

This contribution is a part of the special series of Inaugural Articles by members of the National Academy of Sciences elected on April 25, 1995

Induced intensification: Agricultural change in Bangladesh with implications for Malthus and Boserup

B. L. TURNER II^a AND A. M. SHAJAAT ALI^b

^aCenter for Technology, Environment, and Development (CENTED), George Perkins Marsh Institute and Graduate School of Geography, Clark University, 950 Main Street, Worcester, MA 01610; and ^bDepartment of Social Sciences, 3900 University Boulevard, University of Texas, Tyler, TX 75799

Contributed by B. L. Turner II, September 19, 1996

ABSTRACT Bangladesh is dominated by a small-holder agrarian economy under extreme stress. Production shortfalls, increasing economic polarization, and chronic malnutrition are persistent, but major famine has been diverted in part by significant growth in agriculture. This recent history is open to both Malthusian and Boserupian interpretations—a history we explore here through a test of the induced intensification thesis of agricultural change. This thesis, framed by variations in the behavior of small-holders, has grown from a simple demand-production relationship to a consideration of the mediating influences on that relationship. The induced intensification thesis is reviewed and tested for 265 households in 6 villages in Bangladesh from 1950–1986. A time-series analysis of an induced intensification model provides relatively high levels of explained variance in cropping intensity (frequency and land productivity) and also indicates the relative impacts of household class, environment, and cropping strategies. On average, the small-holders in question kept pace with the demands on production, although important class and village variations were evident and the proportion of landless households increased. These results, coupled with evidence that agricultural growth involved intensification thresholds, provide clues about Malthusian and Boserupian interpretations of Bangladesh, and suggest that small-holder agriculture there is likely to continue on a “muted” path of growth.

The Bengal Basin is one of the most land stressed and economically impoverished regions on earth, and Bangladesh is the anchor of the basin. A country of 143,999 km² is occupied by nearly 119.8 million people, creating an average population density of 832 people per km² (1). Approximately 84% of population is rural, attempting to meet a major portion of its needs through agriculture. Land is intensively cultivated everywhere; the average cropping frequency approaches two harvests per plot per year. Yet, Bangladesh does not meet its production needs (2) and chronic malnutrition persists (3), especially among the 87% of the population below the poverty line (4). Localized famines occur, exacerbated by a 2.0% annual population growth rate and severe tropical storms that ravage the country every 3–5 years. Now, as in the past, Bangladesh is viewed as Malthusian crisis in waiting (5–8).^c

Understanding the relationships among population, technology, and resources embedded in interpretations of such crises remains a fundamental problem confronting the human sciences (9), one viewed through many interpretive lenses (10–13). These relationships are critical to questions of agricultural change in Bangladesh and throughout the less-developed world in general, with serious implications for food

production, nutrition and health, economic development, and sustainability.

Broad social science interest in agricultural change heightened in the mid-1960s with the publication of Ester Boserup's provocative thesis and the rediscovery, particularly in anthropology, of the work of A. V. Chayanov. Boserup's avowedly anti-Malthusian thesis of agricultural change argued that population growth is the central source of demand driving the intensification of cultivation, particularly among subsistence and peasant producers (14, 15). She reversed the simple but prevalent Malthusian-based views of the time—that the state of technology determined the levels of cropping intensity. Much of this technology, Boserup argued, is endogenously driven by the changing pressures placed on cultivation (16).^d Endogenous techno-managerial strategies include those long known to the community but not employed (although they may have been originally introduced from outside the community), as well as those developed within the community through the continuous experimentation of farming. In Boserupian-based perspectives the technologies and strategies of production employed need not represent the capacity known by the community in question.

In Boserup's original formulation, this pressure on subsistence and peasant farmers (henceforth, small-holders) was reduced to population density.^e The rationale centered on the direct link between production needs as measured by the population to be provisioned and the amount of land through which these provisions are met. It also involved a production behavior strongly paralleling that found in Chayanov's “theory of peasant behavior” (17), although Boserup was unfamiliar with Chayanov's work when she produced her own. Chayanov's thesis, drawn from detailed village studies in Russia, argued that the “drudgery of labor” in peasant production was such that farm households did not seek to produce as much as was possible—as in profit maximization—but sought a more restrained and less elastic goal, to provision the household. The amount of labor expended depended on the consumer-producer ratio of the household. Additional inputs to produc-

Abbreviations: ha, hectare; HYV, high-yielding variety(ies).

^cThe United Nations Development Programme ranks Bangladesh 146 of 174 developing countries in terms of its “human development index,” an indicator of socioeconomic well being.

^dA parallel thesis linking research and development in agriculture to the changing pressures on production is known as “induced innovation.”

^eVarious research communities apply different terms to describe farmers who are not fully integrated into market economies; each strongly objects to the terms used by the other. The term used here, small-holder, refers to all farm units not fully integrated into market production and growing a measure of their own subsistence. These farm units for the Bangladesh case study are further classified by the size of land holdings.

tion would not follow unless the consumer–producer ratio changed.

The insights provided by Boserup and Chayanov were powerful stimuli to researchers dealing with agriculture beyond the confines of economics (18, 19). The interdisciplinary subfields working largely among small-holders—cultural ecology, international development, and farming systems, among others—were quick to adopt the insights gained. Empirical analyses demonstrated the general applicability of these insights for understanding the spatial and temporal variability of cultivation intensity, but they also demonstrated various nuances and exceptions that allowed for more robust understanding of the change in question. This research recrafted, if informally, the original thesis into a more expansive theme, labeled elsewhere as the “induced intensification thesis” (20).

The successes of these works notwithstanding, induced intensification is questioned by all the “lenses” through which it might be viewed. The thesis can be seen as supporting a “technological fix” position by focusing on endogenously changing techno-managerial development to solve problems of production. It may be seen by others as directing attention to the trajectories of intensification, rather than on the impacts of change on food consumption, material well being, and sustainability of individual households caught up in the trajectories (21). Yet others envision agricultural change as directed more fundamentally by social and political relations (22, 23). Finally, even those supporting the rudiments of induced intensification question its applicability in high stress conditions, as in Bangladesh, where involution or even stagnation (see below) would seem to be the likely impacts on agricultural change (24).

This study offers an assessment of agricultural change and induced intensification in Bangladesh between 1950 and 1986. The thesis is introduced as it has developed within the interdisciplinary communities of the human ecologies and farming systems. A case study and test of the thesis among small-holders in Bangladesh follows. Finally, the lessons learned are applied to the larger Malthus–Boserup debate and to the future of Bangladesh agriculture.

