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Smallholders, Householders

Farm Families and the Ecology of Intensive, Sustainable Agriculture

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Prologue: An Ethnological Essay in Practical Reason

Anthropological theories of "practical reason" that are natural or ecological, utilitarian or economic like Steward's have in recent years been opposed by scholars who emphasize "culture" as symbolic or meaningful. In the words of Marshall Sahlins:

> The distinctive quality of man [is] not that he must live in a material world, [a] circumstance he shares with all organisms, but that he does so according to a meaningful scheme of his own devising, in which capacity mankind is unique. [This approach] therefore takes as the decisive quality of culture . . . not that this culture must conform to material constraints but that it does so according to a definite symbolic scheme which is never the only one possible. Hence it is culture which constitutes utility. (Sahlins 1976: viii)

This book on the practice of smallholder intensive agriculture by farm-family households relates elements of environment, technology, and human social organization in the tradition of cultural ecology pioneered by Steward (1938, 1955). It is not a study of "culture" in the widely accepted anthropological sense of a distinctive system of shared meanings and a symbolic organization of experience characterizing a particular society or social group. The focus on differences in ways of thinking expressed in language, beliefs, rituals, and myths, and interpreted from a wide range of cultural texts, has been and necessarily remains a central concern of the discipline. But anthropology has also been an empirical social science of practical reason, grounded in an Enlightenment faith that there are regularities in human behavior and institutions that can be understood as filling human biological and psychological needs under particular circumstances of geography, demography, technology, and history. These commonalities can be discerned cross-culturally in groups separated by space and time and displaying a splendid variety of cultural values, religions, kinship systems, and political structures.

The systematic comparison of practices and institutions that reoccur in different societies, and the analysis of how they function and change in a functional and comprehensible manner is *ethnology*, a somewhat quaint and old-fashioned designation that many contemporary anthropologists would never use to characterize their own work. What follows is not an attempt to interpret "culture," a project of eliciting and perhaps creating meaning so grand that only the artist or the literary critic would confidently attempt it. Rather it examines a limited set of social and economic factors that are regularly associated with a definable type of productive activity, despite considerable variation in a number of other "cultural" features that may themselves cohere internally in meaningful, patterned ways.

Smallholders: Characterizing a Type

Smallholders are rural cultivators practicing intensive, permanent, diversified agriculture on relatively small farms in areas of dense population. The family household is the major corporate social unit for mobilizing agricultural labor, managing productive resources, and organizing consumption. The household produces a significant part of its own subsistence, and it generally participates in the market, where it sells some agricultural goods as well as carrying on cottage industry or other off-farm employment. Choices of allocating time and effort, tools, land, and capital to specific uses, in a context of changing climate, resource availability, and markets must be made daily, and these economic decisions are intelligible in rational, utilitarian terms. Smallholders have ownership or other well-defined tenure rights in land that are long-term and often heritable. They are also members of communities with common property and accompanying institutions for sharing, monitoring, and protecting such resources. The existence of separate household enterprises, with a measure of autonomy and self-determination, in a larger economy with institutionalized property rights and market exchange, presents the likelihood of economic inequality, both among households in the community at any point in time and in the changing status of a single household at different times in its developmental cycle. But inequality is not equivalent to enduring class stratification *within* the farming community, and neither does it exclude socioeconomic mobility. The argument of this book is that these characteristics regularly co-occur, and that their systematic articulation and changing relationships can be reliably observed, described, and explained.

Not all food producers are smallholders. The characteristics put forward here do not apply to shifting cultivators practicing long-fallow or slash-and-burn farming where land is still plentiful and population density low, as in some parts of the humid tropics today. Nor does the designation *smallholder* fit herders, whether they be the nomadic pastoralists of East Africa or the ranchers of Texas. It does not match geographically, economically, or socially with the farming systems of dry monocropping of wheat, sugarcane estates, cotton plantations with slaves, or California agribusinesses. Smallholders practice *intensive agriculture*, producing relatively high annual or multicrop yields from permanent fields that are seldom or never rested, with fertility restored and sustained by practices such as thorough tillage, crop diversification and rotation, animal husbandry, fertilization, irrigation, drainage, and terracing. I am not talking here about amber waves of grain but about gardens and orchards, about rice paddies, dairy farms, and *chinampas*.

Even the casual observer has little difficulty in recognizing a landscape domesticated by intensive agriculture. The stepped stone walls and mirrored, ponded fields of Balinese wet-rice cultivation and the neat, fenced, manicured pastures of Dutch farmsteads bespeak high, dependable yields and diligent stewardship. But that these are, in fact, representatives of a distinctive type of land use regularly associated with specific demographic, social, and institutional factors may require something more than a leap of faith in practical reason. It is the virtue of Julian Steward's approach that consistent cross-cultural relationships can be demonstrated empirically despite striking variability in local environment, technology, culture, and politics. The common features form a definable cultural ecosystem with its own evolutionary patterns and probabilities of change.

The smallholder as depicted here may be what Max Weber (1949: 90) called an ideal type—that is, a "conceptual pattern [that] brings together certain relationships and events of historical life into a complex, which is conceived as an internally consistent system." As in Geertz's (1963) characterization of agricultural involution or Popkin's (1979) of the rational peasant, "the researcher posits a structured representation of a social category that singles out certain features and abstracts from others" (Little 1989: 194). The smallholding householders that I examine in this book are alike in that for all of them land is objectively a scarce good, agrarian production per unit area is relatively high and sustainable, fields are permanent, work takes skill and relatively long periods of time, decisions must be made frequently, and the farm family has some continuing rights to the land and its fruits. In these type traits, the smallholder differs in kind or in degree both from other food producers and from those who pursue other occupations. Drawing principally on ethnography, agricultural economics, and geography, I first describe what smallholders do and then attempt to account for the systematic commonalities of behavior and institutions that make a kind of sense according to the plebeian, but still powerful, canons of practical reason. There is no shared culture of meanings among the many disparate groups of smallholders, but the quest for functionally meaningful and coherent systems that transcend the distinctions of societies and regions is also part of the anthropological calling.

Why Study Smallholders? Some Subjective Reflections on Objective Research

It would be misleading and disingenuous to argue that scholarly work that styles itself "social science" arises from a single-minded search for timeless truths existing out there in the real world, or that those of us who essay this approach to knowledge believe that we shall discover natural laws of society, test hypotheses in some irrefutable way, or reliably predict future states of the system. Perhaps one of the attractions (and the solaces) of anthropology is that its deductive models are neither very compelling nor particularly intrusive, and that one is almost sure to learn something interesting and new by fieldwork (even if this is no longer always "exotica and trips"). The formal structuring of problems and hypotheses in the research proposal, and the (sometimes very different) relationships of data, argument, and theory in the finished product seldom overtly reflect the subjective experience or the sentimental journey that led the student in that direction. At the risk of ruminations and other evidences that I may be entering my anecdotage, let me ask how it was that I came to study agriculture, households, and land tenure, rather than, say, kinship terminology, the peasant view of the good life, or caste in India, as my esteemed teachers had. It might also be useful to try to reconstruct why, at this point, I should leave those ethnographic cases that I know at first hand for the much more hazardous terrain of global ethnological comparison and synthesis.

As a graduate student at the University of Chicago in the late 1950s, I read Julian Steward's *Theory of Culture Change* in Fred Eggan's course on ethnological theory and method, and I did a source paper on Fulani ecology for a seminar at Northwestern University with Jim Bohannan. But my proposal for my first field research, begun in 1960 on the Jos Plateau in Northern Nigeria, did not make such interests explicit. As I once admitted, "I did not have a carefully thought out plan of ecological study when I entered the field, and my findings came piece-meal in response to the elementary questions of why people lived where they do, what they did with their time, and how they got enough to eat. Many of my conclusions came in the analysis of quantitative material after leaving the field" (Netting 1968: 23). A generous interpretation of this choice of scholarly direction might be that I admired the apparent self-sufficiency of the isolated Kofyar, and their cultural vitality, and that I wanted to communicate to others some appreciation of the economy and "material culture" that supported this African society. Perhaps it is more accurate to say that I and my assistants had collected a lot of data in a fairly standardized form on household membership by name, gender, age, and kin relationship, and on the crops and domestic animals the household produced and consumed. I was impatient to begin my study before fully mastering the language, and I found that a household census, with its repetitive questions, relatively straightforward answers, and generally nonsensitive content, was a good way for me to get acquainted with people and practice my Kofyar. Perhaps a household survey also reflects a certain lack of imagination. I remembered the advice of Sol Tax, one of my professors at Chicago: "When you can't think of anything else to do, you can always census."

But judging from my field notes, I spent as much time attending divinations, recording folktales, exploring witchcraft beliefs, and drinking beer as I did talking about farming and observing work groups. Although Kofyar cultural concepts and behavior in such areas as gender relationships, politics, warfare, and contacts with the British colonial government have not been neglected (Netting 1964, 1969a, 1969b, 1972, 1974b, 1987), my core concerns have remained stubbornly centered on issues of work, agriculture, households, and rights to the means of production. One can count on the existence of activities and things that can be counted. The mundane, petty facts about residence, kinship, and crops that individuals can tell the interviewer with reasonable accuracy can be transmuted through numbers into statistics. From what people know and see can come approximations of mean and central tendency, classifications by age and sex and village of origin, information about differences (with, one hopes, some measure of significance) between subsistence cultivators and cash-croppers, correlations of household size and wealth. These are things we might guess at, but no one knows the answers accurately until you do the numbers. Moreover, unlike norms or ethical principles or aesthetic judgments, quantitative measures of behavior are not part of people's collective consciousness. Though individuals can and assuredly do make economic decisions about market exchanges, stored food, and labor expenditures, they generally do so without bookkeeping and exact calculations. They have little way of estimating changes in social behavior at the group level; indeed, there may be a vested interest in asserting a somewhat spurious cultural continuity and the strength of tradition (Murphy 1971). Statistical representation of a decline in fallow, an increase in age-specific female fertility, or a process of polarization in household incomes is not information that is available for people to apprehend or incorporate into their stock of cultural meanings. But these trends and changing relationships affect systems of farming, labor, and landholding, and they can be analyzed by the observer using the quantitative methods of practical reason.

It was in examining graphs plotting a regular association between field area and crop production in intensive farming at Kofyar homesteads, in contrast to the direct relationship between labor input and production on cash-crop farms worked by migrants, that I first became aware of differently patterned agricultural systems (Netting 1968: 135, 205). It appeared that farmers in the densely settled Kofyar homeland practiced permanent cultivation of small fields, with high yields per unit of land, as opposed to the *same people's* shifting cultivation of abundant land on the frontier, where fields were large and yields per unit of land were low. Moreover, traditional homestead cultivators had small households and nuclear or extended families, whereas migrant farmers had statistically larger households, achieved by increased rates of polygyny, and more multiple-family households. Household size appeared to correlate closely with land availability, and it varied with different labor needs (Netting 1965, 1968).

The household was not a static traditional grouping generated by fixed cultural rules of postmarital residence or the practice of polygyny (Goodenough 1956; Wilk and Netting 1984). Nor was it a predictable precipitate of a stage in the household developmental cycle of a social structure at equilibrium (Goody 1958). Because farm labor was largely mobilized and consumption organized in the family household, processes of household formation and fission might alter appreciably and quickly. The composition and structure of the household group, as it emerged from the figures of hundreds of household censuses, varied with changed circumstances of production. And this rapid adjustment was unaccompanied, as far as I could see, by changed cultural standards or expectations about household membership, marriage, socialization of children, or rights to land. Kofyar customary systems of meanings remained intact and did not constrain substantial nonrandom changes in social behavior.

Quantitative evidence of change was for me the genesis of recognition that the smallholder household had readily distinguishable characteristics related to a particular type of land use under a specific population regime. It also suggested certain limited ethnological comparisons to test the posited functional relationships. The Chokfem Sura, who lived near the Kofyar ancestral homeland in a similar plateau escarpment environment, practiced shifting cultivation and had a lower population density, with large, multiple-family households. One could also predict that as the Kofyar filled up their frontier land, they would revert to more intensive agriculture, with smaller fields, and that their recently augmented household size would begin to decline. These projections for change over time were in fact supported by a restudy of the Kofyar in 1984–85 (Netting et al. 1989; G. D. Stone et al. 1990).

