insight into the decision-making processes of the villagers, the team conducted semistructured interviews with a subset of the 29 households and used participatory methods such as option ranking and historical diagramming. Informal interviews were conducted with key respondents, including the hamlet leader and traders, also covering sensitive issues such as illegal logging. Detailed information on the

[12] Swidden or shifting cultivation is a form of agriculture also known as slash-and-burn agriculture. The system entails burning a patch of forest, cultivating there for some period until the soil decreases in quality and the land becomes overridden with weeds, and then leaving the plot to lie fallow for soil regeneration while it usually returns, to some degree, to forested land.

study can be found in Hobbes and Kleijn (2006). We do not go into issues here of the exact representativeness for the region or the exact statistical status of all data, because the function of the study is to illustrate a methodology rather than to contribute to empirical area studies.

3.3 The local MFA

The Aggregate MFA of Tat

An aggregate MFA (often called "bulk" or "economy-wide" MFA in, for instance, Daniels and Moore 2002) of Tat was established first. The advantage of this type of MFA is the international comparability of its indicators (Bringezu et al. 2003; Hobbes 2005, Chapter 4). The aggregate MFA follows the principles of Eurostat (2001), which distinguish between two system boundaries as shown in figure 3.1. The inner boundary draws the distinction between the society and its domestic environment. The outer boundary displays what belongs to the society under study and what to other economies. Material flows are defined as displa-

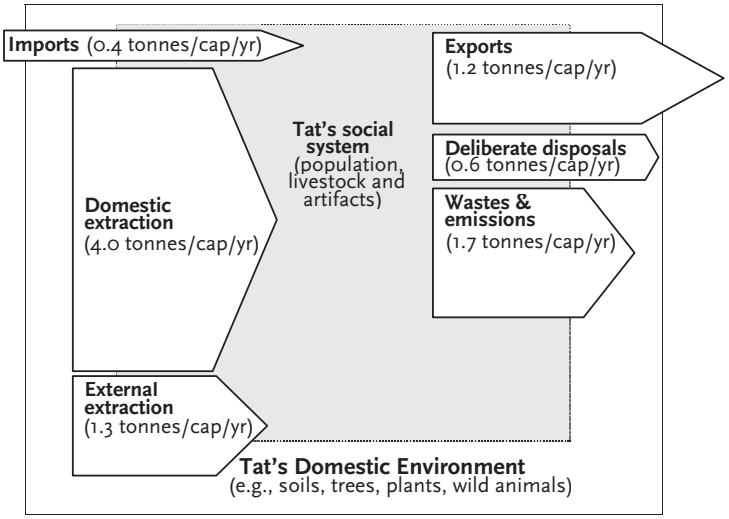

Figure 3.1 The aggregate MFA of Tat (excluding flows related to road paving). Flows are given in tonnes per capita per year, with moisture contents as actually present when the material is used (except for wood that is standardized at 35 percent moisture content and manure that is taken as dry weight). *Source*: Compilation of different data sources based on Stalpers (2003).

cements of materials directly caused by human labor or labor substitutes. Materials flowing into the social system are called inputs. If inputs flow from the domestic environment to the social system, they are called domestic extraction (DE); if inputs flow into the social system from foreign territories via an economic transaction, they are called imports. Because the inhabitants of Tat extracted a significant amount of products from the domestic environments of neighboring hamlets, a flow category called external extraction (EE) was introduced to make a distinction between these flows and the import of goods. Outputs from the social system flow either into a foreign territory (export) or to the domestic environment. In the latter case, the flow is called a deliberate disposal (DD) if the material is disposed with a further purpose (such as sowing seeds or applying fertilizer), and called wastes and emissions (WE) if disposed of without a further purpose. We have excluded the flows associated with the paving of the road that happened to take place during the fieldwork period, because these dominated the MFA without adding relevant insight. For instance, the directly measured net additions to stock (NAS) of the society were 320% over 2001 if the paving is included, compared to 1% if excluded. The NAS is not included in the figure, because it was only 0.034 tons per capita per year. The time frame of the MFA of Tat is from October 2000 to September 2001.

The direct material input (DMI) indicates the material dependency of the society. It is the sum of the imports, domestic extraction (DE), and external extraction (EE). The DMI of Tat was about 5.7 tons per capita per year, out of which 70% was DE and 23% was EE. The remaining 7% was imported from the markets in the lowlands.

Subtracting the export from DMI in order to get the direct material consumption (DMC), we see a drop to 4.5 tons per capita per year. Thus, about 80% of Tat's DMI was consumed within the society, whereas the remaining 20% was exported.

The physical trade balance (exports minus imports) was about 0.8 tons per capita per year; exports weighed 2.3 times more than imports. Typical for a rural economy, this is due to the fact that the exports consisted of raw materials and the imports consisted of final and processed goods (see figure 3.2).[13]

[13] Balancing the inputs and the outputs we notice that the totals do not match. This is mainly due to the different water content of the various materials (Hobbes, 2005).