Small-Holder Behavior: Underpinnings of the Thesis

The induced intensification thesis explains changes in agricultural intensity and, by implication, changes in the technology and management of cultivation. It employs an understanding of small-holder farming behavior in which variations exist in the production goals and rules of manipulating labor and capital toward those goals. This variation follows from the proportion of cultivation for subsistence and market and draws on behavior detailed in two ideal models.

Boserup and Chayanov characterized the subsistence household or farmstead as having the central aim of ensuring basic consumption needs and, in decreasing order of responsibility, that of the extended family, kin groups, and perhaps, village. These needs, elaborated by cultural and historical influences, form the basis of the household’s material (and in some cases, social) expectations and aspirations. Recognizing such influences, these aspirations track well with the “biological demand” of the producing unit (number of people to be nurtured by the household).

Two basic rules of production dominate: minimize risk in and labor to production. In an ideal subsistence economy, there is no need to risk surplus production (that beyond the immediate needs of the household) because there is little to be

gained from achieving it (25).^f Storage capacities are typically small and vulnerable to significant loss, and trading and bartering agricultural production is impeded by the redundancy of production. To ensure basic needs, however, farmers take into account usual losses due to drought, pests, and other production constraints. When these impediments are low, production exceeds expectations, a result known as normal surplus. The second rule follows from Chayanov’s drudgery of labor. Because labor is the primary input and the work difficult, techno-managerial strategies that minimize labor while ensuring basic needs are invariably followed. Intensification usually entails increases in labor, and thus the farmer does not intensify production unless induced to do so by changes in the responsibilities to those to be nurtured (population change) and/or in the conditions in which these responsibilities must be met (land pressure change).

The model of ideal market or commodity behavior was developed in the middle of this century through the work of agricultural and development economists undertaken largely in South Asia (26–28). As small-holders move increasingly into market production, changes take place in social structures and aspirations that transform behavior. Responsibilities for nurturing shift from lineage groups or villages to the household per se. The presence of the market reduces redundant production and increases aspirations (29).^g With higher aspiration levels, farmers respond to market signals, adjusting their factors of production accordingly. Small-holders, however, have few safety nets and must consider their minimal needs and the various risks to production, and thus adopt strategies that play-off maximum production against the minimum required.

The degree to which the small-holders efficiently allocate their inputs to agriculture is related to how well they are integrated into the market, either through the economy at large or their relative position within it. Because of poverty and other limiting factors (e.g., geographical isolation), some farmers may not be able to respond fully to market signals, particularly if responding entails high levels of risk (30). The resulting behavior—responding to the market under severe constraints—has been labeled an allocative proficient behavior (31).

The power of these two “ideal” models notwithstanding, the overwhelming majority of small-holders throughout the world are neither pure subsistence nor pure market farmers. Rather, they are engaged in various mixes of both kinds of production (32–34), often through strategies that are plainly observable, such as gender or other divisioning of fields or different inputs placed on different crops (35–37). Many involved in small-holder research conclude, if only informally, that these production mixes translate into “hybrid” farming behaviors, ranging along a continuum between the two ideal models. The outcomes of this behavior may differ little from those observed in the allocative proficient behavior, but the rationale giving rise to them are significantly different. Small-holders may fail to respond to market signals not only because of the constraints confronting them but because their production goals and logic are not fully market in orientation. Hyden’s “economy of affection” (38) and Scott’s “resistant peasants” (39) capture in alternative ways the hybrid behavior in question here.

^fSubsistence farmers may engage in “prestige” production to demonstrate their skills and status within the community, but this production usually involves a small fraction of total inputs and outputs of production.

^gThese changes also release the safety nets structured to ensure basic needs, offering instead the potential for some individuals and households to raise their material standard of living and for others to fail to do so. Increased polarization of material standards of living among households usually follows.

Induced Intensification and Trajectories of Change

Small-holders not only differ in their economic status, from the poorest of the poor to the relatively well-to-do, they differ in their adherence to subsistence and market mentalities and thus to their responses to differing sources and signals of demand. As these demands increase (or decrease), the techno-managerial strategies of production do as well. All else equal, it is usually more labor (and risk) efficient to increase the area cultivated than to intensify in the face of increasing demand, and the former strategy is usually followed in land surplus circumstances. As land pressures increase, more attention is given to intensification. In some cases, both options may be taken simultaneously (40). Intensification is usually the only option under high land pressures, requiring additional inputs (labor and capital) to raise land productivity in the face of the increasing stress placed on and draw-down of the environment (41).

A particular level of demand—as interpreted from the mix of signals to which the small-holder household responds—results in a techno-managerial strategy consistent with it. Further increases in demand are met first by increasing labor and capital inputs within this strategy, until marginal returns prompt a switch to another. The next strategy, however, may entail major outlays of labor and capital (e.g., terraces, irrigation networks) and/or a restructuring of resource allocation rules (e.g., access to water for irrigation), creating a “threshold” to intensification. Small-holders may resist crossing this threshold but do so if demand continues to rise and other options are lacking. Once crossed, however, the marginal utility of production realigns accordingly.

The broad trajectory of techno-managerial growth and intensity is, therefore, a stair-stepped one with the threshold zones constituting the critical junctures in the process.^h These thresholds may serve as major impediments to intensification, leading to conditions of involution and stagnation. Involution, as coined by Geertz, implies that production increases are made, but with significant declines in the marginal utility of inputs, and are done so because few, if any, options exist (42). Stagnation, in contrast, means that production does not increase and may even decline (43).

Socio-economic impediments or distortions to the ideal trajectory of induced intensification range in kind from state regulations to institutional structures (43). This range and the variations of impacts are sufficiently large to hinder generalizations of them. For example, rigorously enforced rules of land access can enhance or impede agricultural intensification in the face rising demands, depending on the larger circumstances in which they operate. Private ownership promotes conditions conducive to landesque capitalⁱ improvements and intensification where the agricultural sector dominates land-use (44), but it may retard such improvements, even leading to disintensification in peri-urban areas of competing land uses (45, 46). Likewise, secure usufruct (the right to use without ownership) promotes the intensification process where the land manager is committed to full-time farming, but impedes them where the manager is not so committed or lacks the labor and capital to do so. Such structures can be so significant as to mask the underlying processes in question here.

