Rural Household Micro-Demographics, Livelihoods and the Environment

Alex de Sherbinin

Table of Contents

Executive Summary

Early research on population and the environment generally assessed aggregate population impacts on the environment and natural resources. The emphasis was on population size, growth and density, and how these interacted with various resources such as forests, freshwater, land and soils, or alternatively, how they caused environmental degradation in the form of pollution or 'overuse' of resources. In the early 1990s new research approaches were developed that began to couple economists' and demographers' understanding of the household economy and population dynamics with advanced statistical and geographic tools such as GPS, GIS and remote sensing, with the express purpose of delving into the complexity of local-level population-livelihood-environment dynamics. This research also built on earlier demographic research focusing on land-fertility and land-migration relationships. After more than a decade of such research, this is an opportune time to assess how far we've come in our understanding of the linkages and potential areas for further exploration.

This paper reviews a range of literature and finds:
- *Regarding household fertility:*
  - There is some (but limited) evidence supporting for the vicious circle hypothesis, which postulates that poverty and environmental degradation are linked in self-reinforcing ways to high fertility and large family sizes. Alternative hypotheses that high fertility is driven more by cultural factors, or that what are being identified as 'vicious circles' have their

> roots in far deeper societal disparities and power imbalances, exacerbated by economic globalization, cannot be ruled out.

- *Regarding the impacts of morbidity and mortality:*
    - o There is evidence that supports the notion that natural resources can play an important cushioning effect against household shocks such as morbidity and mortality by providing a supplementary source of income, or replacing goods that might otherwise be purchased. Morbidity and mortality are likely to increase the stress on household finances, pushing families into poverty, with concomitant increases in natural resource dependence.
    - o AIDS-related morbidity and mortality has had a significant impact on subsistence based agricultural households and natural resource management in sub-Saharan Africa. Since the impact is mediated through household poverty, the policy response would not seem to differ substantially from broader interventions targeting public health and poverty reduction.
- *Regarding household migration:*
    - o Environmental and resource factors do play a role in influencing the decisions of households to send migrants, but households in areas that are significantly resource-depleted or environmentally constrained may actually not have the resources to cover the costs of a move.
    - o Any consideration of household migration strategies and their relationship to the environment and natural resources must account for the role of remittances, which may reduce impacts on resources by allowing households to substitute local for imported goods or by investment in resource conservation strategies, or which may increase negative impacts through investment in environmentally destructive livelihood activities or eroding the traditional knowledge that comes with resource dependence.
- *Regarding Household lifecycles:*
    - o Evidence broadly supports the Chayanovian theory that household size and labor availability predicts the amount of forest clearing, at least in forest frontiers. In the Brazilian Amazon there seems to be a pattern, closely tied to lifecycle, of moving from subsistence to cash crops to cattle. On the other hand, closing frontiers, where land is less plentiful, show more complex patterns of deforestation.

We are far from being able to make widespread generalizations about the relationship among household population dynamics, livelihoods and the environment. Many of these relationships are highly dependent on a range of contextual factors (market access, macro-economic policy, institutions governing resource access, globalization and production of exportable resources), the type of resource under consideration (e.g., forests or fisheries), and other region-specific dynamics. However, this research *does* have an important role to play in formulating national and regional policies addressing natural resource access and use, biodiversity conservation, and social safety nets for the poorest rural households. The policy implications are briefly assessed at the end of each of the four sub-sections in Section 3.

Rural Household Micro-Demographics, Livelihoods and the Environment

Alex de Sherbinin

1. Introduction

One of the major areas of population-environment research in the past decade has focused on household-level population dynamics and their relationship, through livelihood strategies, to environmental change. Studies have investigated the relationships among population variables (household size, age and sex composition, fertility, on-farm population density, migration, and mortality), biophysical variables (forest cover, coastal mangroves, and soil quality), and natural resources (firewood, timber, non-timber forest products, bushmeat and water) in the Amazon Basin, Central America, Southeast Asia, Oceania, and Africa (e.g., Pichon 1997; Entwisle *et al.* 1998; Zaba and Madulu 1998; Adger *et al.* 2001; Godoy *et al.* 2001; McCracken et al. 2002; Vance and Geoghegan 2002). The research teams involved in these efforts have spanned the social and environmental sciences and have employed a wide range of methodologies, such as household surveys, participant observation, ground-level analyses of biophysical variables, and integration of remotely sensed imagery.

An understanding of household dynamics is important because it is the aggregate of household-level decisions that form the building blocks of a country's population dynamics. A better understanding of household dynamics can help researchers and policy makers to understand the motivations and perceived costs and benefits of certain kinds of demographic behavior, especially fertility and migration, as they relate to livelihood strategies. From the environmental perspective, household dynamics can affect local environmental outcomes and resource dependence, and these dynamics may have significant repercussions for biodiversity conservation in regions such as Amazonia and Guatemala's Petén. Conversely, changes in the quality and quantity of natural resources can have important impacts on household population dynamics – everything from morbidity and mortality, to fertility and migration. These multiple and multi-level dynamics between household demographics and environmental variables, mediated by contextual factors such as local and regional environmental variability, policies, institutions and markets, makes this for a complex area of study, but also one that is ripe for new discoveries and insights.