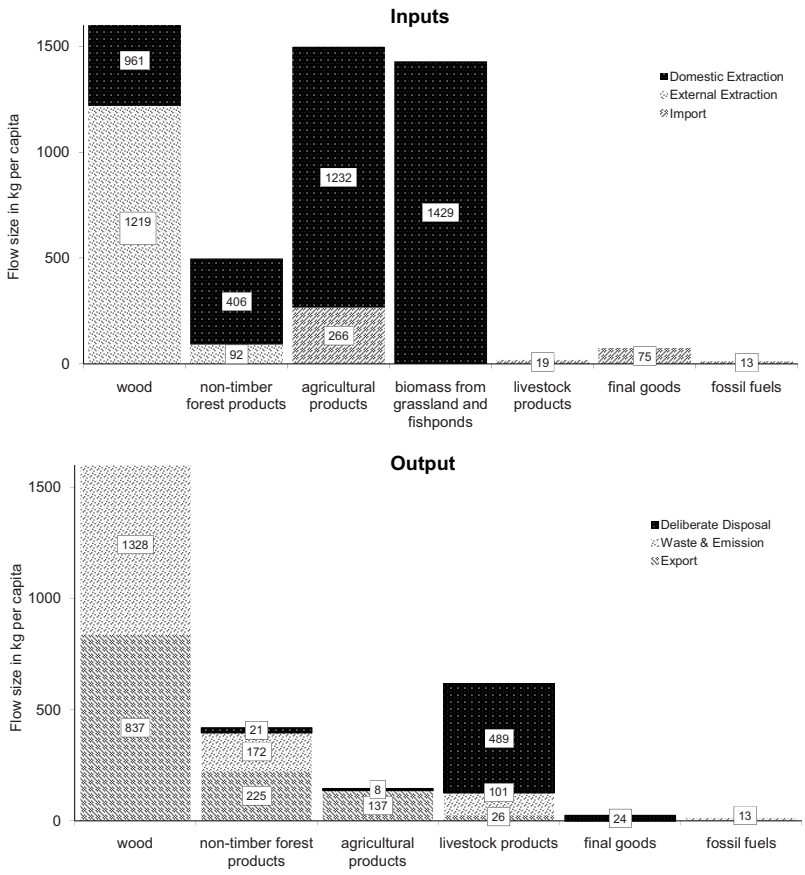

Figure 3.2 The input and output sides of the MFA of Tat hamlet (excluding flows related to road paving). Flows are given in kilograms per capita per year, with moisture content as actually present when the material is used (except for wood, which is standardized at 35% moisture content, and manure, which is taken as dry weight). Outputs exclude human excrement. The first two digits are significant. Note that the (wood) data being represented by the first bar on each graph actually far exceed the height of the graph, but the bar has been truncated on each graph to save space. Source: Compilation of different data sources based on Stalpers (2003).

Disaggregated Values of Material Flows

It is well known (e.g., Kleijn 2001) that aggregate MFAs do not link up unambiguously with environmental impacts, because all materials flows are accounted for on a mass basis regardless of their per-kilo environ-

mental impact. Moreover, and of special relevance for the linkage between MFA and explanatory social science, the aggregate flows cannot be connected with the concrete decision making of actors. Therefore, figure 3.2 gives more disaggregated information on the input and output flows.

The figure shows that the inputs for Tat came mainly from the forest and soils with only a small contribution from final goods. Wood constituted the largest flow, adding up to 2 tons per capita per year. The domestically extracted portion was firewood, returning as waste and emission (WE) in the outputs. The other portion of the wood input was timber extracted from the territories of neighboring hamlets (EE). Of this amount, 30% ended up as WE in the conversion from round to square logs. About 98% of the remaining timber was exported.

Bamboo and bamboo shoots are included in the nontimber forest products (NTFP) category in figure 3.2. Of the approximately 200 kg of bamboo collected per capita per year, about 85% was used as fuel and 15% for construction. About 130 kg of fresh bamboo shoots per capita per year was collected, of which about 70% was marketed. The marketable variety was not available in Tat's own territory any more and was externally extracted. Other NTFP were mainly domestically extracted — sun-dried broom grass for marketing (about 34 kg per capita per year), sundried palm leaves for roofing (about 85 kg per capita per year), green manure (a combination of leaves, grass, and cattle manure; about 19 kg per capita per year), and plant roots for food and for medicines (about 3 kg per capita per year).

Agricultural products formed the second largest component of the DMI at about 1.5 tons per capita per year. About 18% of Tat's agricultural products were imported, such as livestock feed, seeds, and foodstuffs (e.g., rice, vegetables, and fruits). The remaining agricultural products were locally produced in the paddy fields (about 15%), swiddens (about 69%), and home gardens (about 14%). Rice, cassava, corn, potatoes, vegetables, and fruit were grown mostly for personal use, with most of the cassava, corn, and potatoes consumed by livestock, especially pigs. At the output side we see some deliberate disposal of seeds. The exports of agricultural products consisted of canna, ginger, and cassava roots, all originating from the swiddens and amounting to about 137 kg per capita per year.

Livestock consumed all of the biomass that originated from the grasslands and fishponds (grass and water vegetables). The biomass returns at the output side as the deliberate disposal of livestock products shown

in figure 3.2, which was almost wholly manure of pigs, used to fertilize paddy fields, home gardens, and fish ponds at about 100, 5, and 380 kg per capita per year, respectively. About 26 kg per capita per year of livestock products, mainly meat, was exported.

Material Flows Selected for Explanation

As previously stated, material flows must be sufficiently disaggregated to be open to actor-based explanation. The whole of the aggregate MFA could be explained by focusing on all major flows one by one. Here, we will focus on only a few of them, selected for reasons of relevance to the population of Tat, analogously to Pfister's (2003) case study in Nicaragua, in which she focuses on the flows most strongly connected to sustainability and basic needs.

The (disaggregate) MFA shows that Tat imported rice. The MFA also shows that Tat produced about 63 tons of dry milled rice, which, when divided by the World Health Organization (WHO 1985) standard of calorific need for an average rural adult in the developing world of 2,500 kilocalories per day (equal to 252 kilograms of dry milled rice per year), can be shown as indeed not sufficient to feed the population. Although rural communities in Southeast Asia would prefer to be self-sufficient in rice, the rice deficiency of Tat would not be really problematic if the cash needed to buy the rice supplement could be earned by sustainable activities. This appears not to be the case, however. Of the four main export flows (figure 3.2), timber and NTFP were extracted in the territories of neighboring villages, their own territories already depleted. Of the exported agricultural products, the major flow came from the swiddens. Swidden cultivation may be sustainable at approximately 20 inhabitants per square kilometer (km2) in tropical forest areas (Dove 1985). This figure may be somewhat higher in Tat because people extracted some 15% of their agricultural products from nonswidden (paddy) land, but the actual population density was far beyond that, at almost 67 persons per km2, even if we take the full 7 km2 of the village territory as available for swiddening. Cuc and Rambo (2001) confirm this problematic situation, as did our own observations. People of Tat mentioned a strong decline of swidden productivity (between 20% and 50% in recent years) due to soil degradation.