^hThese processes work in reverse creating “reduced” intensification or disintensification. As demand for agricultural production declines, so too do the inputs to cultivation, ultimately resulting in a decline in land productivity. Disintensification, however, may involve a considerable lag-time between drops in demand and intensity of cultivation, particularly where significant land improvements have been made. Such systems may continue to function long after maintenance capital ceases or declines.

ⁱLandesque capital is “permanent” improvement of the land for cropping and usually involves terrace, drainage, and irrigation systems.

Environmental impediments may operate similarly (47), but unlike their socio-economic counterparts, their general impacts have been postulated. One view holds that environmental extremes, prime or poor lands, exacerbate the intensification process beyond the associated level of demand (48). Prime lands yield well and tolerate frequent cropping, thus leading to high land productivity per unit of input. Poor lands, in contrast, require considerable investment for permanent cultivation, and these costs are typically focused on small, intensively cultivated parcels (49, 50).

Such influences notwithstanding, the broader trajectories of change articulated in the induced intensification thesis and their correlations to changing levels and structures of demand have been demonstrated repeatedly. Compilations and reviews of the studies supporting induced intensification (as well as those that may not) exist elsewhere and are not reviewed here (51, 52). Strongest support is found where conditions best fit one or the other of the ideal farming behaviors noted (subsistence or market) and where environmental and socio-economic impediments are not extreme. The nature of induced intensification in these extremes are explored in the case study that follows.

Bangladesh, 1950–1986: A Case Study and Test

Land Intensive Economy. The conditions of rural Bangladesh in the mid-1980s differed little from those existing today. The population density was an astounding 723 people per km² (53). About 87% of the populace was “rural,” mostly small-holder and landless households engaged in sharecropping and wage-labor on large-holder farms, and as much as 58% of the country’s gross domestic product was derived from the agricultural sector (54). The intensive cultivation of paddy (rice) on small plots primarily for subsistence dominated the countryside, although the production of market cultivars beyond the traditional export crop of jute was growing. Nearly all arable land (about 91%) was cultivated on an annual basis or more frequently; by the mid-1980s, the average cropping frequency for the country approached or exceeded 150% (55).

Virtually no “open” land existed for agricultural expansion (56), and arable lands were lost to settlement. Agricultural growth, therefore, focused on increasing land productivity—intensification achieved primarily through increased irrigation, which facilitated double and triple cropping and the use of “green revolution” inputs (i.e., crops, fertilizer, pesticides). Socio-economic constraints to the intensification process operated, however, including government policies that favored the urban consumer over the farmer and the large-holder over the small-holder (2), as well as the overall impoverished condition of most farm households that made capital improvements difficult (57).

Agroecology. Given these circumstances, Bangladesh is fortunate to have quality soils for cultivation, owing to the sediments delivered throughout the Bengal Basin during the annual monsoon flooding. About two-thirds (94,295 km²) of the country was cultivated regularly in the mid-1980s, and most of this area received sufficient water to ensure annual rice harvests. The tropical climate permits year-round cultivation in three seasons—nor’wester (March–May), monsoon (June–October), and winter (November–February). Soils are so extensively worked that their native properties may be less important to cultivation than the vagaries of water on them. Flooding during the monsoon is so immense—the annual basin discharge of the river systems at 42,481 m³/s is second only to that of the Amazon (58)—that it has not been and, perhaps, cannot be controlled in most areas (59). It reduces the effects of fertilizers on the yields of modern rice varieties and impedes cropping for a portion of the year on much of the land (60). Paradoxically, dry season cultivation in many locales is hampered by insufficient water. Groundwater for irrigation is

plentiful in many parts of the basin, although recharge rates are controversial (61). In addition, soil and water salinity problems plague much of the coastal zone. Control of water, therefore, was in 1980 and remains today the major technological challenge confronting Bangladesh agriculture (62, 63).

Farm Conditions. Within these conditions, the 68,000 farm villages of Bangladesh cultivated some 9.4 million hectares (ha) of land in the mid-1980s (64). The average farm household or farmstead had 1.13 ha composed of 3–4 scattered plots (65). Four distinct “classes” of farmsteads were recognized, however: landless with 0.2 ha or less, small-holders with 0.2–1.0 ha, medium-holders with 1.0–3.0 ha, and large-holders with more than 3.0 ha (66). As much as 48% of rural households were landless, whereas 6–15% were large-holders who controlled a majority of the cultivated land. Two caveats are warranted about these last figures. Some authorities claim that general survey methods inflate estimates of the landless (67). And, successful market gardening can be pursued on farmsteads of extremely small size (68). Almost all farmers, regardless of class, pursued both subsistence and market cultivation in the mid-1980s. Large-holders produced the overwhelming surplus, however, and may be considered almost totally market oriented.

Farming everywhere followed similar cropping schedules, corresponding to the seasons noted above if not impeded by environmental problems. Land was raised and lowered over time to deal with local flood regimes and was prepared largely with “traditional” tillage technologies. Rice cultivation involved considerable field preparation, including leveling and bunding. Local and high-yielding varieties (HYV) of rice were used, as were fertilizers and pesticides (69). In the nor'wester and winter seasons, HYV rice required irrigation water supplied through special projects or by way of low-lift pumps. Rice yields were low by global and Asian standards, created by poor access to and inefficient use of inputs, the impacts of flooding on them, and inadequate irrigation (70).

Jute was the next most important crop to rice, grown totally for an international market (71). Dwarf wheat increased among farmers in the mid-1980s as did mustard, rape, pulses, and sundry vegetables. Market gardening and off-farm activities were increasing in peri-urban locales (72). The shear marginality of most farm households, however, required that they produce the majority of their own food, which was only sold under conditions of normal surplus (rare) or duress (e.g., debt).

Finally, farmstead class and land tenure maintained various relationships with production. Total land productivity was higher on owned than rented land (73), but various studies

indicated that cropping frequency and yields were negatively related to farm size and that small-holders tended to be more efficient in production than large-holders (74).

The Study Villages and Data. The six case study villages selected for study represented the range of agroecological and socio-economic conditions prevalent in the Bengal Basin of Bangladesh in the mid-1980s (Table 1, Fig. 1). Population densities in the villages ranged from 171–1,535 people per km² and cropping frequencies ranged from 91 to 280%. Throughout the study period, each village witnessed major growth in population and pressures to provide market products. The different conditions in which they operated, however, led to different growth trajectories of intensification. Bhatshala, Damarpota, and Surjapur—those performing less well—had lower population densities and cropping frequencies; Bijoy-nagar, Khazanagar, and Shyampur–Purbahati—those performing better—had higher population densities and cropping frequencies (Table 1, Fig. 1).