Comparing and Generalizing: How to Recognize Smallholders

Like most people most of the time, the Kofyar have no means of reducing behavior to statistical terms, but they were quite ready to explain the patterned actions that the enthusiastic anthropologist had "discovered." Why shouldn't a young adult man remain in the parental household when his father provided bridewealth and a motorcycle from the family's new cash-crop earnings? Women recognized the value of an extra pair of hands and pressured their husbands to marry co-wives (M. P. Stone 1988). Successful farmers argued with me over the costs and benefits of cooperative beer-party work groups as opposed to wage labor. It may be that there is a strong streak of practical reason in certain areas of Kofyar life, just as there seems to be among other smallholders. It is also possible that the economically minded investigator asks questions that elicit pragmatic responses. But just as systems of meaning and behavior are not exhausted by a materialistic, ecological approach, so the utilitarian activities of production and reproduction are not solely culturally constituted or changed.

Could the Kofyar be nothing more than an interesting, but perhaps anomalous or idiosyncratic, ethnographic case? Smallholders are usually thought of as peasants with an intermediate technology of the plow and draft animals, living in a state, and subject to demands for tax or tribute from other elite groups in the complex society. The Kofyar practiced hoe cultivation in a rugged escarpment area of the Jos Plateau, where they had remained largely outside the political system and market economy of northern Nigeria's Hausa-Fulani kingdoms. Kofyar country was only made part of the British colonial state in this century, and they have retained a large measure of control over their own land and production system down to the present. They did not fit easily into the standard peasant mold.

The smallholder adaptation only became a generalizable category for me inasmuch as it appeared to encompass other examples of peoples practicing intensive agriculture and resisted conformity to the older and more conventional typologies to which these groups had been consigned. The most usual way of pigeonholing farmers is by contrasting technologies, often along an implicit evolutionary scale. Primitive farmers or horticulturalists use the hoe, the axe, the digging stick, and perhaps the sickle, and agriculturalists add animal draft power and the plow to these manual implements. The more developed technology captures nonhuman energy, presumably lowering human labor inputs and increasing agricultural production over larger land areas. Mechanization, energy from fossil fuels, and scientific methods of fertilization, plant breeding, and crop protection (using pesticides and herbicides) carry the same evolutionary process further. Smallholders with relatively simple tools farming small, often fragmented fields, and relying on traditional "prescientific" understandings of agriculture, are automatically relegated to a lower, and presumably earlier, farming type.

Scale and productivity are, however, slippery concepts. The bigger fields made possible by the use of nonhuman sources of energy do indeed save labor, and production per hour rises. But productivity as reflecting production *per unit of land* may in fact be *lower* under more extensive, technologically advanced systems. Because intensification refers to achieving and maintaining relatively high land productivity over time, it can be applied to farming systems with varying dependence on nonhuman energy. The Kofyar first claimed my attention because, with nothing more than iron-bladed hoes, digging sticks, and sickles, they achieved relatively high and reliable yields from small land areas, using compost manuring, intercropping, stall-feeding of animals, arboriculture, ridging for water retention and drainage, and terracing. The high labor inputs of intensive agriculture increase yields and reduce variability by conserving and enhancing soil nutrients and diversifying production.

If we include under the rubric *technology* the repertoire of skills, the folk knowledge and ethnoscience brought to the task, and the building and maintenance of intricate systems of irrigation, flood control, and drainage by means of hand tools, the evaluation of technology along the single axis of "labor-saving" becomes inadequate. Intensive techniques applied with care, and frequent monitoring of the field, garden, or orchard, also imply a *sustainable* agriculture that prevents the erosion and degradation that frequently accompany large-scale, extensive land use. Part of my reason for beginning research in alpine Switzerland during the 1970s was to see a system that had persisted for centuries in an easily damaged environment of steep slopes, short growing seasons, and low rainfall. Historical documentation attested to continuous use of irrigated mountain meadows, terraced vineyards and grainfields, forests, and high-altitude pastures with no evidence of erosion, declining soil fertility, waste of irrigation water, overgrazing, or deforestation. As in the Kofyar case, techniques of crop rotation, manuring, and controlling the tendency of worked soil to creep downhill were practical rather than based on a "scientific" understanding of hydrology and soil chemistry. Yet low-tech, highly effective methods maintained relatively dense, permanently settled local populations in a manner that both conserved and enhanced the production of existing natural resources. The modernist cant that traditional intensive cultivators must be taught how to farm with machines, purchased inputs, and scientific knowledge is directly contradicted by the land productivity, the reliability, the ecological sustainability, and the adaptability of these systems.

The fact that the Nigerian Kofyar and the mountain Swiss are both geographically and economically peripheral to the concerns of modern industrial nation-states stimulated my interest in smallholders who not only persist but play a dominant role in market production as well as subsistence. Though peasant smallholders have had an abiding presence in the north of Portugal, the Netherlands, parts of Germany, and Denmark, it is the ancient wet-rice societies of Asia where the type is most clearly and pervasively exemplified. There, with long-term, high-density populations in China, Japan, and Java, skill replaces scale (Bray 1986), renewable energy competes successfully with imported and mechanical energy, and household management demonstrates its superiority to both hired labor and collective farming. The great Chinese river valleys have proved more highly productive and more agriculturally sustainable, through cycles of intensification, than any comparable region on earth. Although the historic form taken by labor-intensive smallholder enterprises in the Chinese market economy (P. C. C. Huang 1990) may not be a model for emulation elsewhere, it does suggest the durability and amazing resilience of the smallholder techno-social type. As an ethnological comparison, the richly documented Asian cases best call into question the reigning hegemonic ideal of large-scale, energy-expensive, mechanized, specialized, scientific, capital-intensive, labor-saving agriculture enshrined by the West. Under certain circumstances of high population density and market economy, there *is* a viable smallholder alternative.

Myths of Modernization: Evolutionary Mystifications and Smallholder Persistence

Why have smallholders been ignored or regularly stigmatized as old-fashioned, resistant of innovation, inefficient, and a barrier to modernization? Almost from the beginning, my field experience tended to collide with and contradict conventional views of a unilineal development in agriculture and a static subsistence segment. No outsider had recently introduced the Kofyar to concepts of composting green vegetation with goat manure or preventing erosion by making rectangular ridges on top of bench-terraces. When the Kofyar summarily discontinued these practices in favor of slash-and-burn farming on the frontier, it was not a sign of some evolutionary regression but a reasonable reaction to abundant land and the desire to make labor more productive. Kofyar later bought and used chemical fertilizer as well as motorbikes and trucks for transport, but refused both the ox plow and the tractor, which got in the way of intercropping. They responded to growing land scarcity by reintensifying agriculture on smallholdings rather than taking the path of cultivating large-scale farms with hired labor. And the options they chose were fitted by trial and experiment to a savanna environment with seasonal, soil, and cropping differences that were in part new to them.

The Swiss smallholders had modestly revolutionized their alpine farming system twice, once with the adoption of the potato as a greater and more dependable source of calories in the eighteenth century, and again when garden tractor-mowers for cutting hay replaced the scythe a few decades ago. This latter-day technology allowed agriculture to continue as a part-time activity along with employment in industry and the tourist trade. But the ancient peasant subsistence system had always coexisted with and mutually supported households whose income came in part from off-farm employment as everything from mercenary soldiers to chambermaids. The security of a diversified and intensive farming system maintained an astonishing proportion of village family lines from before 1700 through 10 to 13 recorded generations to the present (Netting 1981: 70–89), yet necessary cash and manufactured goods always came from outside the community (Netting 1984).

Perhaps the most stubborn and pervasive myth about smallholders is that their physical isolation in rural areas, their simple technology, and their modicum of self-sufficiency remove them from dependency on a market and the mentality of maximization, greed, private property, and inequality that is thought to be the market's inevitable accompaniment. Again, the evolutionary construct of the peasant mode of production, or of a precapitalist social formation where labor and resources are shared and reciprocity is unreckoned, did not seem to fit the intensive cultivators I knew. Scarcity was not an artificial, arbitrary creation of some elite but a condition of the ratio of population to land. Resources like irrigated fields or terraced vineyards, where the investment of labor and capital over years had built up and buttressed the productivity of the land, could not readily be loaned to others or periodically reallocated among village families. Ethnological comparison cross-culturally and through time assured me that intensive agriculture under circumstances of real, objective limitations on arable land makes primitive communism impossible.

Where money, legal titles, notaries, and courts exist, as in medieval Switzerland, land is bought and sold, and its price seems remarkably high. But even where market relationships are economically insignificant and no state legal system intrudes, as among the precolonial Kofyar and the Philippine highland Ifugao, households have clearly defined, very valuable rights in real property, and land is heritable. With the assertion of continuing use, occupation, temporary exchange by loan or lease, and public litigation over disputed rights, an institution very close to private property comes to exist, even if permanent alienation by sale seldom occurs. Individualized, socially recognized rights to scarce, highly productive resources and the improvements that increase and maintain their yields are inherited along lines of close kinship or transferred in exchange for other valuable goods. At the same time and place, land with low or temporary production with little potential for intensification, as in marginal, long-fallow bush fields or rough grazing areas, may remain in communal tenure with occasional redistribution or shared, controlled access (Netting 1969a, 1982a). The documentary evidence that the resident families of the Swiss village had exercised private property rights in irrigated meadows, grainfields, gardens, and vineyards since the thirteenth century while maintaining legally instituted common property in the community alp and forest convinced me that there was no evolutionary watershed separating an earlier stage of communal rights from a later period of private property emerging with the market and the state (Netting 1976). Smallholder intensive cultivators hold land, and, all other things being equal, it is the ecological factor of land use that most strongly determines land tenure.

One implication of the scenario depicting small cultivators as low producers with poor technology, little market participation, and communal tenure is that they are homogeneous in property and wealth (Redfield 1941, 1955). Even as smallholding peasants within a state, they are perceived as economically stagnant and politically inert, forming a mass "of homologous magnitudes, much as potatoes in a sack form a sack of potatoes," as Marx notoriously put it.[1] The closed corporate community of peasants systematically cuts back emerging inequalities of wealth by di-

1. Marx 1971 [1852]: 230. Marx found the French peasants of the nineteenth century a conservative, antirevolutionary group who cared only for their selfish and narrow interests in property: "The smallholding peasants form a vast mass, the members of which live in similar conditions but without entering into manifold relations with one another. Their mode of production isolates them from one another instead of bringing them into mutual intercourse. The isolation is increased by France's bad means of communication and by the poverty of the peasants. Their field of production, the smallholding, admits of no division of labor in its cultivation, no application of science and, therefore, no diversity of development, no variety of talent, no wealth of social relationships. Each individual peasant family is almost self-sufficient; it itself directly produces the major part of its consumption and thus acquires its means of life more through exchange with nature than in intercourse with society. A smallholding, a peasant and his family; alongside them another smallholding, another peasant and another family. A few score of these make up a village, and a few score of villages make up a department. In this way, the great mass of the French nation is formed by simple addition of homologous magnitudes, much as potatoes in a sack form a sack of potatoes" (ibid.). It is noteworthy that the same characteristics of isolation, homogeneity, and self-sufficiency that represent the strength and cultural integrity of the folk society for Robert Redfield conveyed to Marx only stagnation, ignorance, and a bar to evolutionary progress.

recting gossip and envy against the rich through an idiom of limited good (Foster 1965), redistributing use rights in the commons, requiring leaders to sponsor fiestas and host feasts (Wolf 1957), and relieving subsistence crises through forced generosity (J. C. Scott 1976).

Although such "leveling mechanisms" assuredly do exist, it is my impression that they by no means equalize access to resources within the rural community. What smallholders have, they hold on to with a tight grip, and they compete with vigor and craft for a scrap of garden, a larger herd of goats, or a new granary. A single family household may grow from relative poverty when an adult couple supports many young dependents to a large, prosperous group with several productive workers. Because families are at different points in their domestic developmental cycles, and because they do not all follow the same trajectory, inequality in wealth is the rule rather than the exception. There are few mechanisms of gifts among kin, religious charity, or communal sharing that effectively redistribute such important resources as residential buildings, livestock, and land.