Good locations for making swiddens were ever farther away from the village. Besides buying rice (and basic needs such as school fees), the cash earned in the exports was needed to buy the hybrid rice seeds and fertilizers (approximately 85 US$. per hectare per year) to keep up the domestic rice production. All in all, then, it appears that not only the

rice supplement but also the domestic rice production, and with that Tat's most basic staple, was based on unsustainable extraction and swiddens. Against this background, it was decided to focus further study on the flows of timber, bamboo shoots, and swidden products.

3.4 Action-in-Context: the framework as applied here

Following principles laid down by Vayda (1983), the Action-in-Context (AiC) framework developed by De Groot (1992) offers a structure for explaining human activities. The application starts out from the activity (or deliberate inactivity) to be explained and then works its way outward into an ever-widening context of actors, factors, and mechanisms.

The first step in AiC is always as follows: Starting out from this or that activity, who are the actors? Actors are defined as social entities with decision-making influence over the activity in question, which in MFA is the generation of a material flow. These may be individual people, collective actors such as firms, organizations, or government agencies, or categories of these assumed to have sufficiently equal properties (Botsford 1992). After the identification of actors, the assumption is that people act the way they do because (a) they *can* do it and (b) they *want to* do it. These two conditions for human action go under many names in the social sciences, such as "capacity", "opportunities", and "desires" (e.g., Elster 1989; Bebbington 1999). In AiC, they are called "options" (i.e., the actor's alternative courses of action) and "motivations" or "motivational factors" (i.e., the considerations the actor uses to arrive at a decision between the options, such as financial cost and benefits, cultural value, or long-term value). Options and motivations, in turn, are causally embedded in culture and the structure of society. To elucidate this linkage, AiC supplies a conceptual scheme of broad rational choice with elements such as the actor's resources, knowledge, and interpretative frames. The decision making of actors in AiC may be specified as either maximizing or satisfying (Simon 1978) and either deliberative (Fishbein and Ajzen 1975) or based on social comparison (Jager et al. 2000). Moreover, AiC supplies a meta-model of decision making that includes also the moral domains of *homo communalis* (ethics of care; Gilligan 1982) and *homo honoris* (with honor and duty as the primary moral dimension; De Groot 1992). For the present study, however, it was found that a simple scheme with a multicriteria structure (see table 3.2 later in the chapter) yielded straightforward explanations, mainly because options clearly dominated each other.

Usually, other actors may be identified behind the primary actors that influence the action in question. This defines the AiC concept of the a*ctors field*, to which we pay some special attention here because of its relevance for the present chapter and because, to my knowledge, it is a unique feature of AiC. Actors fields depict *social causation* (Giddens 1979, 49), that is, the exertion of political, economic, or cultural power of one actor on another, intended or unintended, overt or covert (Gale 1998). Because, as said, actors make decisions based on their options and motivations, influence on the decision making of an actor is exerted by influencing that actor's options and/or motivations. Examples on the options side are to provide knowledge or credit so that more options come within the actor's reach, or to reduce the options range by way of prohibitions, pollution limits, and so forth. Examples of motivational influences are the establishment of levies or subsidies, changing land tenure systems so that future benefits of farmers' investments in the land become more secure, or changing the cultural image of options (e.g., smoking). Therefore, actors fields are constructed by identifying what actors, through what actions, influence options and/or motivations of other actors. From the primary actors outward, causal linkages are first explored in the direction of secondary actors that influence the options and/or motivations of the primary actors. From there, tertiary actors influencing the options and/or motivations of the secondary actors may be identified, and so on. In this way, the construction of actors fields identifies all of the actor groups that are potential target groups for policy making to influence the action in question. One example of a causal chain in the actors field is that a landlord (secondary actor) may prohibit farmers (primary actors) from growing a perennial crop because he fears that the government (tertiary actor) may change the land tenure system so that perennial crops give rise to ownership claims by the farmers. Behind this, the World Bank, threatening the government with withdrawal of agricultural loans, may be a quaternary actor. Thus, we see that the actors field concept is actor-based throughout, up to the world level, contrary to, for instance, the stepwise contextualization of Blaikie (1985), which moves from primary actors such as farmers up to the regional and world *systems*.

On a more theoretical note, the actors field concept should be clearly distinguished from the concept of social networks that forms the dominant idea on actor connections in social science. Social networks are composed of actors exchanging services or information between themselves, through ties of kinship, friendship, and so forth. Power is only a secondary issue. In actors fields, however, power constitutes the very links between actors. Actors in an actors field may often not share the same social networks, and may in fact not know each other at all. An actors field around poor farmers is typically composed of landlords, tra-

ders, governmental agencies, and so on, possibly running all the way up to the World Bank, as we saw. The social network of poor farmers, on the other hand, will tend to comprise only other poor farmers, with much weaker connection to social causation.

In terms of Giddens' truism that "institutions make actors" and "actors make institutions", the actors field concept focuses the researcher on the first of these linkages, whereas the concept of social network brings the researcher closer to how actors may "make institutions" through, for example, collective action. Thus, the concepts of social network, collective social capital, collective action, and institutions naturally overflow into each other, as may be seen, for instance, in the work of Janssen (2005), who, focusing on multiagent modeling, first discusses the architecture of the individual actors, then takes communication (i.e., social networks) as the key connection between actors, and then moves on to the evolution of cooperation (i.e., collective action). Focusing as we do here on social causation of the material flows, the actors field concept will be used for the social contextualization of these flows.