Bhatshala occupies a hoar or depression, which is deeply flooded throughout much of the year, limiting the cropping season to the winter only. As well, it is some 5 h travel by boat to Bhairab Bazar, the nearest market of any size. Damarpota, located along the Betravati River in the Moribund Delta, suffers from water salinity problems. Government constructed embankments alleviated saline water intrusions from the tide-affected river running through the village, but soil salinity emerged with use of groundwater. Surjapur has insufficient rainfall for winter and nor'wester cultivation, and terracing is required for rice cultivation on shallow, undulating terrain.

Bijoy-nagar occupies prime farmland adjacent to a market, and participated in a state-sponsored contract growing scheme. Khazanagar, near the Kushtia market, was rescued by the Ganges–Kobadak irrigation and flood control system (Ganges River), which facilitated dry-season cultivation and helped to create small-scale rice processing activities. Shyampur–Purbahati are neighboring peri-urban villages of Dhaka, where market-gardening increased dramatically as well as off-farm employment.

Data were generated for 265 farm households in 6 villages by way of detailed surveys and repeated interviews, the results of which were checked against local and district records, village elders, and, in some cases, household records. A stratified random sample procedure was attempted, structured to the class differences among the farm households but had to be abandoned because so many households, particularly those of the landless, were unable to provide the kind of information that could be verified by alternative sources of information. We thus focused on households or farmsteads that could supply

Table 1. Characteristics of the six villages and sample, 1985–1986

Village	Population density, per km ²			Cropping intensity					
	Absolute*		Sample	Cropping frequency, %		Land productivity, kg/ha/yr	Environmental constraints	Proximity to major market	State or NGO assistance
	Village	Village		Village	Sample				
Bhatshala	438	422	301	91.0	85.7	2372	Prolonged and major flooding	5 h by river	Nil
Damarpota	228	457	584	111.0	118.0	1991	Water and soil salinity	30 min by road	Riverine embankment
Surjapur	171	457	457	133.3	134.2	2439	Insufficient dry season water	1.5 h by road	Nil
Bijoy-nagar	825	923	1019	212.8	222.3	5001	Minimal	15 min by road	Contract scheme
Khazanagar	290	1301	1242	234.0	240.4	5196	Insufficient dry season water	30 min by road	Irrigation project
Shyampur–Purbahati	1535	1647	1466	279.5	279.5	5247	Flooding	30 min by road	Nil

NGO, non-governmental organization.

*Absolute density = total population ÷ village area.

†Relative density = total population ÷ land controlled.

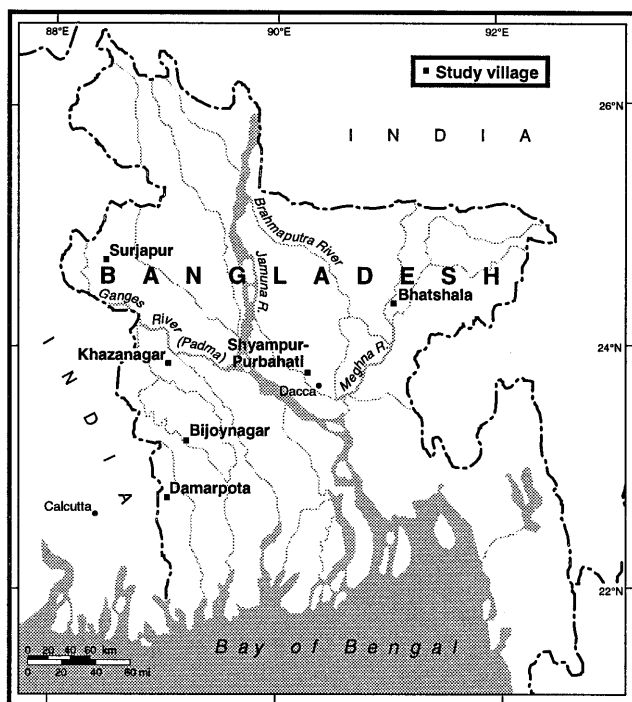


FIG. 1. Bangladesh and the study villages.

verifiable information, while attempting to adhere to the village class composition as best we could. The resulting sample under-represented the landless and functionally landless households and over-represented all other classes. The differences in the percent of households in the villages and sample by class were 4%/10% for large-holders, 11%/42% for medium-holders, 32%/41% for small-holders, and 55%/7% for landless and functionally landless.

Thirty-five variables dealing with the character and change of the farm household, farm, and environment were collected, 15 of which were used in various time-series analyses. The data were coded to four time frames: three linked to major historic events in Bangladesh—1950, 1960, 1975, and 1985–86 the time of field work.

Village Trajectories of Change. Every village experienced significant growth in demand on agriculture and in land pressures from 1950 to 1985 resulting from increases in the population to be fed, decreases in per capita land for farming, and the increasing proportion of cultivation for the market. The farmers responded by increasing average cropping frequency to 188% and average land productivity to 3874 kg per ha per year. This change came at high costs; capital outlays for HYV packages increased and average labor investments rose to 425 worker-days per ha per year (worker day = 8 adult h).

Intensification from 1950–1986 appears to have taken place in a series of steps, although the time intervals in the data do not permit strict confirmation. Field surveys and discussions revealed that, from the farmers' perspectives, at least two thresholds in the intensification process were experienced. By the 1950s, the intensification process had slowed or involuted, but switches to "green revolution" techno-managerial strategies significantly increased land productivity, in tandem with irrigation, cropping frequency (56). This step in the process leveled off during the 1970s, but intensification jumped again apparently through shifts to market gardening. By 1985, however, output growth appeared to be leveling and, in some cases, stagnating.