Inequality among smallholders, as opposed to the quite profound differences among farmer-owners and merchants, government officials, professionals, and landless laborers, is present and measurable but not rigidly stratified. Over time, Swiss villagers showed considerable mobility, both up and down the economic scale, but they did not polarize into a class of landowning, wage-labor–employing managerial farmers, or kulaks, and an impoverished group of minifundistas and rural proletarians (McGuire and Netting 1982). Even without substantial charity, public redistribution, or institutional checks on accumulation, there seem to be economic factors acting to circulate wealth. The Chinese case shows rich farmers incurring transaction costs for recruiting and supervising paid labor while households provide more skilled and dependable workers willing to accept lower marginal returns on their work. The combination of higher costs, lower production per unit of land, and high land prices means that rich farmers can get better returns on their capital in commercial or other urban occupations outside of agriculture. Partible inheritance may also divide a big estate among many sons of the owner. On the other hand, intensive agriculture rewards management skills, conscientious work, knowledge of resources, and careful, long-term planning. Thus the more clever and industrious smallholders can potentially increase the size and wealth of their enterprises over time.

Population Parameters and the Smallholder

There is something of a paradox in the particular cast of thought and theory that I bring to the problem of the smallholder as an enduring social and economic type. Consideration, some of it quantitative, of systematic interrelations among factors of demography, technology, environment, economy, and social institutions, in search of cross-cultural associations and regularities in processes of change is an exercise in practical reason, but it does not fall neatly into place with the major paradigms of materialism. The most general orientation toward the functional interactions of what I have called effective environment, productive and protective technology and knowledge, and social instrumentalities (Netting 1965) was that of Julian Steward's cultural ecology. But despite his theoretical emphasis on causal change and evolutionary patterns, Steward (1938) was most persuasive in outlining a relatively simple hunter-gatherer ecosystem from his own superb Great Basin ethnography. The dynamic roles potentially played by change in population, technology, or environment appear only obliquely in comparisons between Owens Valley and other Paiute peoples or between Basket Maker and Pueblo settlements (Steward 1955). Where intensive cultivators appear in Steward's writings, they are pawns in the schematic play of hydraulic power politics of Karl Wittfogel's irrigation civilizations.

For me, a more precise and better-articulated model of agricultural change came from Ester Boserup. Reading her book *The Conditions of Agricultural Growth* (1965) only a few years after completing my dissertation on Kofyar farming gave me an electrifying sense of an inclusive and consistent pattern that logically accounted for both the regularities and the processes of contemporary change reflected in my data. The intensive, highly productive, permanent agriculture of the Kofyar homestead farm that I had described as occurring with dense local population, high labor inputs, and individualized land-tenure rights (Netting 1963, 1965) represented a subsistence type that apparently occurred worldwide as an adaptive response to population pressure. Boserup also asserted that if land increased in abundance, people would save labor by reverting to more efficient shifting cultivation—which was just what the Kofyar were doing on the Benue plains frontier.

My own variation on the Boserup theme was to emphasize the role of the small, nuclear or polygynous family household as the social unit that typically mobilized labor, pooled consumption, and exercised tenure over the intensively tilled farm. I saw household size and composition as correlated with and responsive to farm area, cultivation techniques, and especially the labor needs of the agricultural operation. It was easy for me to postulate that a dense local population, drawn to the Jos Plateau escarpment both for its desirable rainfall and oil-palm vegetation and for the protection it offered from slave-raiding neighbors, would create the higher demand for subsistence food that gave a selective advantage to intensive methods of agriculture. The numerically preponderant presence in the census of relatively small family households as the units of farm production and consumption, landholding, and residence suggested that a social dimension could be added to the original Boserup formulation that population pressure caused or made highly probable a more permanent and intensive system of cultivation.

The brilliant reductionism of the Boserup hypothesis seemed, however, to treat population growth as an exogenous factor rather than as a variable element in a local ecosystem. Under what circumstances of changing fertility, mortality, and migration did population increase? Were there environmental limits to agricultural intensification beyond which population could not grow, and could stability be achieved by social means or only through the harsh imposition of Malthusian checks? My attempt to reconstruct the demographic history of the Swiss peasant village of Törbel was an effort to examine the dynamics of a smallholder system in which documented population change could be seen as both caused and causal. The record reflected an alpine community continuously occupying a fixed agrarian territory, and a medieval population dense enough to require impressive irrigation works for intensive dairy / grain subsistence pursuits (Netting 1974a).

Törbel was not, however, a self-regulating ecosystem, delicately balanced in its mountain environment (Netting 1990).[2] In 1532–33, the Black Death eliminated many local families and opened places for in-migrants, and the Napoleonic invasion of Valais coincided with a dip in population (Netting 1981: 72, 118). The smallholder pattern, however, persisted as village population doubled between 1774 and 1867, well before the advent of modern medicine (ibid.: 95–97). These results convinced me that an exogenous technological change—in this case, the introduction of the potato as a food crop—could promote an increase in female fertility and raise the potential of village territory to support more people. There was equally good evidence that local institutions of land tenure, inheritance, marriage, and sexual control had operated to restrict fertility by encouraging relatively late marriage and frequent celibacy on the part of villagers while also promoting out-migration. Culturally specific ideals and practices of partible inheritance, monogamous marriage, chastity, and long lactation figured in the Swiss demographic regime, and other dense farming populations displayed functional systems different in operation but similar in effect. The sometimes remarkable persistence and continuity of the smallholder adaptation in this case appeared to lie

2. The homeostatic ecosystem with deviation-counteracting feedback loops was the favored model of biological ecologists in the 1960s and 1970s (Odum 1969, 1971; but cf. Worster 1990). As anthropologists looked to technoenvironmental relationships to expand their structural-functionalist formulations, the ecosystem became a major heuristic device (Geertz 1963; Rappaport 1968; Flannery 1968).

not only in the possibility of raising farm production to feed more people but also in indirectly controlling population growth itself. Despite doomsday scenarios of runaway world population growth, smallholder farms did not appear to be endlessly fragmented, their resources degraded, or their households impoverished.

The Smallholder Meets the Market

The greatest problem with modeling a viable system of rural population, land, technology, and labor has been the tendency to treat such systems as self-sufficient and independent. In fact, smallholders do not normally live in isolation from larger networks of economic exchange or political organization; indeed, the scarcity of their resources and their desire for goods and services they cannot produce at home necessarily involve them in important external relationships. Boserup tends to see a more complex division of labor, specialization, and trade as stimulated by the same population increase that fosters agricultural intensification. But it is also possible that market demand (Turner and Brush 1987) and the taxes or tribute of political systems that protect and extend the sphere of market activity may impel cultivators to produce a surplus considerably above their subsistence requirements.

If land is abundant, as it was originally on the Kofyar frontier, extensive or shifting methods may be used to raise production most efficiently. The original motivation for adding bush cash-cropping to existing intensive homestead farming was the desire to enter the market. As land availability and fertility declined on the frontier, the Kofyar reintensified their agriculture to maintain and even expand the amount of surplus food they could sell. It is true that population concentration along roads or in periurban areas often coincides with truck gardening or the intensive production of crops of high value, like fruits, dairy products, condiments, and flowers. But a unicausal model of smallholder intensive household farming systems that neglects either population pressure or market demands is inadequate to account for the prevalence of the type.

Just as smallholders are seldom solely subsistence cultivators, so the need to compensate for insufficient resources and turn unused agricultural labor to other productive purposes means that household members will generally pursue a variety of full- and part-time occupations. Processing and selling food; cottage industries like weaving, basketry, pottery, and knitting; and sidelines in trade, transport, and construction may all be potential sources of income for the farm family. The records of the Swiss village of Törbel showed that numbers of local men served abroad as mercenary soldiers in the seventeenth century, and jobs as muleteers, cheesemakers, herdsmen, mail carriers, cooks, waitresses, and factory workers have helped to support farm families for the past 150 years (Netting 1981: 97–108). Though the household may not be a full-time agrarian unit, the pooling of income from many sources, periodic cooperation to perform farm tasks, and the protection against risk that comes from a diversified economic base increase the resilience of the smallholder enterprise.

The salience that I give to the smallholder household is mirrored in the powerful characterization of the peasant household by the Russian economist A. V. Chayanov (1966 [1925]). The Chayanovian farm household is a subsistence unit whose workers expend only the effort or labor "drudgery" necessary to provide for the consumption needs of all household members. Although supported with impressive statistical data, this radically simplified characterization does not fit the case of intensive cultivators. At the most basic level, in Chayanov's model, the demand of more household consumers for more subsistence food is met by enlarging farm size or "sown area," an alternative not readily available on the land-scarce smallholding. Though the peasant household's activities in allocating labor and leisure conform in broad outline to the assumptions of neoclassical economics, they take place in an idealized context where there is no significant production for the market and no wage labor. Though Chayanov's ideas have been appropriated by many social scientists as a general characterization of peasant economy, they struck me on first reading as possibly applying only to shifting cultivators farming for subsistence in a land-abundant environment. The consumer/worker ratio bore little relation to the per capita production of each Kofyar worker, either on the homestead farm, where field size correlated with crop production, or on the big bush farms, where more effort was made by those who wanted to participate in the market.

Indeed, Chayanov draws systematic contrasts between his Russian case and that of peasants in Switzerland, where land is scarce and individually owned, where labor input per hectare is inversely related to farm size, and where holdings are unequal. Perhaps the major and still largely unacknowledged reason for the poorness of fit between the Chayanov model and most intensive cultivators, whether peasant or not, is that the Russian system was grounded in land-abundant, long-fallow cereal cultivation; a generally sparse rural population; periodic reallocation of fields in at least some communities; the former system of estate serfdom, where workers had little direct access to the market; and large multiple- or joint-family households under patriarchal direction. In almost every respect, traditional Russian farmers did not follow a smallholder pattern.

Unpaid household members can indeed produce subsistence when the employment of wage labor would be unprofitable, but Chayanov is merely specifying the conditions under which economic decision making took place. Workers increased their per capita labor sufficiently to feed household members, while minimizing the drudgery this entailed. I accept the motivational hypothesis that peasants are rational maximizers of personal or family welfare,[3] but I would insist that intensive cultivators calculate their interests over long spans of time, forgoing immediate benefits such as might come from cash-crop specialization in order to lessen risk in the short term (Cancian 1980). Savings in order to buy land and investment of effort and capital in land improvement are regularly made to secure the interests of future generations and of the elderly. A narrow neoclassical perspective may also deny the ability of peasants to take collective action for shared interests and manage common property at the village level (Popkin 1979). My own experience suggests that communities of farmers can support cooperative institutions for irrigation, grazing, and forestry and can protect their resources from some hypothetical "tragedy of the commons" (Hardin 1961). The dangers of free riders, theft, and mutual mistrust that economists derive from a postulated individual rationality (Little 1989: 34) can be mitigated by institutions for communication, monitoring, and sanctioning in active smallholder communities (Ostrom 1990).

Marx Against Smallholding

The tension between what I knew of the ethnographies of smallholder households and their societies on the one hand and the prevailing schematic, often polemical, categorizations of peasant cultivators on the other became particularly acute for me when I confronted the dominant concepts of Marxism and political economy. Neither the "lineage mode of production" nor the various descriptions of precapitalist and peasant social formations coincided with the systems of land use and social organization of the intensive cultivators I knew. The more aggressively materialistic and doctrinaire the political-economic assertions, the more rigidly evolutionary and abstract were the generalizations. In "primitive" societies, seen as both technologically rudimentary and representing an ear-

3. Those who, as I do, criticize a strictly "cultural" approach to understanding human behavior and institutions are said to be guilty of a simplistic and reductionistic economism. Economism "is the view that the moving forces in individual behavior (and thus in society, which is taken to be an aggregate of individual behaviors or some stratificational arrangement of them) are those of a need-driven utility seeker manoeuvering for advantage within a context of material possibilities and normative constraints" (Geertz 1984: 516). Sahlins makes a similar point when he refers to "the home-bred economizing of the market place . . . transposed to the explication of human society" (1976: 86). While I have tried to understand certain limited kinds of social behavior as they relate to work, household organization, and property rights in economic terms, I offer no comprehensive explanation of "society" nor of culture as "a moving and diversified frame of socially constructed meanings" (Geertz 1984: 513).

lier stage in cultural development, agrarian resources were supposedly not scarce, and neither did population pressure lead to competition. Rights to land were believed to be held communally, and the inequality that derives from private property had allegedly not yet emerged. The household as an important, semiautonomous unit of production and consumption tended to disappear.