3.5 Applying Action-in-Context, I: the primary actors

To explain the selected flows, insight has to be gained in all the household's main livelihood options, because for their decision-making, actors compare the merits of all these options. Table 3.1 gives an overview

Table 3.1 Livelihood activities (sources of income), the percentages of households participating in these activities and the contribution of the activity to DMI in percentages

Source of income	*Percentage of households*	*Percentage of direct material input (DMI)[a] for which responsible*
Agricultural land	89	22
Paddy fields	85	3
Swidden fields	63	15
Home gardens	negligible	3
Logging	78	38
Collection of non-timber forest products	86	11
Livestock (pigs, cows, buffalo, fish)	83	minimum of 23
Services	34	negligible

Sources: For agricultural land, collection of non-timber forest products and services: Stalpers (2003). For logging: Duong (2001).

[a] The minimum of 23 percent of materials going to livestock consists of grass, and water vegetables. A total of 78 percent of the swidden products are fed to the one's own livestock. The 6 percent of DMI that is unaccounted for consists of imports of consumer goods.

of these options in Tat and shows that the great majority of households made a living by combining basically all activities. The third column in Table 3.1 shows the amount of materials that these activities brought about in terms of percentages of the direct material input (DMI).

Economic returns appeared the most decisive motivational factor for choosing between the possible livelihood activities, in our field study. Farmers distinguished between land and labor productivity (i.e., returns per hectare and returns per working hour); these are mentioned separately in Table 3.2. For rice, the farmers maximized their yields, caring less about the time expenditure. For the swidden products, mostly cash crops, a labor productivity strategy prevailed, balancing yield and labor expenditure without paying much attention to the yield per hectare. The respondents pointed at two other economic motivations, namely *no investments* and *no risk* (of losing investments). The farmers preferred options without high physical demands (*no hardship*) or risks. Women said that they preferred work that brings the *fun* of working together with other women. The motivational factor of *food quality* comprises the taste, smell, and size of the food item and the dislike of chemical pesticides on vegetables. *Food variety* was valued by the respondents saying that the diet of farmers can be dull. Because the people often stressed the importance of efficient use of time and materials in combining different activities, we identified the motivational factors *material and time connection* (efficient combinations in terms of product exchange and time-use, respectively).

Table 3.2 displays the basic quantification of the motivational factors of the livelihood options of the farmers. In what follows, the various options will be discussed in greater detail.

Very little new paddy land has been created in Tat since the 1970s (Cuc and Rambo 2001). There is no economically suitable land (i.e., flat enough with access to water) left for creating more paddy fields more than the 22 hectares in the central valley. As shown in Table 3.2, paddy farming was regarded as relatively comfortable work and easy to combine with other activities (because the fields are close to the houses). In spite of the prime focus on land productivity, paddy turned out to have a high labor productivity too, mainly due to high-yielding varieties and chemical fertilizers introduced by the government.

Swidden farming, as Table 3.2 shows, did not offer a favorable labor productivity compared to other land uses. Moreover, as is indicated by the negative value on the no hardship factor, the women (who did most swidden work) disliked swidden farming because it is extremely de-

Table 3.2 Main livelihood activities and motivational factors of the primary actor "farmer households"

Main livelihood activities	*Land productivity (kg/ha)*	*Labor productivity (VND/day)*[a]	*Labor productivity (kg rice equivalence/ day)* [b 2]	*No risk*	*No hardship*	*Connection*		*Fun*	*Food*		*Investment*	
						Material	*Time*		*Quality*	*Variety*	*No initial*	*No maintenance*
Swidden												
Rice	?	10,000	3.7	-	-	0	-	0	++	++	0	+
Canna	?	7,000	2.6	-	–	0	-	0	n.a.	n.a.	0	+
Cassava	?	6,000	2.2	+	-	+	-	0	0	+	+	+
Ginger	?	7,000	2.6	0	-	0	-	0	0	+	0	+
Paddy rice	3,200	28,000	10.4	+	+	+	+	+	++	0	–	–
(Non) timber forest products												
Bamboo shoots	n.a.	26,000	9.6	0	–	0	-	+	+	0	++	++
Broom grass	n.a.	28,000	10.4	+	-	0	-	+	n.a.	n.a.	++	++
Logging	n.a.	25,000	9.3	–	–	0	–	+	n.a.	n.a.	+	+
Animal husbandry												
Cattle	n.a.	+		+	+	+	+	0	n.a.	n.a.	–	+
Pigs (white)	n.a.	21,000	7.8	–	-	0	+	0	+	+	–	–
Pigs (Muong)	n.a.	15,000	5.6	0	+	+	+	0	++	+	-	-
Chickens	n.a.	+		–	+	+	+	0	+	+	0	-
Ducks	n.a.	14,000	5.2	–	+	+	+	0	++	+	0	+

Sources: field interviews and Staplers (2003). VND = Vietnamese Dong (1 US$ = 17,000 VND = 0.7 euro). Explanation of quantifications: ? = unknown; n.a. = not applicable; 0 = neutral; + = positively corresponding with the motivational factor; ++ = strongly positively corresponding with the motivational factor; - = negatively corresponding with the motivational factor; – = strongly negatively corresponding with the motivational factor.

[a] Displays rounded off averages for labor productivity. Assumed is that eight working hours constitute one working day. For the agricultural options the labor and other input costs include all the hours and monetary costs (including maintenance costs) spent on the main activities converted linearly to hectares.