The overall pace and magnitude of intensification was not consistent across village or farmstead, however. Those villages

most incumbered environmentally, lacking direct support from the state, and/or isolated from major markets—the poorly-endowed cases of Bhatshala, Damarpota, and Surjapur—had more muted responses to increasing land pressures. Bhatshala's growth was stymied by deep and prolonged flooding in the hoar, which circumscribed a single season for cropping. Agricultural intensity grew to only 91% and land productivity to 2372 kg per ha per year, limited to increasing yields and changing the value of the crops grown. Despite the construction of embankments to protect Damarpota from tidal waters, its cropping frequency rose only to 111% and land productivity to 1991 kg per ha per year, apparently constrained by salinity from groundwater irrigation and shrimp farming (from which most villagers gained little). Finally, deficient access to low-lift pumps and irrigation water constrained activities in Surjapur. Yet, its cropping frequency rose to 133% and land productivity to 2439 kg per ha per yr. Of these villages, only Damarpota had easy access to a major market and yet was not involved in market gardening, apparently because of the impact of soil salinity. Bhatshala's shift to market crops other than rice and jute involved the less perishable groundnut.

In contrast, the highly endowed and performing villages not only had fewer environmental constraints, they were privileged by location and/or scale of government assistance. Thus, Bijoy Nagar boomed in part from state contracts for produce and Khazanagar, from a major irrigation project. In Bijoy Nagar and Khazanagar, cropping intensities rose to 213% and 234%, respectively, and land productivity to 5001 kg per ha per yr and 5196 kg per ha per yr. Finally, Shyampur-Purbahati, on the outskirts of Dhaka, made a full shift to nearly year-round market gardening, complete with vertically spaced intercropping. Its cropping frequency rose to 280% and land productivity to 5247 kg per ha per yr.

Test of Induced Intensification. Tests of the most direct induced intensification linkage—the surrogate variables for subsistence and market demand to the intensity variables of cropping frequency and land productivity—yielded weak but significant results in the low-performing villages and strong and significant results for the high-performing villages. The underlying premise of induced intensification was not rejected, however, because the complexity and variability of individual farmstead dynamics in this land-pressured economy play havoc with analyses undertaken at the farmstead level. Rural farmsteads in Bangladesh are constantly losing land, while a small number gain. In some cases, households become functionally landless, only to regain land at a later date. Owing to these conditions and the differences between the two types of villages, we explored a broader induced intensification thesis that seeks to account for the differences observed.

To test this thesis, a model is employed that links demand to intensification through the conditions facing the farmer (Fig. 2). Demand for subsistence production is measured by population density (PDEN) and that for market production by the level of market involvement (MARK). Owing to the mix of crops and production aims present (subsistence and market), an independent measure of market demand was difficult to derive. The actual proportion of production sold served as a surrogate measure (65).¹ These input variables operate through three groups of status variables. The household-farmstead group, a surrogate for farm "class," accounts for the size (ha) of the homestead (HOME) and farm (FARM), and the average size of cultivated plots (PLOT). Environmental attributes/constraints include four land levels (QL II–V) with different attributes in the timing and depth floodwater, and an environmental constraint index (ENVINDEX) registering the

¹Many capital inputs were obtained in the informal sector, including associated debts. We suspect that a significant amount of produce is sold in this sector as well. Our field data did not seek to identify in which sector the produce was sold, only the total amount involved.

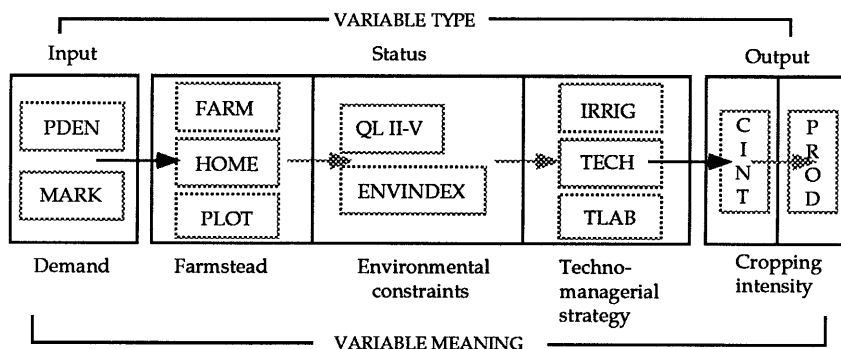


FIG. 2. Induced intensification model. Linkage 1A and B: Demand through farmstead to cropping intensity; Linkage 2A and B: Demand through farmstead and environmental constraints to cropping intensity; Linkage 3A and B: Demand through all status variables to cropping intensity (Results found in Table 2).

amount of land affected by inadequate dry-season water, excessive flooding, and soil salinity problems. The last group are the techno-managerial strategies (other than land leveling, QL) central to intensification: amount of work for landesque capital (TLAB), amount of chemical fertilizer used (TECH), and percent of land irrigated (IRRIG). The model proceeds to the output (intensity) variables of cropping frequency (CINT) and land productivity (PROD).

Using the six village data set, all possible causal linkages from the demand or input variables to the frequency-productivity output variables are identified and tested as a multiple-linear regression with a 36-year time-series data of 1060 observations (265 farmstead units × 4 time periods) (Table 2, Fig. 2). Linkage I represents demand through the class of farmstead-to-cropping frequency and through the latter to land productivity. Linkages II and III add, respectively, environmental and technological variables, both of which prove to be important. Analyses are run with all the data from the six villages and with the data segregated into low- and high-performing villages.

The major implications of the results are noted below. All explained variance (R^2) coded by number and letter (e.g., 1A) refer to Table 2. The others are taken from unpublished results.

(i) Aggregating the villages (poorly and well endowed) and adding the structure (mediating variables) through which demand operates significantly increased the explained variance in agricultural intensity. The R^2 values for cropping frequency and land productivity rise to 0.78 and 0.84, respectively (3A and 3B).

(ii) Environmental constraints on agricultural change were profound, increasing the six village explained variance for cropping frequency to 68% (2A)—of which 51% followed from the constraint index alone—and for land productivity to 73% (2B). The low-performing villages, which were highly constrained by flooding and inadequate water, accounted for most of this outcome. Virtually no improvement in the explained variance in intensity was found for the high-performing villages by considering environmental variables.

(iii) Of the techno-managerial responses employed, irrigation had the most profound impact on intensity for the simple reason that it is required for most cultivation during the winter and nor'wester cropping seasons, especially for rice. It accounts for 40% of the explained variance in cropping frequency for the high-performing villages and 11% of that for land productivity. In these cases, land productivity followed from cropping frequency.

(iv) As a measure of intensity, land productivity (71%, 1B) correlates more strongly with demand than does cropping frequency (38%, 1A). This result, long implied in the literature (65), follows from the fact that cropping frequency is only one factor in output intensification, and in Bangladesh it cannot be adequately increased where severe flooding is uncontrollable or irrigation water is insufficient.