In line with Lewis Henry Morgan and other nineteenth-century evolutionists, Marx believed that "in the most primitive communities work is carried out in common, and the common product, apart from that portion set aside for reproduction, is shared out according to current need" (Engels 1884, quoting Marx's letter to Vera Zasulich, as cited in Meillassoux 1972: 145). French neo-Marxist anthropologists (Meillassoux 1981; Terray 1972) have found in traditional African societies a lineage mode of production where descent-group work teams farm collectively, store the produce in communal granaries, and receive food allocated by elders. This may well typify large multiple-family households of shifting cultivators, and lineages may indeed allocate land and provide for territorial defense (Johnson and Earle 1987; Netting 1990), but I know of no cases anywhere where descent groups above the level of the household were the primary social units of production and consumption. Though intensive cultivators may have a variety of reciprocal exchange and cooperative labor groups, and though their communities often administer clearly defined rights in common property, households characteristically farm and eat separately, providing for their own reproduction, and protecting rights in valuable, heritable property.

If I had cherished any expectation that the Kofyar, like many hunter-gatherer groups, were primitive communists, because they had only recently been incorporated in a state or a market economy, their firm insistence on property rights in land and livestock and their autonomous corporate households rapidly disabused me. Given the lack of sound comparative data in evolutionary formulations and the "wistful romanticism" of the nineteenth century, it is perhaps no wonder that Marx "clearly failed to realize the complexity of rights over property, including property in land, characteristic of a primitive agricultural community" (Firth 1973: 36). It is less easy, however, to justify the equation of simple farming technology with lineage productive groups, communal rights to resources, and primitive egalitarianism in an anachronistic evolutionism that is still with us.

It can be argued that I have been self-deluded by ethnographic will-o'-the-wisps, projecting functional integration and timeless stability on contemporary groups of numerically insignificant cultivators who are technologically backward, economically undeveloped, and peripheral to the capitalist world system. For reasons of geographical isolation, folk cultural conservatism, or political-economic exploitation by the colonialist state or merchant capital, the Kofyar and the mountain Swiss may be seen as merely the detribalized or impoverished peasant remnants of previously autonomous, healthy societies. Although I must indeed plead guilty to consciously seeking out groups that have, or recently possessed, a modicum of self-sufficiency, a traditional low-energy tool-kit, and few direct relationships with dominant economic or governmental elites, I have come to feel that groups of smallholders with some essentially similar characteristics exist and persist in a wide range of social formations throughout the world. Their distinctive system of rural population density, intensive land use, household organization of production, and private property rights cannot be consigned to some evolutionary stage. Smallholders may use hoes or ox plows or tractors and live in rain forests or oases or temperate savannas. Their mode of agriculture or horticulture is not regularly associated with one set of political institutions, be it tribe or chiefdom or state (Sahlins and Service 1960; Netting 1990).

Marxist attempts to place smallholders unequivocally on one side or the other of some great historical divide separating use values and accompanying lack of accumulation, capital, and private property from exchange values with scarcity, inequality, wage labor, alienation, and capital (Firth 1975) seem to me to fabricate a Procrustean bed. Though households and village communities may appear inextricably bound up with the practice of intensive agriculture, more inclusive "relations of production" to absentee landlords or tax collectors or moneylenders seem more variable and less determinant (Attwood 1992: 42). I have avoided the "mode of production" designation as well, in part because of the resource abundance and production limited to basic needs implied by the lineage mode (Meillassoux 1981), the domestic mode (Sahlins 1972), the kinship mode (Wolf 1982), and the peasant economy (Chayanov 1966 [1925]), but also because smallholders flourish in such a variety of ideological and political contexts that links between infrastructure and superstructure become tenuous (Legros 1977; Friedman 1974).

It may be foolhardy of me, and it is certainly unfashionable, to question the singular role of capitalism in transforming peasants from small-scale, communal subsistence farmers to market-dependent, economically polarized rural people. But I have trouble finding those intensive cultivators of the Alps, the Low Countries, northern Iberia, or Scandinavia in Charles Tilly's succinct, magisterial characterization of European peasantry:

> The peasant version of subsistence farming—in which land-controlling households devote a portion of their production to the market—expanded under the early phases of capitalism and state-making before declining under the later

> phases of the same processes. Capitalism reinforced private appropriation of the factors of production and gave priority in production decisions to the holders of capital. Thus capitalism challenged the collective use of the land, resisted the fragmentation of rights to the same land, labor, or commodities, and worked against the autarky of the household or village. By the same tokens, capitalism provided farming households with the means and incentives to dispose of a portion of their products for cash outside the locality. These features of capitalism promoted the conversion of a large number of peasants into agricultural wage-workers, pushed another large portion of the peasantry out of agriculture toward manufacturing and services, and gave a relatively small number of peasants the opportunity to become prosperous cash-crop farmers. (Tilly 1978: 408)

The admitted concentration of wealth and power in the factories of the Industrial Revolution, or even in the extensive agriculture of commercial East Prussian grain estates or Spanish sheep farmers of the Mesta (Tilly 1978: 410), may not reflect smallholder social processes under structurally different systems of organization and land use. We need also to explain why capitalist landlords were often unable to dispossess an existing smallholder peasantry. Land use *does* make a difference. Small-scale, intensive agricultural producers are not synonymous with "peasants," "precapitalist subsistence farmers," "petty commodity producers," or "rural proletarians," and smallholders demand their own explanations.

The literature of social science generally defines peasants not so much by what they *do* as by what they *don't* do, and by what is done *to* them. Marx found them a politically inert mass, lacking a consciousness of their own class status and unwilling to join the industrial proletariat in revolution. Modernization theorists have claimed that peasant conservatism and traditional values prevented the technological innovation necessary for land consolidation and economic development. A similarly universalistic dependency theory insisted that the social dynamics of agrarian societies are everywhere the same, varying only to the degree that production is oriented to external markets. Where external forces of world capitalism are overwhelmingly powerful, factors of regional and local ecology and history can have only negligible explanatory significance (cf. Attwood 1992: 12). Anthropologists have viewed peasants as politically and economically subordinate. "It is only when a cultivator is integrated into a society with a state—that is, when a cultivator becomes subject to the demands and sanctions of powerholders outside his social stratum—that we can appropriately speak of peasantry" (Wolf 1966: 11). Peasants "have very little control over the conditions that govern their lives," and the basic decisions that keep them poor and powerless are made outside their communities (Foster 1967: 8). Although I find the study of history as a material social process theoretically trenchant and illuminating, it does not seem to me that smallholders are adequately encapsulated in the "peasant" category of a political economy that primarily analyzes "social relations based on unequal access to wealth and power" (Roseberry 1989: 44). While not denying the elements of political and economic domination that affect many aspects of smallholder life, I contend that we must also examine the ecological relationships of population, agricultural technology, household organization, and land tenure that characterize a distinctive smallholder adaptation to local environment.

Julian Steward's strength was in part that his cultural ecology never tried to explain everything,[4] and the cross-culturally recurring elements of the smallholder pattern smack more of limited, middle-range explanations than of the technoenvironmental determinism of nomothetic cultural materialism (Marvin Harris 1969). But as I looked beyond my own field experience to the ethnographies and histories of peoples as different as the Ifugao, the Aztecs, the Chinese, and the Dutch, recognizable smallholders emerged from the obscurity of evolutionary stereotypes and overdetermined categorizations.

Modernization and Evolution: Smallholder Greening or Withering Away?

Evolutionary schemata combine conjecture about the past with an evaluative conception of the present and speculation about what represents "progress" in the future. It is intriguing that for both the socialists and communists of the left and the free-market capitalists of the right, the agreed-upon path to agricultural development has been the large-scale, mechanized, energy-dependent, scientific, industrialized farm. Smallholders have been universally stigmatized as unproductive, regardless of their yields per unit of land, on the grounds that (1) they use too much labor; (2) they do not produce a large surplus for the market; and (3) they do not make rational economic and scientific decisions about production and innovation. For most of my professional life, I have been content to remain within the conventional anthropological niche, attempting to understand human behavior in small-scale ethnographically specific societies with preindustrial economies. But the dominant evolutionary paradigms of agricultural change, both within and beyond the Third World, have increasingly seemed to be contradicted by the practice, and ultimately the logic, of the smallholder pattern.

Modernization theory that laid out apparently obvious stages of global agricultural development in the flush of optimism after World War II prescribed economic growth through applied science, capital investment, mechanization, a need-for-achievement mentality, and vastly increased

4. As Geertz points out, cultural ecology "forms an explicitly delimited field of inquiry, not a comprehensive natural science" (1963: 10).

labor productivity (Rostow 1960). It was believed that foreign aid and developed technology would inevitably (and rapidly) replace traditional, stagnant subsistence cultivation, freeing the poor and "underemployed" rural masses for the urban industrial sector where they belonged. I envision the emblem of this movement as a tractor triumphant on a field of Iowa corn. Its flaws, at least in Africa, had something to do with the Western hubris that ignored the existence of working indigenous solutions to the problems of farming an alien environment. Local ethnoscientific knowledge of soils, rainfall, crop varieties, and pests was not appreciated by outsiders and could not readily be duplicated on experimental farms and in laboratories (Paul Richards 1985). No one seemed to consider the fact that bigger fields, even with machine plowing, might require more seasonal weeding and harvesting labor than a typical household could muster (Baldwin 1957), or that shifting cultivators might be working less and enjoying higher returns per hour than intensive farmers (G. D. Stone et al. 1990). Furthermore, the costs of high-tech irrigation systems and manufactured inputs for rice or wheat in West Africa were far in excess of what the disappointing yields would ever cover (Pearson et al. 1981; Andrae and Beckman 1985).

Where modern Green Revolution technology of high-yielding rice varieties, chemical fertilizer, and improved irrigation was most effectively adopted, Asian systems of intensive cultivation were already operating and the scale-independent innovations were accessible to smallholders. Agricultural economists also began to detail the advantages of household labor in comparison to the opportunity and transaction costs of hired agricultural workers (Binswanger and Rosenzweig 1986; Pingali et al. 1987). The spontaneous and very effective effort of the Kofyar to produce a surplus for the market, using hoe technology and mobilizing labor by household and reciprocal means, suggested that a mechanical modernization model of development was not adequate to understanding this process (Netting et al. 1989; G. D. Stone et al. 1990).

The template of large-scale, monocropped, labor-saving agriculture dependent on fossil fuels was applied with equally uncritical abandon to systems of production in the socialist countries. There, however, the vision of radically reformed farming brought with it an ideological stress on the communal organization of production and the abolition of inequality founded on private property rights. The history of land reform after the Russian Revolution, followed by Stalin's forced collectivization campaigns, the violent seizure of grain, and massive rural starvation suggested the depth of peasant resistance to communist economic policies. The notorious failure of collective farms to allocate the factors of production efficiently and to provide incentives for responsible skilled-labor inputs has been a major cause of the long-term Soviet agricultural crisis (Shanin 1990: 188–205).

Even in the midst of those huge spreads of dry wheat, invariably depicted with ranks of combine harvesters under fair summer skies, the individual household plots of collective members remained significant suppliers of the nation's food. Tim Bayliss-Smith (1982) describes a 3,144-hectare collective farm in the Moscow district with only 7 percent of its 1,700 arable hectares in private plots. Yet over half of all household labor time was devoted to these fields and gardens, achieving yields per hectare that were six times those of the collective area. Energy returns on each calorie of input were estimated at 11.2:1 as opposed to 1.09:1 on the heavily mechanized collective farm. Although the private plot was not technically owned by the user, it resembled a smallholding in being near the house, receiving constant care and attention, being heavily manured, and supporting diversified plant and animal production. Decisions concerning these small operations were made by the household, with women playing a more important role than men. Such management differs decisively from that of the collective, where "any response by farmers to signals from their environment must, in all important respects, be made with reference to instructions from a remote bureaucracy, instructions which cannot foresee all the local vagaries of weather, disease, and soil conditions" (Bayliss-Smith 1982: 97). The inherent contradiction between smallholder efficiency and communist ideology has at last been recognized by Gorbachev's call for the freeing of Soviet farmers from the state-run system of collective agriculture. "Comrades, the most important thing today is to stop the process of de-peasantization and to return the man to the land as its real master," Gorbachev has been quoted as saying (*New York Times*, October 14, 1988). The return of private property in some form is a foregone conclusion.