[b] By expressing the labor productivity in kilogram rice equivalence per day (the staple crop), the figures of labor productivity in different currencies are (inter) nationally comparable. In Tat, the local market price is 2,700 VND per kilo rice.

manding and dangerous. The increasing distance to the new swidden fields made it difficult to check the swiddens regularly; going there had become a whole-day enterprise. This is reflected in the negative value put on the *time connection* factor in Table 3.2. Nevertheless, 64% of the households still cultivated a swidden, due to monetary needs, lack of other options during some periods of the year, the *material connection* of cassava (cassava roots and leaves used for livestock constitute about 76% of the material flows from swiddens), and the persistent swidden farming tradition (Cuc and Rambo 2001).

Timber and Non-Timber Forest Products (NTFP) were another source of monetary income. In the 1960s, primary forest still covered much of the territory and people used to hunt regularly on, for example, wild pigs, deer, and the occasional tiger. Only tiny remnants of primary forest survived on extremely steep slopes. Except for broom grass, collecting NTFP for other than one's own use was prohibited by law. The possibility of fines and confiscation is reflected in the *risk* factor in Table 3.2.

Table 3.2 shows that collecting NTFP and logging constituted income sources that required low initial investments and also that these activities were more interesting than swidden farming in terms of labor productivity. Somewhat surprisingly, the modest activity of collecting and selling broom grass appeared to be the best option on almost all accounts among the forest products. Additionally, broom grass is the best option in terms of sustainability. It is a seasonal product, however, and people needed money all year round. This is why people still went for logging and bamboo shoot extraction, in spite of their illegality and lower labor productivity. Implementation of forest protection policies was too weak to dissuade people from these options. In fact, timber and bamboo shoot extraction skyrocketed once the road connected Tat to the lowland markets.

As for animal husbandry, much feed was provided by cassava from the swiddens. Table 3.2 shows that animal husbandry could be an interesting alternative in Tat. Labor productivity does not include the high risk of diseases and the high investment costs of medicines. The positive *time connection* of animal husbandry strongly appealed to the farmers, however, as it mainly concerned housebound activities that may be easily integrated with other work.

The overall explanation of land use in Tat including the selected flows appears to be the limited availability of favored options. Table 3.2 indicates that paddy was clearly the superior option, followed by broom

grass. These two options have limited availability however; paddy is restricted by space and broom grass is restricted by time, being highly seasonal. Therefore, after fully exploiting these options, people chose the two next-best options, which were bamboo shoots and logging. Logging, however, was dependent on incidental market connections, and bamboo shoots are seasonal. Thus, the remaining energy was spent on the swiddens, even though the labor productivity was very low and other factors did not offer great enjoyment either. Animal husbandry formed a year-round option, but was limited by high risk of disease. Consequently, the largest material flows are economically not the most attractive, as Table 3.1 demonstrates. Rice and broom grass, for instance, amounted to only 3 and 1% of DMI.

3.6 Applying Action-in-Context, II: actors fields

Now that we understand the land use practices of the primary actors that stand at the nature-environment interface causing the material flows, the actors fields of the selected flows can be construed.

Figure 3.3 depicts the actors field, with actors connected to each other through influence on options and motivations, both for bamboo shoot collection and for swidden cash crops. A major linkage exists between the farmers' (economic) motivations and the improvement of the road. The road brought on a forest exploitation boom by linking the households to the market without effective forest protection mechanisms in place.

Because the primary driving force of the two activities was commercial, the linkage between the households and the (regional) traders, mediated by the middlemen in Tat, forms the backbone of the actors field (indicated by the bold arrows). Figure 3.3 shows that these traders sold the products on the (inter)national market: the canna to the noodle factory, cassava to the cassava factories and the ginger to Japanese traders (not drawn in the figure). Here we see that two types of government actors were involved in the same trade. These were the local and regional authorities, which should be motivated to regulate illegal products trade, and the government-owned factories, which are financially interested in the reverse.

Other linkages in the actors field connect to risk as the second motivational factor of bamboo shoot collection and swidden farming. The (non-commercial) government actors mainly accommodated the illegal activities by not posing real risks of confiscation. It starts with the local