(v) The high-performing villages—those with less constraints on options, particularly for small- and medium-holders—maintained the more direct and strong link between demand and intensity. Here demand and farmstead variables accounted for 49% of the explained variance in cropping frequency and 67% of that for land productivity (1A and 1B).

(vi) Regardless of the linkage, population density accounted for more of the explained variance in intensity than did market participation, even though the sample was biased toward those classes of farms engaged in market production. This result probably reflects the significance of subsistence production within the large majority of farmsteads, although the inadequacy of the surrogate measure of market production must be recognized.

(vii) Finally, considering demand as subsistence and market in origin increased the explained variance of intensity in all paths.^{k1}

Elaborating the Results

Rural land pressures in Bangladesh were high in 1950 and rose rapidly during the study period, resulting in exceptional land pressures by any measures by 1985. Farmers struggled to intensify cultivation under these conditions, while facing various and serious impediments: too much, too little, or too saline water from nature; inadequate transportation infrastructures for marketing; unfavorable state policies; and general impoverishment, among others. Surely, if the process of induced intensification were to not operate, it would be here.

Table 2. Induced intensification model results (R^2)

Linkage	Six villages	Low-performing villages	High-performing villages
1A	0.38	0.20	0.49
1B	0.71	0.10	0.67
2A	0.68	0.51	0.49
2B	0.73	0.14	0.69
3A	0.78	0.61	0.65
3B	0.84	0.47	0.82

Results significant at the 0.0001 level. See Fig. 2 for descriptions of the linkage codes.

^kThe variables used for PDEN and MARK were not complementary. The bivariate correlation between the two was not statistically significant.

¹In our larger work, the model includes positive and negative feedbacks from the output variables to the input variables. The results of this loop suggest that higher intensity levels reinforce demand through larger populations, whereas lower intensities dampen demand through smaller populations.

Our test suggests otherwise. Even allowing for significant variations in farmstead and village conditions—including those in which the impediments to intensification would appear to be overwhelming—the “average” response to increasing demands on agriculture was to increase land productivity through increased cropping frequency, yields, or value of crops. Changes in the demand by farmstead class accounted for nearly 50% of the changes in cropping frequency, where impediments were low, and for 71% of the changes in land productivity for all villages (Table 2, 1A and 1B), the ultimate measure of output intensity for the thesis in question.

The lower explained variance for the poorly endowed villages (1A and 1B) indicates the strong roles of environmental and other constraints on agricultural change at this level of intensity. Accounting for these conditions raised the total explained variance in cropping frequency to 68% (2A). Techno-managerial strategies alleviated some of these impediments, particularly that of water shortages for multicropping in the winter and nor-wester seasons. Unfortunately, the model does not account for constraints on access to these strategies beyond farmstead class (and presumed wealth). It does demonstrate that these strategies were consistently adopted in the face of rising demand, almost to the exclusion of farmstead class,^m and that by accounting for their use, most of the changes in the intensity of cultivation could be explained (3A and 3B).

These results provide support for the induced intensification model used, complementing the findings by Boyce (62) for the Bengal Basin and Dalrymple (75) for south Asia in general. Identification of the high- and low-performing villages also provides insights about some of the conditions that facilitate and constrain intensification, offering a bridge between the broader trajectories of change noted by Boyce and Dalrymple versus the case for agricultural stagnation developed by Ahmad (2).

Our analysis, however, also demonstrates the strong effects of the environment and technology on intensification, providing support for explanations making them the primary causes of intensification.ⁿ We do not favor such explanations, however, because technology and environment are, by definition, required to change if intensification is to take place. They are “proximate” variables, which invariably maintain strong statistical relationships with the event to be explained. More importantly, such explanations fail to consider the basic behavioral rationale for the decision to intensify in the first place and thus cannot explain the absence of intensive cultivation in good environments, the presence of it in poor environments, or the non-application of an available technology.

Finally, our analysis does not adequately demonstrate the presence or absence of the hybrid behavior of small-holders embedded in various induced intensification themes. The majority of farmers in the six villages attempted to grow their own subsistence, suggesting production goals and behavior commensurate with the subsistence production. Yet, over the study period, most farmers increasingly engaged in market

cultivation, responding to pricing signals for various crops. Improved explained variance in the intensification results followed from a consideration of the sources creating demand in subsistence and market farming. Thus, whereas the farmstead conditions and output responses are those implied in the hybrid behavior of induced intensification themes, an explicit link to the production intent and behavior of the small-holders was not made.

Bridging Malthus–Boserup, with Implications for Bangladesh

Bangladesh has long been viewed as a Malthusian crisis in waiting, given its extreme land pressures and impoverished agrarian sector (65). Yet, the country’s small-holders in fact increased agricultural production significantly from 1950 to 1986 through the intensification process, and the percentage of the population below the poverty line decreased, according to some sources (4). The 265 small-holder farmsteads in this study actually produced a small surplus, and the test of the induced intensification at the village level were strongly favorable. These average results, however, were achieved under increasingly polarized conditions. By 1986, the larger holders accounted for the surplus production, while the increasing landless households suffered from chronic production shortfalls and, apparently, malnutrition.

Malthus or Boserup? Which views do these results support? On closer inspection, Malthus and Boserup may be more complementary than the various applications based upon their views imply (76, 77). They share various assumptions about the relationships among population, technology, and resource use but differ primarily in their views of the origins of technology. Malthus implies that technology is exogenous in the sense that its development is not necessarily linked into the population–resource condition. Boserup, in contrast, grounds this development directly into that condition; technological change is endogenous to it.

Initial tests of induced intensification focused largely on less intensive agriculture than that examined here, cases in which the threshold steps in intensification process were not approached. In these cases, the Boserupian process of endogenous change apparently operate. Yet some cases positioned closer to the intensification thresholds suggest Malthusian-like responses of involution and stagnation. The case for Bangladesh from 1950 to 1986 indicates how both paths could be observed. Over the entire period, induced intensification proceeded in a Boserupian path, although its pace was muted by the extreme conditions noted. This path was marked by several thresholds, however, each of which had the potential to spin-off into a Malthusian path and, when viewed from that stage alone, led to such conclusions (2). The first threshold in the 1960s was adverted by the adoption of HYV technologies, and the second in the 1980s by a shift to crops with high market values, especially market gardening in more favorable locales.^o Given the pace of growth in production pressures, the 1990s portended yet another threshold. Economic and policy barriers to irrigation technologies impeded production in food staples and the poor state of transportation infrastructures inhibited most villages from moving into market gardening. Subsequent to this study, barriers to various technologies, such as low-lift pumps, were reduced and their increased use throughout Bangladesh led to yet another spurt in land productivity through increased dry-season cultivation.