When I began to think tentatively about the extension of some general characteristics of smallholder farm households to cultures with long traditions as complex civilizations, the case of China was both attractive and problematic. Even the casual student (and I am no sinologist) is aware that Chinese agriculture uses methods of double-cropping, controlled irrigation, fertilization, and terracing in a highly productive system of wet-rice agriculture, and that China supports an unusually dense rural population. Given a continuous, documented history, I inferred that the tools and techniques of intensive agriculture and perhaps some indications of labor organization and land tenure could be investigated over time. Recent work on Chinese agricultural history (Hsu 1980; Chao 1986; Anderson 1989), on sustainable energy input/output measurements (Wen and Pimentel 1986), and on the distinctive features of comparative Asian wet-rice economies (Bray 1986) suggested the exciting possibilities for such an investigation. It was the massive, politically inspired, and centrally planned institution of agricultural collectives in the People's Republic of China in the 1950s that really piqued my curiosity. If an archetypal system of intensive cultivation could indeed be carried on by extra-household work teams, if harvested goods and income could be shared equally, and if private property could be replaced by communal control of pooled land and livestock, my smallholder speculations would be just another romantic anthropological Just-So story. Marx's primitive communism might in fact have a dramatic modern analogue, and there might already exist a bountiful, egalitarian future at work on the farm. According to many popular and scholarly reports, to propaganda, and to theoretical analysis, collective agriculture had succeeded.

It was only in the mid-1980s that I began to hear of an official retreat from communes, brigades, and work teams and their replacement by a national agricultural policy of *baogan daohu*, or the household responsibility system. Households were given use rights on collectively owned land, and they contracted to fill quotas for delivery of certain products at fixed prices to the state in return for the right to dispose of their entire surpluses on the free market (Perkins and Yusuf 1984). An administrative change initiated in 1978 encompassed the majority of Chinese villages by 1982 and was all but universal by 1984 (Smil 1985; Hartford 1985). Linking economic rewards directly to output and encouraging household initiative, innovation, investment, efficiency, and risk-taking explosively raised production and the rural standard of living, effecting what has been called "the most far reaching and orderly socioeconomic transformation of the 20th century" (Smil 1985: 118). An unparalleled experiment in the social engineering of agriculture had been reversed, and I resolved to follow the smallholder story to China.

Any discussion of smallholder household farming worldwide raises expectations that it cannot fulfill. The tendency of many Americans is to categorize the issue as the familiar one of the family farm, whose demise at the hands of agribusiness, a national government of subsidies and controls, a volatile land market, the agricultural-research establishment, and international commodity trading has been heralded for decades. Values ranging from the agrarian democracy of Thomas Jefferson to the virtues of raising hard-working and pious children in the salubrious country air have been enlisted in this debate, and we are now entering a decade in which questions of the mythic economies of scale (Strange 1988), stewardship of the land (Berry 1987), and sustainable systems (Francis and Youngberg 1990) will be rightfully (and righteously) publicized.

I once thought that the plenitude of North American land, its frontier history of relatively sparse rural population, its marvels of technology

TABLE P 1
Agricultural Output in Six Countries, 1880 and 1970

	Hectares per male worker		Output per hectare		Output per male worker		Fertilizer (kg/ha)	Workers per tractor
	1880	1970	1880	1970	1880	1970	(1970)	(1970)
United States	25	165	0.5	1	13	157	89	1
England	17	34	1	3	16	88	258	–
Denmark	9	18	1	5	11	94	223	2
France	7	16	1	4	7	60	241	3
Germany	6	12	1	5	8	65	400	–
Japan	1	2	3	10	2	16	386	45

SOURCE: Boserup 1983: 401. Used with permission.

NOTE: *Hectares* refers to agricultural area—that is, to all land on farms. *Output* refers to output of both crops and animal products (excluding fodder consumed by the farm animals). This output has been recalculated in wheat units, equivalent to one ton of wheat, by Yujiro Hayami and Vernon Ruttan (1971). *Workers* includes adult male workers, but not women and children. Kilograms of chemical fertilizer are measured in fertilizer content per hectare of arable land—that is, agricultural area minus pasture and fallow.

and science, and its cheap power made most considerations of smallholder intensive agriculture here, and by extension in any modern state, either trivial or anachronistic. I was wrong. Quantitative comparisons among leading industrial nations show that the logic of population density and agricultural intensification distinguishes types and defines trajectories through time (see Table P 1). Since 1980, U.S. male workers have greatly increased the areas they farm and their output, but output per unit of land has not kept up with that of Denmark, France, and Germany, and is only one-tenth that of Japan. Surprisingly, fertilizer per hectare gives the same picture of extensive U.S. as compared to intensive European agriculture. Although productivity grew in all modern nations from 1880 to 1970 (Ruttan 1984), Japan and Germany have raised land output, while the United States has pushed up labor output (Fig. P 1). Secular trends in the relationship of population to arable land, the cost of energy, and the dangers of erosion, chemical pollution, and declining fertility point to more intensive and sustainable methods of land use on an Asian or European model as an inescapable necessity even for the United States. We ignore the proven advantages of household labor, management, ownership, and inheritance at our peril.

My purpose in this book is not to describe U.S. agriculture or prescribe some illusory smallholder panacea. The adaptations that will surely come with changing energy prices (Pimentel 1973), government subsidies (Strange 1988), water and soil depletion, and new models of alternative agriculture (National Research Council 1989) have legions of able and passionate expositors. The large class of self-provisioning family farmers that existed in the United States before World War II has almost disappeared in a sea of specialized commodity production, and "by the

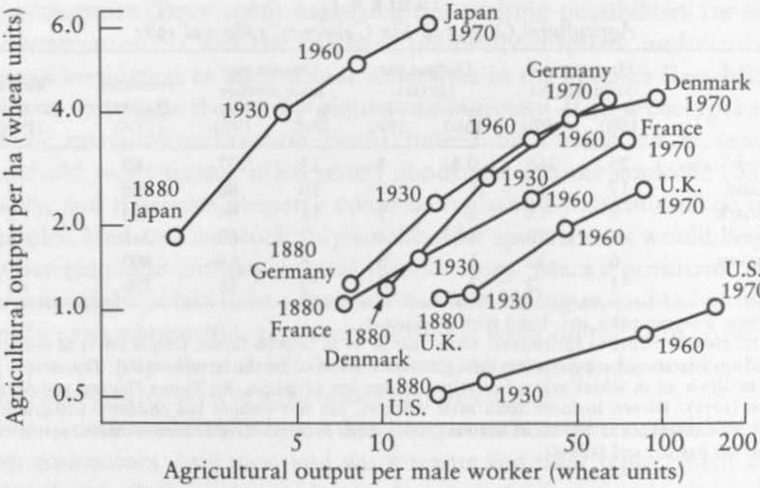


Fig. P 1. Historical growth paths of agricultural productivity in the United States, Japan, Germany, Denmark, France, and the United Kingdom, 1880–1970. (From Ruttan 1984: 109)

1980s the farm household had become virtually isolated from the farming operation" (Adams 1988: 467). Where facets of the old smallholder system remain, as among the Amish, in the diversified, family-descended, "yeoman" operations of Illinois (Salamon 1985), and in part-time and retirement farms in Georgia (Barlett 1987b), I shall note them. But it is in the Third World, with its sweeping dynamics of population growth, market expansion, and agricultural change, where an understanding of the smallholder pattern may be most relevant.

Though I never became the applied anthropologist and secular missionary that I expected to be when I entered graduate school, my concerns with the cultural ecology of cultivators, and more generally with social change, have brought me into repeated contact with students of development. From the vantage point of an occasional consultant, I looked at the economics of rice production in Senegal and the Ivory Coast, the proposed dams on the Gambia River, and the small farmers in northern Portugal on the eve of EEC membership. Perhaps even more important was my long-term view of the indigenous development of the Kofyar as they entered a market economy with almost no outside planning, extension, new technology, or credit (Netting et al. 1989). Reports of the death of the smallholder in a modern high-tech, large-scale world have proved to be vastly exaggerated. Indeed, scarcity of rural resources and national demands for food production create just those circumstances in which agriculture intensifies and the household organization of production demonstrates its comparative advantage. But in the shadow of proliferating industry, bureaucracy, and education, smallholders often become invisible or embarrassing.

The fact is that Asian smallholders, with an assist from Green Revolution methods, have astoundingly kept ahead of food demands, sidestepping the sinkhole of involution in Java, and liberating unimagined effort and productive enterprise in China. Where state policy has allowed agricultural prices to escape the controls of marketing boards, and where inputs like fertilizer are no longer left to the (mal)distribution of parastatal firms in Africa (Bates 1981), rural people have usually responded with a deluge of food. Where conditions of population density and market relationships are conducive to intensive, sustainable production, we can reasonably expect smallholders to rise phoenixlike from the ashes of thousands of collective farms. Even the indolent estates and deforested ranches of Latin American oligarchs may someday become the scene of much higher yielding gardens and orchards (Anderson 1990) if they are portioned out to solvent, experienced peasant households by effective land reform. I believe that intensive agriculture by landowning smallholder households is economically efficient, environmentally sustainable, and socially integrative. This book is an attempt to use the evidence of social science, the logic of practical reason, and the personal conviction of a garden-variety ethnographer to show how the smallholder works.

the production of firewood for warmth and cooking and of timber for construction. That a single community could encompass and afford access to this diversity of products meant that a relatively dense population in an area of constrained biotic potential could maintain a remarkable degree of security.

Despite the appearance of difficult, marginal subsistence potential in the Alps, agricultural change could increase the potential of this area and allow more intensive exploitation. Grain crops are not well adapted to high mountains, and even hardy winter rye may yield poorly if spring is late and an overcast, rainy early summer retards ripening. There is evidence that climatic conditions of this type led to widespread harvest failure in the latter part of the eighteenth century. It was at this time that the Swiss, along with other European farmers, were able to broaden their subsistence base by the adoption of the potato, an American tuber crop domesticated in the Andes, where environmental conditions resemble those of the Alps. In Törbel, potatoes could produce almost 15 times as much as rye from the same area by weight and 3.3 times as many calories (Netting 1981: 163). Moreover, growing potatoes did not mean that grainfields had to be sacrificed. Previously, rye had been planted every other year in a field, but it was found that potatoes could occupy the fallow period and thus raise the total production of the land. They could grow in poorer soil and at higher altitudes than rye, could occupy small patches of land too steep to plow, and resisted the hailstorms that devastated grain crops. Potatoes, which are rich in carbohydrates, could supplement a diet that already had good sources of proteins and fats in its dairy products. The new food crop, which rapidly became a regular item of daily consumption, increased the support capacity of the existing land, and in Törbel and similar European alpine communities, it may have been instrumental in sustaining a doubling of population over the next hundred years (Netting 1981: 164–68; Viazzo 1989: 212–14, 269).

Protection of agricultural plants and animals among the Swiss was less a matter of inhibiting the growth of competing organisms, as in the tropics, than of sheltering livestock from the elements and keeping domestic animals out of the crops. The lush individual meadow plots, which averaged only about 1,300 square meters each, were too small to divide up with fences or hedgerows. There were a few wooden fences along heavily used paths, but animals were usually either closely herded when they were in transit to other barns or pastures or tethered to a peg and moved about in a meadow of their owner's. Today, temporary pasturage is defined by portable electric fences, powered by batteries, which are strung up to enclose small areas. Because of the long winters, all livestock must be confined to barns or stables for warmth and proximity to their stored fodder. Substantial log buildings with roofs of local slate ring the Swiss villages and hamlets of Valais and dot the meadows. Sometimes a barn with its haymow will be joined to a cabin for temporary residence when the farm family must care for cows at some distance from the settlement. A farmer might have access to five different barns, but in many cases only a fractional share, averaging two-fifths of the structure, would be owned. In the past, groves of tall trees were left standing around stone-walled corrals on the alp to give the cows protection from late spring and early fall storms.

Valuable crops may be subject to specific pests, and today farmers use a variety of chemical sprays. Potatoes are menaced by the Colorado beetle, and the grapes must be sprayed periodically against mildew and insect larvae. In the nineteenth century, the phylloxera epidemic ruined many of the Törbel vines, and the vineyards had to be replanted with American root stock. There is a large traditional pharmacopoeia for treating animal diseases, and in the past, the death of one of the average family's two adult milk cows would have been a severe economic hardship. Today scientific breeding has produced animals with higher milk yields, and veterinary medicine is readily available. Though dogs were too expensive to maintain in former times, many families had cats to keep down rodent infestation that threatened stored foodstuffs. In the long-domesticated Swiss landscape, there have been no large animal predators for many years. Theft of livestock was also unlikely in the small, isolated, face-to-face community.