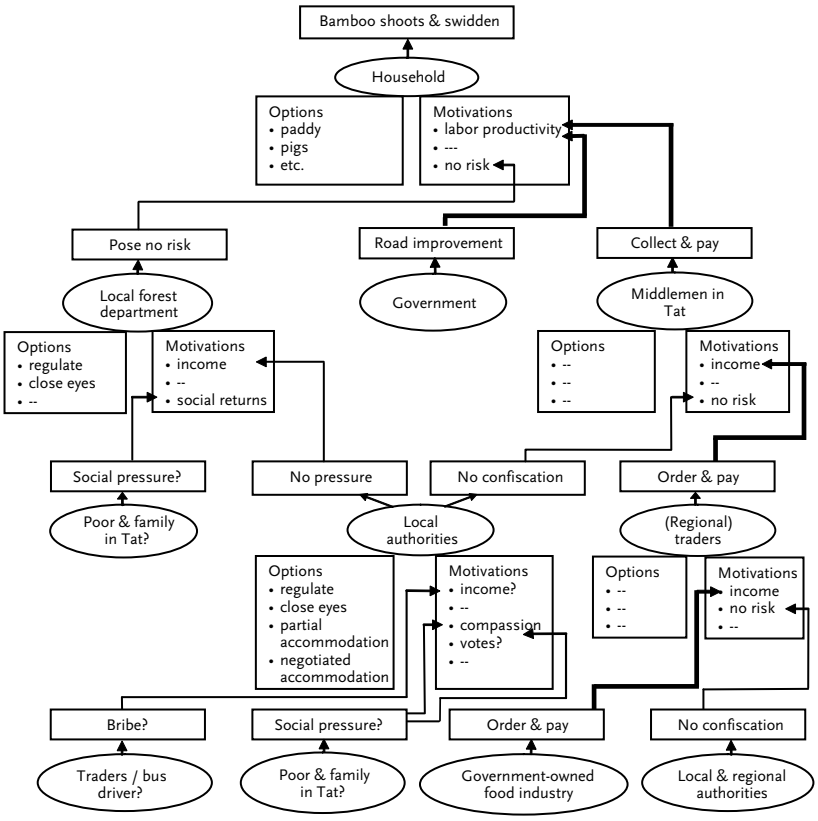

Figure 3.3 Summary of actors field for bamboo shoots collection and swidden farming. Below each actor category, the boxes indicate the options and motivations leading to the actor's actual action. Pose no risk, for instance, is the action by the Forest Department that influences the motivational factor risk of the households. The pose no risk action results from basically two options (regulate and close [one's] eyes) and motivational factors such as income and embeddedness in the community (social returns). No options and motivations (boxes) have been specified when the factors are obvious, unknown, or not interesting for this paper. Question marks refer to supposed actors and supposed lines of influence where no research has been done. The bold arrows refer to commercial influence, the others to all other sorts of influence.

forest department that mediated between the local people and the local authorities. The local forest officials felt unable to resist the social pressure from the local people and were, moreover, not forced by the local authorities to do so.

At the level of the local authorities, three new "power lines" were identified. Compassion with the local poor made the authorities close their eyes for the unfortunates breaking the law. As one official stated during the fieldwork: “The people rely on the forest to earn a living. If you catch them, they will be so miserable”. As indicated by the question mark, a supposed line of influence is that the authorities ignored the offenders because of social pressure from their fellow villagers, affecting the position of the local authorities in terms of votes and popularity. Finally, a question mark indicates a hypothetical bribe paid by the traders to the local authorities allowing the transport of illegal products. This bribe, if any, would be small, reflecting the relatively small value of this trade at the village level. This is likely to be different at the next level of the actors field, where larger (regional) flows were accommodated by higher (regional) authorities.

Overall, the actors field shows that although commercial actors generated the main driving force of the NTFP and swidden products, government actors played key roles too, first by connecting the hamlet with the commercial actors by the construction of the road and then by accommodating the illegal flows, for social reasons or for private benefit.

Figure 3.4 displays the actors field of logging. The protected forests had been allocated to individual households in 1998, and since that time, loggers had to make (financial) arrangements with the owners of forest plots to prevent a fight and to prevent being reported to the local forest department with a stiff fine as result. This is displayed in the actors field as the causal chain of the forest owners posing no risk to the loggers and the loggers offering the bribe/share to the owners. As the actors field further shows, the local forest department may also have been bribed to refrain from any action independent of the forest owners.

The actors field shows the traders mediating between the local people and the big traders. They acted as secondary actors buying the products from the people, and as quaternary actors bribing the forest officials. During the fieldwork, a respondent informed us about the latter procedure: “I have not often been caught during the three years that I have transported logs, and then I usually get off the hook by buying off the forest officials with small amounts of money, around 20,000 VND [1.3 USD] per person”. The next level in the marketing line, concerning the regional traders, involved bigger flows of wood and proportionally bigger amounts of money circulating between the non-commercial government actors and the traders. Most of the timber produced in Vietnam ends in the furniture industry for the (inter)national market (USDA 2003), so it is expected that the illegal wood flow from Tat ended there as well.

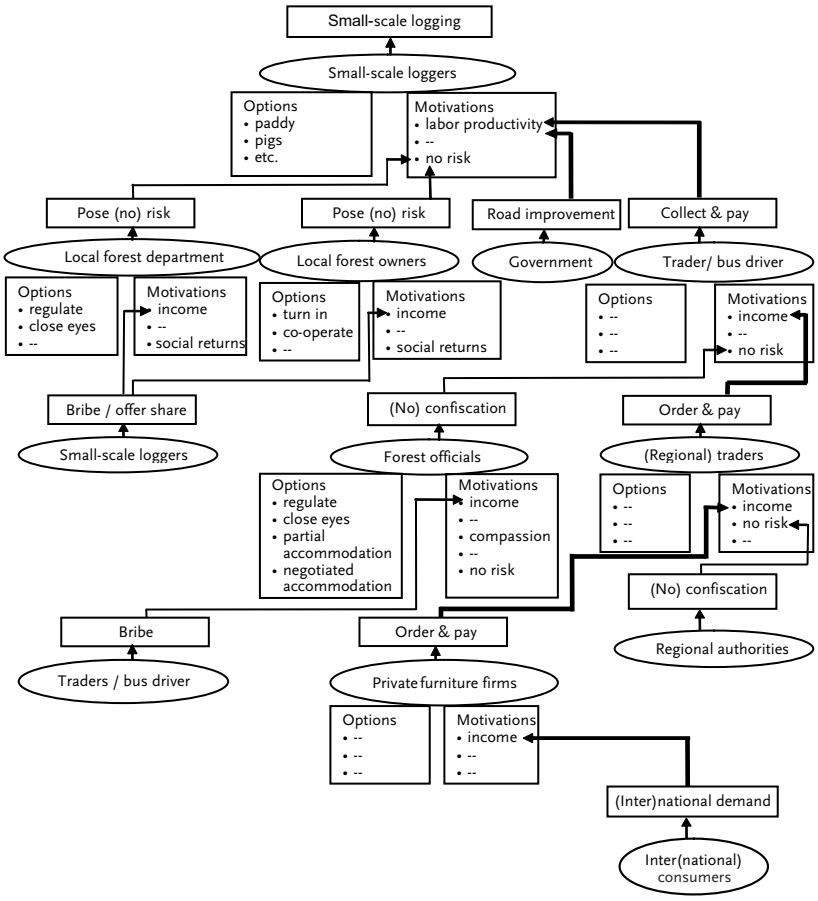

Figure 3.4 Summary actors field for small-scale logging.