Induced intensification theses have thus moved beyond a simple Malthus–Boserup debate, demonstrating how both

^mOther studies show that various inputs to cultivation, including capital inputs, vary little by farmstead class in Bangladesh because land pressures are so great that any cultivation requires them. Class was a factor for ownership of low-lift pumps, but owner-plots only could not be served because of land fragmentation. Other farmers with adjacent plots purchased water. While the pump owner reaped handsome benefits, irrigation increased on other farm plots (2).

ⁿEnvironmental themes are self-explanatory. Technological themes, such as those that underpin most diffusion and some development theory, treat changes in technology as an exogenous variable that once introduced is uniformly and voluntarily adopted. Typically, these themes do not explicitly include a rationale of small-holder behavior—goals and decision rules—and thus do not link the use of the land or adoption of the technology to the larger forces to which the small-holder responds.

^oWhether or not the origins of the impacts of “green revolution” technology support Malthus or Boserup is a complicated question that cannot be addressed here, but the answer depends in a large part on temporal and spatial scale of the analysis employed.

positions might be supported depending on where in the intensification process the analysis is undertaken or on the temporal scale of analysis employed. Less well-developed conceptually are the processes that divert intensification into the involution and stagnation paths, and improvements of this kind are required for a fully developed theory of agricultural change among small-holders. This development, however, informs us only of the general conditions of cropping, not of the people so engaged—household equity, well-being, and economic development more broadly. Thus, whereas Bangladesh will likely continue its muted path of agricultural intensification—diverting a major famine—it will likely do so under increasing household, even village, polarization.

We thank the individuals who offered comments on our larger work and this paper, especially James Boyce, Robert Huke, Robert W. Kates, and Samuel Ratick. Support for this research was provided by the National Geographic Society (Washington, DC) Grant 2960–84, the Agricultural Research Council (Bangladesh), Clark University, the Cecil and Ida Green Center for the Study of Science and Society, University of Texas at Dallas, and the Center for Advanced Study in the Behavioral Sciences (National Science Foundation Grant SBR-9022192).