Wet-Rice Farming as an Intensive System Par Excellence

Perhaps the epitome of intensive agriculture is represented by the irrigated wet-rice systems of Asia. No brief survey can do justice to the technological achievement, the ecological sophistication, and the variety of such systems, but a few examples may illustrate the principles and some of the specific practices of cultivation. The smallholder who cannot gather the grain of a wild cereal grass from a swamp or a seasonally inundated river valley, and who lacks the forested tropical uplands to grow dry rice by slash-and-burn methods, must domesticate and control an environment specifically adapted to this plant. The underlying soil may be quite poor in plant nutrients, and sources of organic replacement may be limited, but managed water can supply these deficiencies and has done so over centuries of use. Clifford Geertz (1963: 31) likens this means of converting natural energy into food to "the fabrication of an aquarium," a felicitous image that recalls the first model of a balanced ecosystem that many of us learned about in elementary school science textbooks. On a wet-rice terrace or pond field, the base of impervious clay, the low banks or bunds around the edges, the precisely leveled surface, the water inlets and the outlets, are all designed to retain water at measured depths for accurately timed periods in accordance with the needs of the developing plant. The "rice-growing brew," though it may be from rainfall, serves its fertilizing function best if it conveys dissolved nutrients and silts from a river or some other external source (Hanks 1972: 37). Irrigation water not only restores crop-depleted nutrients to the soil annually but also promotes the fixation of atmospheric nitrogen (up to 50 kg/ha) through the symbiotic association of blue-green algae and fern that it supports (Altieri 1987: 76). In the words of L. M. Hanks:

> A flooded field is short on oxygen . . . , yet oxygen becomes available through the bacteria that break up the organic products of fermentation. In this dank airlessness nitrogen is converted by other bacteria into ammonia rather than more familiar nitrates. In the presence of ammonia the brew tests more nearly neutral or even [more] alkaline than acid, so that phosphorus becomes available to plants as ferrous and manganese phosphates rather than the more familiar phosphorous acid. Unlike roots in dry soil, the rice roots at the bottom of a flooded field serve mainly to anchor the plant, while the higher rootlets drink in the necessities of growth. (Hanks 1972: 33–34)

The chemical and bacterial decomposition of organic material, including the remains of harvested crops, contributes to this process.[5] Dissolved nitrogen can be brought in by the water, especially if there is a slow flow through the pond field (Seavoy 1986: 156), and the rice rizosphere can also fix considerable amounts of atmospheric nitrogen (Ruthenberg 1976: 184).

Where irrigation is practiced, the high water table prevents the vertical movement of fluids, thus limiting nutrient leaching (Altieri 1987: 76). Standing water also fills a protective function, shielding the soil surface from high temperatures and the direct impact of rain and high wind that could induce erosion. An inundated field restricts the growth of many weed plants that would compete with the growing rice for space and nutrients. With water as the crucial variable determining rice productivity, the timing of its application is also important. "Paddy should be planted in a well-soaked field with little standing water and then the depth of the water increased gradually up to six to twelve inches as the plant grows and flowers, after which it should be gradually drawn off until at harvest the field is dry" (Geertz 1963: 31). Small fields permit the maintenance of an even depth of water and varying it on a schedule that may stagger crop maturity so that the critical transplanting and harvesting operations need

5. Under dry-land conditions in the tropics, the nitrogen in organic matter is changed during decomposition into ammonium, rapidly oxidized to nitrate, and then quickly leached or denitrified into a gaseous form that is lost to the atmosphere (Bayliss-Smith 1982: 72). Waterlogging slows the decomposition rate of organic matter and the rate at which nitrogen oxidizes, making nitrogen available to the growing wet-rice crop.

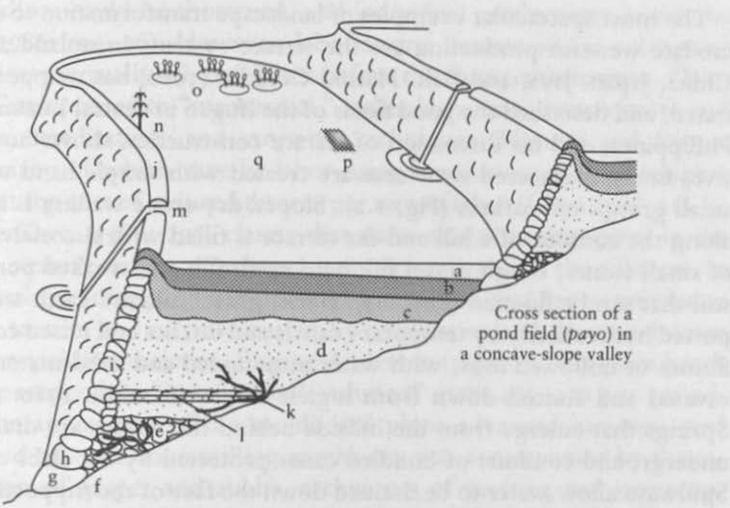
not be performed on all fields at the same time. Even temperature can be regulated by moving water along a short course, thus retaining warmth, or over a longer distance that allows it to cool (Hsu 1980: 119). Creating and precisely controlling a liquid microenvironment for rice not only optimizes and stabilizes crop yields but may in fact improve soil quality under permanent land use over the long run of 50 to 100 years (Ruthenberg 1976: 184).

On both irrigated and rain-fed fields under a variety of crops, Asian intensive cultivators used a wide variety of complex and laborious fertilization techniques. Texts from the Han period in China (206 B.C. to A.D. 220) show the existence of an elaborate soil classification of three grades and fifteen types, along with the knowledge of how their agronomic qualities could be improved (Hsu 1980: 94). Green manuring by cutting, burning, and soaking weeds or by turning them under is attested by the fifth century B.C. Terra-cotta models of Han pigpens with adjoining privies show how pig manure and human feces were collected by pipes and channeled to a lower clay plate for drying and later distribution to the fields in powdered form (Hsu 1980: 97). The most careful fertilization was devoted to the seedbed, as in the instructions of a medieval Chinese agronomist quoted by Francesca Bray:

> In autumn or winter the seedbed should be deeply ploughed two or three times so that it will be frozen by the snow and frost and the soil will be broken up fine. Cover it with rotted straw, dead leaves, cut weeds, and dried-out roots and then burn them so that the soil will be warm and quick. Early in the spring plough again two or three times, harrowing and turning the soil. Spread manure on the seedbed. The best manure is hemp waste, but hemp waste is difficult to use. It must be pounded fine and buried in a pit with burned manure. As when making yeast, wait for it to give off heat and sprout hairs, then spread it out and put the hot fertiliser from the centre to the sides and the cold from the sides to the centre, then heap it back in the pit. Repeat three or four times till it no longer gives off heat. It will then be ready for use. If it is not treated in this way it will burn and kill the young plants. Neither should you use night soil, which rots the shoots and damages human hands and feet, producing sores that are difficult to heal. Best of all the fertilisers is a mixture of burned compost, singed pigs' bristles and coarse bran, rotted in a pit. (Bray 1986: 45–46)

The products of other farm activities, such as silkworm excrement, bonemeal from slaughtered animals, and pond muck containing decomposed plants and waterfowl droppings, were all systematically collected for manuring. Old straw thatch and cooking-fire ash entered the midden, and even carbon-impregnated brick stoves and adobe walls were broken up and returned to the soil (M. C. Yang 1965 [1945]: 240). There was also a thriving market from as early as medieval times for organic materials from external sources. Night-soil collectors called regularly on urban

Fig. 1.2. Land use and settlement in the central portion of Baynīnan, an Ifugao district community in highland Luzon, Philippines. (From Conklin 1967: 115)



a	*lobong*	water	i	*topeng*	stone retaining wall
b	*līyo'*	worked pond-field soil	j	*banong*	dike, bund, pond-field rim
c	*haguntal*	hard earth fill			
d	*'ādog*	rough gravel fill	k	*'abbūbul*	submerged water source
e	*gāngal*	coarse fill, small stones	l	*'anul*	drainage conduit
f	*doplah*	bedrock; or *lūta* original valley-floor earth	m	*gūheng*	spillway
			n	*pumpudūngan*	property marker (site)
g	*gopnad*	foundation stones, markers	o	*'inādo*	vegetable mulch mounds
h	*'aldoh*	second-course walling stones	p	*tāu'*	fish sump
			q	*bawang*	enclosed pond-field surface

Fig. 1.3. Ifugao pond-field terrace composition. (Adapted, with permission, from Conklin 1980: 16)

households before dawn, and there was trade, sometimes over considerable distances, in oil cake, fish meal, waste from making bean curd, mollusc shells for lime, and river mud (Bray 1986: 49).[6] Modern manufactured chemical fertilizer fits naturally and inevitably into this process, but it may not have the same effects on soil tilth and texture. This vigorous historic recycling effort was undoubtedly a key element in the energy efficiency and sustainability of Chinese agriculture (Wen and Pimentel 1986).

6. A similar process of intensification was compressed into a relatively short period in Japan, where a general shift from dry- to wet-rice farming took place in the eighteenth and nineteenth centuries, weeding was introduced, irrigation was extended, new rice varieties were diffused, and commercial fertilizers such as dried fish, oil cake, and urban night soil were used to supplement barnyard manures and ash. Few of these technological changes were the result of inventions, and most were known techniques that spread from the localities where they had been developed. See Smith 1959: 86–97.

The most spectacular examples of landscape transformation to accommodate wet-rice production are the terrace systems in upland areas of China, Japan, Java, and Bali. Harold Conklin (1980) has mapped, illustrated, and described the pond fields of the Ifugao in central Luzon, in the Philippines, and his discussion of terrace construction shows how massive, finely engineered structures are created with simple hand tools by small groups of workers (Fig. 1.2). Sloped dry-stone walling is built up along the contour of a hill and the terrace is filled with successive layers of small stones, rough gravel fill, hard earth fill, and worked pond-field soil that can be flooded (Fig. 1.3). Rock, gravel fill, and earth are transported hydraulically by temporary canals and ditches and raised conveyor flumes of hollowed logs, with water impounded and solid materials excavated and sluiced down from higher slopes (Conklin 1980: 16–17). Springs that emerge from the hillside behind the terrace are drained by underground conduits of bundled canes protected by flat slabs of rock. Spillways allow water to be drained down the face of the supporting wall to terraces below. The field surface is slanted slightly downward toward the uphill-side margin of the terrace to prevent total loss of ponded water if there is a washout. When the field is intentionally drained, an excavated sump confines the mud fish that have been stocked and allowed to mature in the seasonal ponded environment. Walling stone can be quarried and split from boulders or outcrops with metal and wooden wedges, assisted by fire and pry bars (Conklin 1980: 18). The time spent in the original construction of terraces and water channels is greatly added to by the frequent need to repair damage caused by landslides, seepage, and rainstorms (Conklin 1980: 29). Wet-rice production in terraced pond fields exemplifies the skills and labor intensification that support Ifugao populations of some 250 per km^2 of cultivated area (Conklin 1980: 51).

Technological Change in Chinese History

There is a temptation when describing Chinese agricultural intensification to recount marvels—the clever techniques for capturing and creating organic material that restore soil fertility, the practical and sophisticated understanding of biological processes, the disciplined and skillful application of labor. But even the fascinating history of agrarian technical virtuosity describes a series of spurts rather than a straight line of development through time. The artifacts, images, and writings of a literate civilization allow us to reconstruct the course of technological change in agriculture. The introduction and wide adoption of iron tools in the pre-Han era (before 206 B.C.); of the moldboard plow during the Han period; and of steel for the edges of plowshares, hoes, and sickles under the Tang dynasty (A.D. 618–907) meant in each case that farmers could till larger areas, fallow could be shortened, and individual productivity could rise (Chao 1986: 194–96). However, labor-saving innovations in cultivating implements virtually all took place before the fourteenth century. "Biological," as opposed to "mechanical," technology involves new crops and varieties, fertilization, and cropping techniques (Hayami and Ruttan 1971), many of which may be labor-using innovations that give higher output at the cost of reduced returns per unit of labor (Chao 1986: 21).[7]

Kang Chao (1986: 198) claims that there was a turning point in the twelfth century when population pressure compelled the Chinese to adopt multiple-cropping, reclaim land and extend land use to inferior or difficult terrain, and increase output by fertilization and the introduction of higher-yielding varieties. Eugene Anderson (1989), on the other hand, finds the seeds of the "first Green Revolution" in the 400–100 B.C. period, when the appearance of the moldboard plow, advanced harrows, seed drills, and oil- and flour-milling machinery was accompanied by the introduction of grapes and alfalfa, techniques of grafting and intercropping, the pretreatment of seed with fertilizer and insecticide, and the lining of storage bins with pesticide plants. Intensive pig rearing and aquaculture of several crop species were also developed, along with the dryland farming techniques of rolling snow into soil and dust mulching. Farming populations had already become concentrated around cities, and their strategies of intensification were powered in part by the drive to participate in a growing market-dominated economy (Anderson 1988: 109).