Both being market-driven, the actors field for small-scale commercial logging was quite similar to the actors field of bamboo shoots collection and swidden farming, including the role of the road. The main difference was that logging was more illegal and that more money was involved.

3.7 Scenarios and policies

The understanding of the social causes of the selected material flows built up in the preceding sections enables us to look into future scenarios and explore possible effective policies.

The situation in Tat was characterized by intense land scarcity, with virtually all suitable land developed already into paddy fields, surrounded by steep slopes on which only a few activities are sustainable. During the research, the paddy production was too low to feed the population. Cash was needed for additional rice but also for inputs in the paddy production. Because of this urgent need, the lack of alternative options, and the lack of effective (self-)regulation, people did not stop depleting the swidden soils and exhausting the forest. The swidden and forest exploitation boom is soon to go bust and with that, the unsustainable material flows may vanish, as will people's current livelihoods. The key actors in the actors fields of these material flows were the actors in the product marketing lines and the public actors accommodating the market lines of illegal products.

To overcome this Malthusian scenario of land degradation, poverty, and disintegration, policies have to be developed that combine alternative livelihoods with straightforward implementation of the law at the local level and intervention in the illegal trade at higher levels. This section aims at providing the basic insights.

Problems of unsustainability can be solved by either increasing the productive capacity of the environment, or by reducing the unsustainable material flows. The latter, in general, amounts to either reducing the number of actors generating the flows, or reducing the flow per actor. For Tat this heuristic scheme, together with insights from the disaggregate MFA, additional sustainability indicators and some key elements out of the AiC such as the overall viability of rice, suggests that options to support future livelihoods are (1) paddy production development, (2) sustainable non-paddy agriculture (3) the development of value-added industry and (4) out-migration providing remittances.

Option 1: Paddy production development. Both local people and the government are highly interested in higher rice production. Price incentives will not make any difference here because the rice is only grown for their own consumption and motivations are focused on land productivity anyway, but yields could improve by 40% to 4 tons per hectare per year (Bong 2000).

Option 2: Sustainable non-paddy agriculture. A transition will have to take place towards sustainable non-paddy agriculture with a comparative advantage with regard to the lowlands. Stabling of all pigs and cattle will be necessary to reach the optimum output and to prevent crop damage. Anything more than what may be sustained by the village's own biomass surplus does not appear to be a viable option, because externally

fed livestock can be produced much cheaper in the lowlands. If we would assume that out of the village's 700 hectare territory approximately 150 hectares is suitable for swiddening, and assuming that the swiddens are sustainable with 8 years of fallow after 2 years of cultivation, 30 hectares of swiddens would be available. If these would be fully planted with cassava for pigs (yielding an estimated 4 tons per hectare), and if the pigs' food intake is the same as during the study (187 kg cassava per pig per year) a total of about 600 pigs could be fed sustainably from the swiddens. Another viable option for sustainable non-paddy agriculture links up with the emergent practice of planting timber trees such as *Xoan* (*Melia azedarach*) and high yielding bamboo such as the *Luong* (*Dendrocalamus membranaceus*) on the swidden fallows. Assuming 100 hectares of forest gardens (former swiddens) planted with bamboo and timber, a production of at least 20 tons per ha biomass may be expected. Furthermore, production of vegetables and fruit trees that are specifically suited for the uplands might form a sustainable and viable activity.

Option 3: The development of value-added industry. The development of a value-added industry might form an important addition to income. One such activity is the manufacture of brooms, instead of selling the broom grass.

Option 4: Out-migration providing remittances. Out-migration is likely to start one day or another, due to the general land constraint and the growing population. Out-migration is not necessarily a doom scenario; Tat could become one of the world's many sustainable and culturally stable places from which young adults migrate to the cities in order to help themselves, but also keeping up the economy and culture of their place of origin by way of remittances, for example.

The government is the crucial external actor for realizing these future scenarios for Tat. Besides supporting the intensification process of the paddy fields, the government could assist in the development of alternative crops and activities by, for example, supporting market connections, credit, knowledge and collective action. As said, such assistance should be combined with the strict implementation of the forest protection policies, including the interruption of illegal trading networks as our actors field analysis has shown. This implementation is not necessarily a one-way affair. Sustainability of the steep slopes is highly significant to government and local people alike.

We estimated a hypothetical MFA of Tat for a situation that satisfies two central criteria, namely sustainability and self-sufficiency in rice, the pil-

lar in rural communities in Southeast Asia. With intensified paddy production (see option 1), a total of 88 tons of dry milled rice is produced, which would be enough to feed 350 people following the standard of WHO (1985) and allowing for some waste, unequal distribution, and so on.

Illegal logging, large-scale NTFP collection and swidden cash crops, being unsustainable, are assumed to come to a halt. On the swiddens, we follow the cassava option described under 2, *inter alia* because cassava does not require intensive labor. The pigs will be fed as well by rice waste and home garden crops. High yielding bamboo and timber trees will be planted on former swiddens; this forms a smaller but less risky second pillar of people's cash income. The other livelihood activities such as gathering of broom grass are assumed to remain equal. Table 3.3 shows the resulting aggregate MFA in comparison to the MFA of the empirical situation. Although no rice is imported anymore, the increase in wealth results in more imports of finished goods and fuel, so that imports are about equal in the two MFAs. The domestic extraction is higher in the new sustainable situation, which is mainly due to sustainable logging and bamboo gathering from the forest gardens. In other words, although the focus of the agricultural production has changed drastically, the amount of biomass extracted is about the same in the new situation. Export of livestock, wood and bamboo leads to higher exports in the sustainable village in comparison to the present one. The higher figure of the wastes and emissions is due to the amount of the manure from the pigs that is not used on the agricultural fields; this is in fact an anomaly in the sustainable scenario. Financially, the new situation would be good for the villagers, with an estimated income of approximately 1,000 USD and 400 USD per household per year from the