1. Population Resource Bureau (1996) *World Population Data Sheet* (Population Resource Bureau, Washington, DC).
2. Ahmad, A. (1984) *Agricultural Stagnation Under Population Pressure: The Case of Bangladesh* (Vikas, New Delhi).
3. United Nations (1993) *Second Report on the World Nutrition Situation: Vol. II, Country Trends, Methods and Statistics* (United Nations and International Food Policy Research Institute, Washington, DC).
4. International Fund for Agricultural Development (1995) *The State of World Rural Poverty* (Int. Fund Agricultural Dev., Rome).
5. Ehrlich, P. R. (1968) *The Population Bomb* (Ballantine, New York).
6. Paddock, W. & Paddock, P. (1976) *Famine 1975! America's Decision: Who Will Survive* (Little, Brown, Boston).
7. Islam, M. A. (1964) Ph.D. dissertation (Clark University, Worcester, MA).
8. United Nations Development Programme (1995) *Human Development Report 1995* (Oxford Univ. Press, New York).
9. Kates, R. W. (1995) *Ann. Assoc. Am. Geographers* **85**, 623–640.
10. Turner, B. L., II (1997) *Ecumene* **4** (2), in press.
11. Ehrlich, P. R. & Ehrlich, A. H. (1990) *The Population Explosion* (Simon & Schuster, New York).
12. Cohen, J. E. (1995) *How Many People Can the Earth Support?* (W. W. Norton, New York).
13. Simon, J. (1981) *The Ultimate Resource* (Princeton Univ. Press, Princeton).
14. Boserup, E. (1965) *The Conditions of Agricultural Growth* (Aldine, Chicago).
15. Boserup, E. (1981) *Population and Technological Change* (Univ. Chicago Press, Chicago).
16. Hayami, Y. & Ruttan, V. W. (1985) *Agricultural Development: An International Perspective* (Johns Hopkins Univ. Press, Baltimore).
17. Chayanov, A. V. (1966) in *A. V. Chayanov and the Theory of Peasant Economy*, eds. Thorner, D., Kerblay, B. & Smith, R. E. F. (Erwin, Homewood, IL).
18. Turner, B. L., II, & Brush, S. B., eds. (1987) *Comparative Farming Systems* (Guilford, New York).
19. Netting, R. C. (1993) *Small-Holders, Householders: Farm Families and the Ecology of Intensive, Sustainable Agriculture* (Stanford Univ. Press, Stanford, CA).
20. Turner, B. L., II, Hyden, G. & Kates, R. W., eds. (1993) *Population Growth and Agricultural Change in Africa* (Univ. Press Florida, Gainesville, FL).
21. Watts, M. J. (1989) *Prog. Hum. Geogr.* **13**, 1–41.
22. Datoo, B. A. (1978) *Econ. Geogr.* **54**, 135–144.
23. Brookfield, H. C. (1984) *Pac. Viewpoint* **25**, 15–44.
24. Grigg, D. B. (1979) *Prog. Hum. Geogr.* **3**, 64–84.
25. Lea, D. (1969) in *Settlement and Encounter: Geographical Studies Presented to Sir Grenville Price*, eds. Gale, F. & Lawton, F. (Oxford Univ. Press, Melbourne), pp. 173–184.
26. Schultz, T. W. (1964) *Transforming Traditional Agriculture* (Yale Univ. Press, New Haven, CT).
27. Mellor, J. & Desai, G., eds. (1986) *Agricultural Change and Rural Poverty* (Johns Hopkins Univ. Press, Baltimore).
28. Lipton, M. (1968) *J. Dev. Studies* **4**, 327–351.
29. Scott, J. C. (1976) *The Moral Economy of the Peasant* (Yale Univ. Press, New Haven, CT).
30. Lipton, M. (1989) *New Seeds and Poor People* (Johns Hopkins Univ. Press, Baltimore).
31. Schuler, M. G. G. & Mount, T. D. (1976) *J. Dev. Studies* **12**, 246–267.
32. Collinson, M. (1972) *Farm Management in Peasant Agriculture: A Handbook for Rural Development in Africa* (Praeger, New York).
33. Gudeman, S. (1978) *The Demise of a Rural Economy: From Subsistence to Capitalism in a Latin American Village* (Routledge & Kegan Paul, London).
34. Ortiz, S. R. (1973) *Uncertainties in Peasant Farming: A Columbian Case* (Althone, London).
35. Burnham, P. C. (1980) *Opportunity and Constraint in a Savannah Society: The Gbaya of Meiganya, Cameroon* (Academic, New York).
36. Folbre, N. (1982) *Cambridge J. Econ.* **6**, 317–329.
37. Carney, J. A. (1992) *Dev. Change* **23**, 67–90.
38. Hyden, G. (1980) *Beyond Ujamaa in Tanzania: Underdevelopment and an Uncaptured Peasantry* (Univ. California Press, Berkeley, CA).
39. Scott, J. C. (1985) *Weapons of the Weak: Everyday Forms of Peasant Resistance* (Yale Univ. Press, New Haven, CT).
40. Doolittle, W. M. (1984) *Ann. Assoc. Am. Geographers* **74**, 124–137.
41. Pingali, P., Bigot, Y. & Binswanger, H. P. (1987) *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa* (Johns Hopkins Univ. Press, Baltimore).
42. Geertz, C. (1963) *Agricultural Involvement: The Process of Ecological Change in Indonesia* (Univ. California Press, Berkeley, CA).
43. Schultz, T. W., ed. (1978) *Distortions of Agricultural Incentives* (Indiana Univ. Press, Bloomington, IN).
44. Lele, U. & Stone, S. W. (1987) *Population Pressure, the Environment, and Agricultural Intensification: Variation on the Boserup Hypothesis, Managing Agricultural Development in Africa* (World Bank, Washington, DC).
45. Ali, A. M. S. (1981) *Environ. Region* **1**, 32–48.
46. Sinclair, R. J. (1967) *Ann. Assoc. Am. Geographers* **57**, 72–87.
47. Meertens, H. C. C., Fresco, L. O. & Stoop, W. A. (1995) *Agric. Ecosyst. Environ.* **56**, 203–215.
48. Turner, B. L., II, Hanham, R. O. & Portarao, A. V. (1977) *Ann. Assoc. Am. Geographers* **67**, 384–396.
49. Gleave, M. B. (1996) *Geogr. J.* **162**, 14–24.
50. Levi, J. F. S. (1976) *J. Dev. Studies* **13**, 61–78.
51. Brush, S. B. & Turner, B. L., II (1987) in *Comparative Farming Systems*, eds. Turner, B. L., II & Brush, S. B. (Guilford, New York), pp. 11–47.
52. Kates, R. W., Hyden, G. & Turner, B. L., II (1993) in *Population Growth and Agricultural Change in Africa*, eds. Turner, B. L., II, Hyden, G. & Kates, R. W. (Univ. Press Florida, Gainesville, FL), pp. 1–40.
53. Population Reference Bureau (1986) *World Population Data Sheet* (Population Reference Bureau, Washington, DC).
54. Parikh, A. (1990) *The Economics of Fertilizer Use in Developing Countries: A Case Study of Bangladesh* (Avebury, Aldershot, U.K.).
55. Bangladesh Bureau of Statistics (1987) *Statistical Pocket Book of Bangladesh: 1986* (Ministry of Planning, Dhaka, Bangladesh).
56. Hossain, M. (1988) *Nature and Impact of the Green Revolution in Bangladesh*, Research Report 67 (Int. Food Policy Research Inst., Washington, DC).
57. de Vylder, S. (1982) *Agriculture in Chains—Bangladesh: A Case Study in Contradictions and Contrasts* (Zed, London).
58. Stepanek, J. F. (1979) *Bangladesh: Equitable Growth?* (Pergamon, New York).
59. Brammer, H. (1990) *Geogr. J.* **156**, 12–22.
60. Paul, B. K. & Rasid, H. (1993) *Hum. Ecol.* **83**, 150–159.
61. Friedkin, T., Lester, R., Blank, H. & Ahmed, N. U. (1983) *AID Project Impact Evaluation Report No. 42* (U.S. AID, Washington, DC).
62. Boyce, J. K. (1987) *Agrarian Impasse in Bengal: Institutional Constraints to Technological Change* (Oxford Univ. Press, London).
63. Boyce, J. K. (1987) *Food Policy* **12**, 332–336.
64. Chowdhury, A. (1983) *Bangladesh J. Soc.* **1**, 75–83.
65. Alamgir, M. (1978) *Bangladesh: A Case of Below Poverty Level Equilibrium Trap* (Bangladesh Institute of Development Studies, Dhaka, Bangladesh).
66. Jannuzi, F. T. & Peach, J. T. (1977) *Report on the Hierarchy of Interests in Land in Bangladesh* (U.S. AID, Washington, DC).
67. Wennergren, E. B., Antholt, C. H. & Whitaker, M. D. (1984) *Agricultural Development in Bangladesh* (Westview, Boulder, CO).
68. Khan, F. K. & Haq, M. (1961) *Orient. Geographer* **5**, 1–21.
69. Asaduzzaman, M. (1979) *Bangladesh Dev. Studies* **7**, 23–52.
70. Khan, A. R. (1972) *The Economy of Bangladesh* (MacMillan, London).
71. Akiyama, T. (1985) *Jute Supply Response in Bangladesh* World Bank Staff Commodity Working Paper No. 13 (World Bank, Washington, DC).
72. Ali, A. M. S. (1980) *Labour Capital Society* **13**, 22–38.
73. Jabber, M. A. (1977) *Farm Structure and Resource Productivity in Selected Areas of Bangladesh* (Bangladesh Agricultural Research Council, Dhaka, Bangladesh).
74. Hossain, M. (1977) *Bangladesh Dev. Studies* **5**, 285–348.
75. Dalrymple, D. G. (1971) *Survey of Multiple Cropping in Less Developed Nations* (U.S. Dept. Agriculture and U.S. AID, Washington, DC).
76. Lee, R. D. (1986) in *The State of Population Theory*, eds. Coleman, D. & Schofield, R. (Blackwell, New York), pp. 96–130.
77. Dupâquier, J., ed. (1983) *Malthus Past and Present* (Academic, New York).