From its beginnings in China, agricultural intensification was encouraged by the state and diffused by a literate elite. The Han emperor Wen propagated the ideology of agriculture as the basis of the state, symbolizing this commitment by himself plowing a ceremonial furrow, while the empress raised silkworms. In more material terms, peasant taxes were kept to a low 3 to 7 percent of the harvest, and large estates were discouraged. Wen "recognized that small farmers are particularly prone to intensify" (Anderson 1989: 141). From the ninth century, woodblock printing allowed the publication of practical agricultural treatises with pictures of tools and appliances. Wang Chen's book in 1313 had 136,000 characters and almost 300 illustrations (Elvin 1973: 116). Methods of steeping seeds in a decoction made of boiled bones, scooping mud from creek bottoms

7. The failure to continue technological development in China because the labor of the fast-growing population was cheaper than machinery or capital-intensive innovations has been called the "high level equilibrium trap" (Elvin 1973) and likened to the involution that Geertz (1963) has characterized in Java (Anderson 1988: 88, 100). The question remains as to whether the biological innovation and intensification of labor sketched in the Boserup model inevitably led to a decline in average rural welfare and the immiseration of the population.

for compost, and applying quarried lime to fields were recommended. A thirteenth-century description of Han-chou mentions swarms of boats carrying away rubbish and night soil from the city and the organized business of ordure carriers who daily emptied the tubs that people set outside their doors (Elvin 1973: 120). An urban life without sewers or fouled water sources and a farming system dependent on recycling valuable organic material had combined in an ecologically symbiotic relationship unmatched in the Western world.

The processes that not only maintained fertility in rich alluvial land but literally created an agricultural medium where it had not previously existed were described in vastly appreciative detail by F. H. King (1911), a pioneer soil chemist from the University of Wisconsin. Irrigated, leveled fields south of Canton produced two crops of rice in the summer before being ridged for a winter crop of leeks and vegetables. Night soil imported 90 miles by boat from the city was diluted with water and applied at the rate of 16,000 gallons per acre to sustain the multicropping (King 1911: 73). Composting reached a pinnacle of baroque organic elaboration in the practice of (1) shipping stable manure from the city to the country; (2) unloading the manure and saturating it with mud scooped from the canal bed; (3) cultivating a field in nitrogen-fixing clover; (4) digging a pit in the field and filling it with alternate layers of composted manure and cut clover; (5) fermenting the mixture for 20–30 days before distributing it over the field for the following rice crop. Excavating canal-bottom mud had the additional effects of preventing the waterway from silting up, adding organic matter to the soil, raising the level of the field, and giving it better drainage (King 1911: 74). King observed a man who had carried about a ton of mud from a 10-foot-deep, tidally exposed canal bottom, using flat pans and a carrying pole, all before 10 in the morning (1911: 169).

Time as well as space was carefully economized in the Chinese intensive system. Interspersed rows planted at different times—for example, wheat nearing maturity with Windsor beans two-thirds grown and cotton just planted—provided for the "fullest possible utilization of every minute of growing season and of the time of the family in caring for the crops" (King 1911: 266). Using a one-acre seedbed for rice plants that would occupy ten acres left nine acres free for 30 to 50 days, giving extra time for a crop there to mature (King 1911: 11). Double- and even triple-cropping could only be achieved with careful leveling of the field to provide a constant and accurately controlled depth of water. The saturated field was plowed, weeds were buried, and harrowing produced a smooth, liquid mud. Transplanting had to be rapid so that the rice plants did not wither between the nursery and the field. Equally important was the precise spacing of the seedlings to ensure the maximum number of plants with enough soil and water to bring each one to fruition (Rawski 1972: 13).[8]

Other crops received similar care. Formerly millet-based agriculture in North China was intensified with the arrival of New World crops such as sweet potatoes and peanuts in the late sixteenth century (Anderson 1988: 79). M. C. Yang (1965 [1945]: 19) describes procedures of selecting peanut seeds, sprouting them in warm water, planting them with fertilizer, flattening the field with a stone roller, weeding twice, cutting the vines, and then plowing the field into a fine powder, from which the peanuts are sifted out. In alternate years, sweet potatoes are grown in the same field. The tubers are first buried in damp sand on a warm brick bed. The shoots are transplanted to a nursery bed with heavy fertilizer and kept wet. The vines are then cut, bundled, and transplanted onto ridges, with a pint of water applied to each plant. To prevent small roots from sprouting, the vines are turned from one side of the ridge to another after every rain. New earth must be applied to the ridge tops as they wash down. Even the processing of the harvest is laborious. Women slice the tubers thin and put them out to dry in the sun, while boys camp in the field to protect them (ibid.: 20–21). After describing the practices of a farmer who supported 20 people from a half-acre garden of cucumber vines trained up trellises, King points out the alertness and efficiency with which the cultivator treated each plant individually. "Forethought, after-thought, and the mind focussed on the work in hand are characteristics of these people" (King 1911: 205).

The multiplicity of tasks in a highly developed system of intensive agriculture, the premium on effective execution, the necessity for planning, scheduling, and managing of farm operations—all of these are elements of production based on skill as opposed to scale. Francesca Bray's discussion of the rice economies of Asia makes this crucial distinction, noting that "Eurocentric" models of historical change in agriculture have always equated progress with the increasingly efficient substitution of alternative forms of energy for human labor (Bray 1986: 2–3). Where land was plentiful and labor scarce, as in the underpopulated New World and Australia, production could be increased most rapidly by land-extensive methods and mechanical technology. The same relationships of land and population that encouraged adoption of the McCormick reaper and the tractor had, at an earlier period, spread the eight-ox, heavy wheeled plow and the horse collar in medieval Europe (Lynn White, Jr., 1962). China's situation of land shortage and abundant labor, already evident in the Han era, gave the advantage to innovations like quick-ripening rice and the

8. In Java, men pull the seedlings from the nursery and women plant clumps of two to six seedlings 20 to 40 cm apart depending on soil fertility and variety grown; 12 to 20 people working as a team can plant 1 ha a day (Seavoy 1986: 157).

techniques of irrigated multicropping. Larger amounts of highly skilled labor were required, but this did not necessarily mean that the productivity of labor was drastically reduced (Bray 1986: 5). Agricultural implements might even become simpler as cultivation techniques became more complex. "When rural populations are dense and opportunities for alternative employment few, technical changes that absorb labour and reduce agricultural underemployment are preferable to those which increase output at the cost of reducing the labour force" (ibid.: 4).

The Ethnoscience and Specialized Technologies of Indigenous Intensification

The practices that characterize and define intensive agricultural systems of course form a continuum with other means of food production. Swidden or shifting cultivators may plant a great diversity of tuber, legume, grain, and tree crops in their burned clearings (Freeman 1955; Conklin 1957, 1961), achieving similar effects of soil protection, shading out competing vegetation, and restricting the spread of insect pests. They may allow leguminous trees to grow there as a means of restoring soil fertility, and they may fence their temporary plots, as do the Tsembaga in highland New Guinea (Rappaport 1968). But none of the normal techniques, such as weeding, are pursued as assiduously or combined with more permanent investments like terracing or irrigation as is the case with intensive farming. Smallholders with a permanent, limited land base must *do* more and probably also *know* more. Ethnoscience refers to local knowledge formalized into systems of classification that can be studied by linguistic methods. The Philippine Hanunóo swiddeners distinguish 430 different cultigens and recognize 10 basic and 30 derivative soil and mineral categories (Conklin 1954). The Tzeltal in the Chiapas highlands of Mexico make fine varietal distinctions in maize and other crop plants (Berlin 1973), and it seems clear that these extensive and orderly lexicons have been elaborated for utilitarian purposes (Hunn 1982).

The Kofyar classify soil by color, texture, and moisture content, accurately judging its organic content, its suitability for specific crops, and the difficulty of working it with a hoe when wet or dried and hard (Netting 1968: 82). Leached, unfertilized bush-field soil becomes lighter in color and increasingly sandy, and the Kofyar explain this change by saying that the water has soaked out its goodness. The natural plant cover and succession give the informed local cultivator an excellent sense of the underlying soil status (Nye and Greenland 1960) and prevent the mistakes that inexperienced settlers may make in an unfamiliar environment like that of the Amazon rain forest (Moran 1981: 108–15). Whereas shifting agriculturalists judge those inherent characteristics of soil that influence disproportionate energy use in some parts of the globe have brought questions of sustainable agriculture to the fore. The technological emphasis in agricultural development on raising production has encountered a slowdown in the growth of cereal yields worldwide since the beginning of the 1970s, and there is now evidence from Japan, Holland, and the United States of definite limits on the ability to boost output with more fertilizer (Douglass 1984). Pests that flourish in monocropped fields are freed from their natural enemies and at the same time become resistant to pesticides, demanding the development of more toxic chemicals. The same industrial systems threaten soils with topsoil erosion, waterlogging and salinization through irrigation, and the buildup of toxic substances. As larger proportions of petrochemically derived energy are used on the farm, the costs of these inputs rise.

Sustainable agroecosystems (Conway 1985, 1987; Marten and Saltman 1986; Douglass 1984; Chapin n.d.) can be in part defined in energy terms over time. The attributes of such systems include:

1. Relatively stable production per unit of land. Yields do not decline, because soil fertility and water supplies are maintained within acceptable levels. Weeds, animal pests, and diseases do not progressively reduce the energy needed for plant and domestic animal growth. Land productivity can be at various levels (an "integral" system of shifting cultivation achieves stable though infrequent crop yields from a given unit of land without environmental degradation), but increases in production should not be temporary, and the system should be resilient in the face of short-term or seasonal perturbations. Soil erosion or "mining," falling groundwater supplies, or declining resistance of crop plants to drought or insects, suggest that production will decline, even if it has not already begun to do so.

2. Predictable and relatively stable inputs of energy. Rapid increases in demand for labor, mechanical power, fertilizer, or water suggest ecosystem imbalance and the difficulty of maintaining the higher level of inputs.

3. Economically favorable rates of return between inputs and outputs, both in energy and in monetary terms. Consistently exceeding the energy budget, even if unrenewable energy sources are cheap, risks decreases in necessary energy inputs when their costs increase or when farm prices decline. When a significant portion of energy inputs come from the farm itself, when energy is conserved and recycled, stability in the face of uncontrollable changes in outside energy costs and prices is easier to preserve. Diversity limits risk and strengthens stability (Norgaard 1989).

4. Returns to labor and other energy inputs sufficient to provide an acceptable livelihood to the producers. This includes not only subsistence, with nutrition that sustains strength, health, and normal growth,

but also sufficient saving and accumulation to meet contingencies and to make the investments necessary for long-term productivity (Brokensha 1989).

The combination of stable and diverse production with high yields, internally generated and maintainable inputs, favorable energy input/output ratios, and articulation with both subsistence and market needs is effectively achieved with a smallholder strategy of intensification.