Table 3.3 The aggregate Materials Flow Analyses (MFAs) of Tat, the empirical versus the sustainable and self-sufficient situation

	Empirical figures of the MFA in Tat 2001 (tonnes/capita/year)	*Estimated MFA for Tat that is sustainable and self-sufficient in rice (tonnes/capita/year)*
Imports	0.4	0.4
Domestic extraction	4.0	7.0
External extraction	1.3	0
Exports	1.2	2.7
Deliberate disposals	0.6	0.4
Wastes and emissions	1.7	2.2

The material flows are given in tonnes per capita per year. The first column is taken from figure 3.1. The second column represents an estimated aggregate MFA in the situation in which Tat is sustainable and self-sufficient in rice production. These figures are calculated on the basis of the disaggregated flows of the empirical situation.

piggeries and from the production forest, respectively. Comparing the two MFAs in Table 3.3, the methodological conclusion appears to be that the key differences between the two situations (sustainability, self-sufficiency, population, incomes) do not show up clearly. Only the external extraction (EE) shows a marked difference connected to sustainability, but EE is something rather peculiar for Tat and no part of standard MFA. This finding mirrors the idea that aggregate MFA does not express much in terms of sustainability problems; it does not express much of sustainability solutions either.

3.8 Conclusion

Tat has served here as only a source of illustrative material for our primarily methodological objective. Nevertheless, some conclusions on the village appear to be within reach. First, the case study shows that indigenous forest dwellers, often credited with a great motivation to defend and a capacity to manage the forest they depend upon, may in other cases also revert to exploitation of their forest in a quite unsustainable manner, intruding even on territories of other villages, as soon as the village becomes connected to external markets (see also Colchester 1996). Government, in our case, did nothing factual to protect the local people against themselves and the commercial forces. Second, Tat shows up as an example of a "constrained ecosystem" (Agbo et al. 1993) with a high population density compared to its limited resources. Especially in isolated situations (islands, mountains) without special features that might attract foreign investments, out-migration is often the only option left after the possibilities of agricultural intensification have been exhausted (see for instance Zuiderwijk (1998) on the Mandara Mountains in Cameroon). Third, we have indicated that the external markets also offer opportunities for a more sustainable future through, for example, pig raising, forestry and possibly other options. This requires concerted action from the government and the community, however. The actors fields of AiC have shown that public agencies play pivotal roles; their tendency to succumb under the pressures of bribes and compassion should be changed into a longer-range vision of law enforcement for sustainability, coupled with support to the community to bring the sustainable options within reach.

Methodologically, what is the added value of socially extended MFA? Or, more specifically for the present chapter, what have the two frameworks – MFA and AiC – contributed to the analysis and policy design for Tat? First, standard aggregate MFA did not appear to contribute anything. Its use lies primarily in the fact that it is standard and aggregate, and

thus well suited for comparison cross-scale (local, regional, national) and multi-system on the same scale (more villages in our case). The disaggregate MFA, on the other hand, has yielded a system description and with additional data, a physical problem description (the unsustainability of the swidden flows, the external extraction of timber, etc.). This physical problem description is obviously useful in itself but it does not bring us very far in the direction of explanations and, with that, of solutions. A characteristic recommendation for solutions based on this type of physical problem description is to say that population grows too fast and the forest is overexploited so that solutions lie in family planning and some kind of forest fencing. This, by and large, is how far MFA alone can go in this type of case study. Maybe more important than the physical problem description by itself, however, is the fact that the MFA indicates the points of departure where the explanatory-*cum*-solutions machinery of actor-based analysis can begin; it delivers the problematic actions that Action-in-Context can put into context.[14] Then, it is through the actor-based analysis that we may learn why people follow the unsustainable options, who is behind this, and what consequently might be done about it. On its own, AiC would not be able to deliver much due to lack of direction; it would not be informed as to what to explain. This relationship of MFA and AiC is only one instance of the general pattern of interdisciplinarity in environmental science; the natural sciences (and ethics) bring the problem descriptions and the social sciences then add the insights for explanation and solutions; see the Problem-in-Context framework in De Groot (1992) for environmental science in general and Lifset and Graedel (2003, 14) for the field of industrial ecology.

Industrial ecology appears to have much to gain from socially extended MFA such as exemplified in this chapter. We have preferred an actor-based approach here rather than more aggregate approaches because of the direct causal linkages that this approach offers between material flows and society. We have used the Action-in-Context framework as an example mainly because of its explicit character, which makes it open to criticism and learning. Explicit frameworks such as AiC can also form a bridge towards computerized multi-agent modeling (e.g., Axtell et al. 2002; Janssen 2005). Due to the dominance of social networks as the prime way to conceptualize actor connections, virtually all multi-agent

[14] In field practice, this abstract sequentiality of physical and social analysis will and should be more cyclical, giving rise to more intricate patterns of interdisciplinarity. If, for instance, the physical analysis shows that agricultural intensification is necessary, social scientists may point out that intensification is more difficult for the poor than for the better-off, so that consequently the physical analysis may be separated for the poorer and richer farmers. Another example may be that flows could be disaggregated because they have different chains of explanation.

models contain social networks rather than actors fields but these causal linkages between primary, secondary and tertiary actors are quite open to modeling (Huigen 2004).

Material flow analysis, as a descriptive tool, is important for characterizing the system and for identifying which flows or trends are most relevant to explain. Actor-based explanatory approaches such as action-in-context can then supply this explanation, and serve to get a much better grip on future scenarios and relevant policies than MFA alone can do. In combination, the frameworks can be used for broad national-level explorations, but also for specific local analyses as we have shown. Local analyses may remain close to concrete environmental problems and may help so that the steep slopes of villages such as Tat can remain sources of crops and timber rather than mud flows.

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