Certainly the most enduring and best-documented systems of highly intensive agriculture are the irrigated rice smallholdings of China. For the Jiaxing region with its rich soils, ample 1,300 mm rainfall, irrigation water, and favorable temperatures, *Shen's Agricultural Book* (Zhang Luziang 1956) from the seventeenth century allows a reconstruction of energy flows in farming. Dazhong Wen and David Pimentel (1986) have evidence that heavy production of rice, wheat, mulberry leaves for silkworms, and livestock has been sustained over centuries by human labor, using intensive practices of composting and green manuring, crop rotation, irrigation, and animal husbandry. Draft animals or other sources of imported mechanical energy were not used, and the soil was tilled with a rakelike iron tool that reached more than twice the 10 cm depth of a plow drawn by water buffalo. A major labor investment amounting to one-third of the 2,330 hrs/ha involved in rice cultivation went into processing and distributing 10,000 kg/ha of animal and human manure composted with rice straw. Summer rice could be alternated with winter crops of wheat, barley, rape, or beans, producing, for example, 3,900 kg/ha of rice and 1,300 kg/ha of wheat from the same field. Another type of crop rotation that was somewhat less labor-intensive involved growing one-third of a hectare of Chinese milk vetch, which provided 7,500 kg of green manure for a hectare of the following rice crop. Both the composting and the green-manuring methods required heavy labor inputs in tillage, transplanting, and harvesting. Both were also irrigated by foot-powered waterwheel pumps that required three men to operate them.

Although the production of irrigated wet rice and the energy inputs in an intensive system will always be relatively high, the factors of production are all subject to adjustment. A Philippine system (Pimentel and Pimentel 1979: 76) lowered human labor to less than a third of the seventeenth-century Chinese figures, partially compensating with energy from water buffalo traction and small amounts of nitrogen fertilizer (Table 4.4). Philippine rice production/ha was only 42 percent of Chinese totals, and energy efficiency dropped to 3.29. Among contrasting contemporary cases, Dawa, China shows the potential for increasing even the remarkable traditional yields from pond fields by adding still more labor, using animal power, and introducing large amounts of fossil-fuel energy (Table 4.4). The energy ratio falls to 3.16, but it remains higher

TABLE 4.4

Comparison of the Energy Inputs and Crop Outputs for Philippine, Chinese, and U.S. Rice-Production Systems

	Philippines (1962–63)	Dawa, China (1979–81)	Louisiana, United States (1977)
Input			
Labor (hrs/ha)	576	3,045	25
Animal power (hrs/ha)	272	332	–
Seeds (kg/ha)	108	164	n.a.
Energy (Kcal/ha)	1,825,432	7,577,139	11,460,694
Output			
Rice yield (kg/ha)	1,654	8,094	4,114
Rice yield (Kcal/ha)	6,004,020	29,382,672	14,933,820
Efficiency (ratio of Kcal output to Kcal input)	3.29	3.16	1.30

SOURCE: Wen and Pimental 1986: 4.

NOTE: As in Table 4.1, I have given only the total Kcal expenditures under the heading "Energy." The variations in the forms that energy expenditure takes are very great: for example, human energy accounted for 1,568,381 Kcal/ha in China, but only 12,772 in the United States; yet fossil fuel (including chemical fertilizers) accounted for only 128,568 Kcal expended in the Philippines but 11,447,992 Kcal in the United States.

than in a mechanized system in Louisiana, where human labor has almost disappeared and the energy represented by diesel, gasoline, and natural-gas fuels; nitrogen, phosphorous, and limestone fertilizers;[7] herbicides; drying; electricity; and insecticides reaches almost 11.5 million kcal/ha. A phenomenal labor productivity of over 600,000 output calories for each calorie of direct human work effort has been gained at the expense of an overall energy ratio only 11 percent of that achieved by the Chinese green-manuring system. Where the energy subsidy reaches its epitome in the Central Valley of California, a technology of laser-leveling of fields, aerial seeding and fertilization, and combines that harvest and thresh 8 ha/hr, the enormous energy inputs are almost equally divided between irrigation, equipment, and biochemical uses (Pudup and Watts 1987: 367), a dependence that has emerged in only 70 years and that raises serious questions of sustainability.

7. Manufacturing fertilizer is energy-intensive. Nitrogen is especially costly, requiring 14,700 kcal of fossil fuel for 1 kg of nitrate fertilizer, compared with 3,000 kcal/kg for phosphorus and 1,600 kcal/kg for potassium. Livestock manure contains less concentrated nutrients (0.56 percent nitrogen), but it aids in reducing soil erosion and improving soil structure (Pimentel 1984). Although considerable fuel is required to transport and spread manure with a tractor and spreader, the energy expenditure for commercial fertilizer is almost three times that of manure if it is transported no more than 1.5 km (Pimentel 1984: 128). The issue with the manufacture of chemical fertilizer, as well as with pesticides and herbicides, and with the release of CO_2 and other greenhouse gases as products of motor vehicles and factories, may be less the exhaustion of fossil-fuel energy resources than the environmental damage they cause. Industrial agriculture may very directly threaten its basic resources of soil and water.

Rather than importing fuel and mechanical energy for large-field monocrops, the Chinese farmers of the seventeenth century practiced a diversified, organic strategy that recycled internal and renewable energy resources. The persistence of smallholders in an area that supported 7.8 people/ha of farmland in the seventeenth century and provides for 15 people/ha today testifies to the maintenance of high yields without serious environmental degradation. Sustainability refers not only to the stability and favorable ratios of energy inputs and outputs but also to the source and costs of inputs and the range of economic needs met by outputs. To the extent that inputs are produced on the farm and by means available to the household, the farm family is less dependent on outside forces and less vulnerable to rapid changes in the market or failures in external economic and political systems. Labor energy, though substantial, could not exceed the potential of the household and occasional hired help, and double-cropping, tree cultivation, animal husbandry, and cottage industry provided the diversity of tasks that smoothed seasonal swings in work demand (see Chapter 3) and accommodated gender and age differences in strength and skills through a division of labor.

The stress on collecting or producing, processing, and returning organic material to the soil meant that diverse "waste" materials were never wasted. Of the 930 kg/ha manure (dry weight) applied to the crops, 34 percent came from the human residents, 47 percent from the 3.6 pigs/ha or a combination of pigs and sheep, and 19 percent from silkworm excrement, which could also be fed to fish. Rice straw was either composted or burned as household fuel, with the ashes being composted. The residue from processing rape-seed oil was applied as top dressing to cropland, and the fertile bottom muck from ponds used for irrigation and fish culture was dredged up to fertilize mulberry plantations. Vetch grown solely for green manure fixed substantial amounts of nitrogen for the system (Wen and Pimentel 1986: 8).

It is significant that the farming system included integrated subsystems that were market- rather than subsistence-oriented. Ten percent of the farmland was devoted to mulberry trees for silkworm cocoon production. Labor, at the rate of 1,450 hr/ha/yr, produced 13,800 kg/ha of mulberry leaves, which were in turn fed to sheep and to silkworms. Mulberry-leaf yields had an energy ratio of 0.57. Women reared the silkworms, putting in some 300 hours to feed 1,000 kg of mulberry leaves, producing 63 kg of cocoons and 5 kg of silk (Wen and Pimentel 1986: 20–21). Clearly, large amounts of energy were here being transformed into small but very valuable quantities of commodities. Harvested grain was not merely consumed or sold in raw form. Perhaps one-third of the crop was converted into alcohol, and the residue from the distilleries was fed to pigs (ibid.: 22). Meat for consumption or for sale also came from sheep, from barnyard fowls tended by women, and from the fish raised in ponds, and the droppings of all these animals entered the fertilization cycle. Moving up the food chain, as in feeding 180 kg of rape cake or 250 kg of barley to produce 50 kg of pork in six months, entailed a ratio of feed to meat of 5:1, but the addition of high-quality protein to the diet evidently justified the cost in energy.

With negligible fossil-fuel energy embodied in hand tools, the major source of power for the system was human labor, with an input of 3,756 hr/ha, of which 70 percent was for cropping, 4 percent for the mulberry plantation, 8 percent for rearing silkworms, and 18 percent for tending pigs and sheep. "The other energy used in the agroecosystem was renewable bioenergy produced within the agroecosystem" (Wen and Pimentel 1986: 26). Perhaps the system would have been more effective if wood from trees had replaced crop residues for household fuel, and if both fewer pigs and a somewhat smaller human population had been supported. But there seems little doubt that the system demonstrated ecological and energetic sustainability. Its overall production could have been further increased (although at the cost of some decline in efficiency) with a small input of industrial energy, but this might have risked the balance of energy flow that has been sustained for centuries.

It is striking that intensification of agriculture in the Chinese heartland of the Zhu Jiang (Pearl River) Delta did not approach some climax state of maximum energetic efficiency and then remain static or become involuted. Since the low-lying land was reclaimed by digging ponds and constructing dikes in the ninth century A.D., it has gone from wet rice, fish, and fruit trees to fish culture, mulberry trees, and silkworms for the nineteenth-century silk industry (Zhong 1982). Photosynthetic energy flows from the mulberry leaves to the silkworms. Silkworm excreta in turn feed fish, whose droppings, along with aquatic organisms, create fertile pond mud, which is used as manure for mulberry trees (Fig. 4.3). Vegetables, bananas, and grass (for fish food) can also be grown in rotation with the mulberry trees, and silk cocoons, fresh fish, sugarcane, and vegetables are all marketed. A similar integrated system of nutrient recycling is used for shrimp propagation by Vietnamese smallholders (Fig. 4.4). The Chinese mulberry dike–fish pond complex absorbs twice as much labor as the alternate land uses of rice or sugarcane growing, and it provides a considerably higher income per unit area (Zhong 1982: 201). This agroecosystem has gone through stages of increasing intensification for "thousands of years without apparent deterioration of soil fertility" (Zhong 1982: 192).

My global comparisons between labor-intensive smallholders and large farmers using major amounts of technological energy have tended to contrast different world regions or highly distinctive farming systems

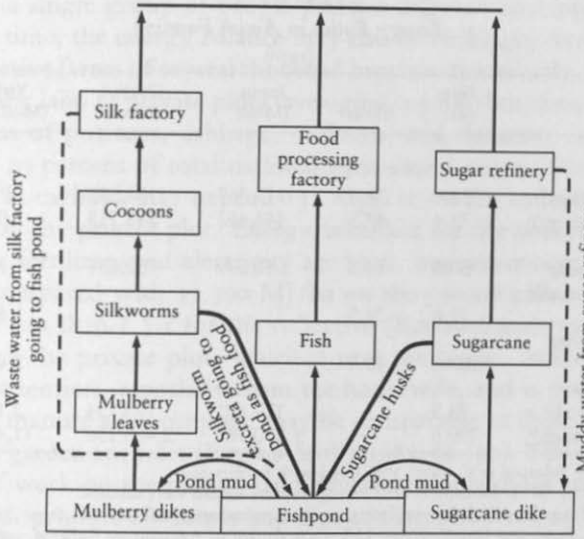


Fig. 4.3. A Chinese mulberry dike / fish pond ecosystem. (From Zhong 1982: 197)

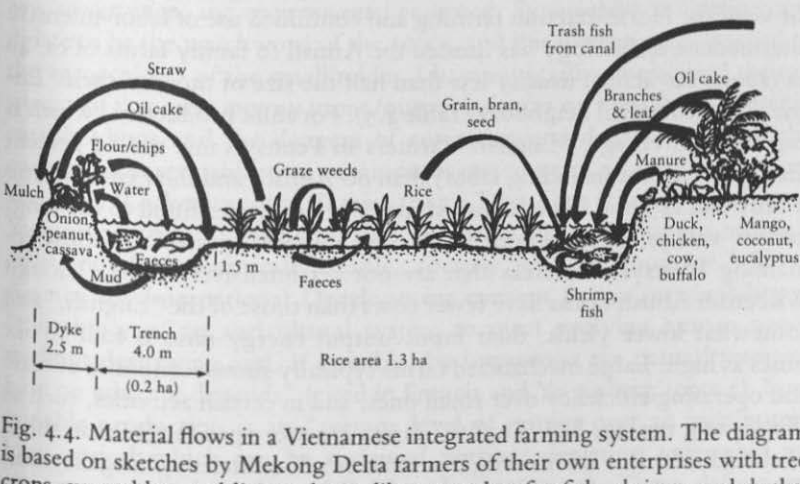


Fig. 4.4. Material flows in a Vietnamese integrated farming system. The diagram is based on sketches by Mekong Delta farmers of their own enterprises with tree crops, vegetables, and livestock on dikes; trenches for fish, shrimp, and ducks; and irrigated rice. The commercially valuable shrimp are protected by submerged mango and eucalyptus branches, and they are fed germinated rice, cassava flour, rice bran, coconut, and peanut oil cake. Vegetable matter and animal droppings reduce but do not eliminate the requirement for chemical fertilizers (Lightfoot and Tuan 1990: 18–19).