This paper reviews some of the major strands of this research, examines common threads and lessons learned, and identifies some remaining research questions. Given the breadth of literature, it is necessarily an incomplete survey, but is offered in hopes that it may stimulate useful discussion and identify new areas of research.

2. Livelihoods[1]

In most rural areas of the developing world, the household is the basic unit of production and reproduction. Production includes activities that produce tradable (or potentially tradable) goods and services that result in income, and reproduction includes household maintenance functions such as childcare, cooking and cleaning, which are not tradable, but are nevertheless essential for household well being (Sousan *et al.*, 1999). In order to survive and prosper in what can often be difficult circumstances, rural agrarian households employ livelihood strategies, which can be defined as "the capabilities, assets (including both material and social resources) and activities required for a means of living" (Carney 1998). Depending on the context, livelihood strategies may include farming, herding, fishing, off-farm employment and, to a lesser extent, exploitation of 'wild' resources through hunting and gathering. In contrast to the nuclear family model prevalent in the developed world, households are often composed of grandparents, sons and their spouses, children, and other relatives, all tied together by bonds of kinship to form the household economic unit.[2]

Households employ five dominant forms of livelihood assets (Carney, 1998):
- *Natural capital*: the natural resource stock from which resource flows useful to livelihoods are derived.
- *Social capital:* The social resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of their livelihood.
- *Human capital:* The skills, knowledge, ability to work, and good health important to the ability to pursue livelihood strategies.
- *Physical capital:* The basic infrastructure (transport, shelter, water, energy, and communications) and production equipment and means that enable people to pursue livelihoods.
- *Financial capital:* The financial resources that are available to people (whether savings, supplies of credit, or regular remittances and pensions) and which provide them with different livelihood options.

The relationship that the household has with its environment, and by extension its impact on the environment, is mediated by these forms of capital, as well as by institutional and cultural factors as presented in Figure 1. Thus, it is hard to speak of a *direct* impact of population upon the environment, for though population size and composition is important, the utilization of natural resources and ecosystem services by a community will depend upon a wide range of variables. If institutional factors are not functioning properly (in terms of determining who has access to which resources), or land tenure arrangements are highly inequitable, it is likely that there will be a higher degree of resource degradation than in cases where common property regimes are respected, and households have sufficient land to pursue their livelihood strategies.

---

[1] This section and portions of the following section were extracted from an earlier paper by the author (de Sherbinin 2000).
[2] The word economy derives from the Greek word *oikonomia*, which means "household management."

3. Household Population Dynamics, Environment and Natural Resources

Household population dynamics encompass several key variables: household size, age and sex composition, fertility, morbidity, mortality, and migration. Households also go through life cycles, and these cycles (e.g., formation through marriage, having young children then adult children, etc.) can have independent effects on environmental variables. Household population variables can both affect the environment through livelihoods, as discussed above, or they can be affected by the environment through factors such as disease and resource depletion or enhancement.

Figure 1. The Household-Environment Relationship
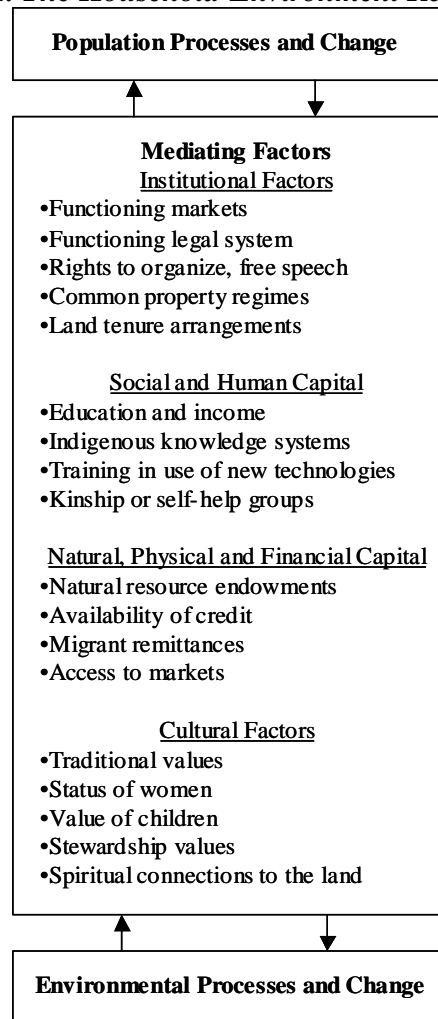
Adapted from Mishra, 1995.

Although this paper will not address the topic directly, it should also be noted that changes in the numbers, size and age composition of households in a country or region can have impacts on the environment, and the impacts of these changes are often greater than the impacts of changes in the size or age composition of the overall population. Research has found, for example, that growth in the number of households may be more

important in predicting emissions that lead to climate change or land-cover changes that lead to biodiversity loss than overall population growth (Lutz *et al.* 2000, Liu *et al.* 2003, Dalton *et al.* 2005).

3.a) Fertility, Environment and Natural Resources

One popular theory to explain the existence of sustained high fertility in the face of declining environmental resources is the vicious circle model (VCM) (O'Neill *et al.* 2001, Lutz & Scherbov 1999). In this model, often depicted diagrammatically (Figure 2), it

Figure 2. The Vicious Circle[3]
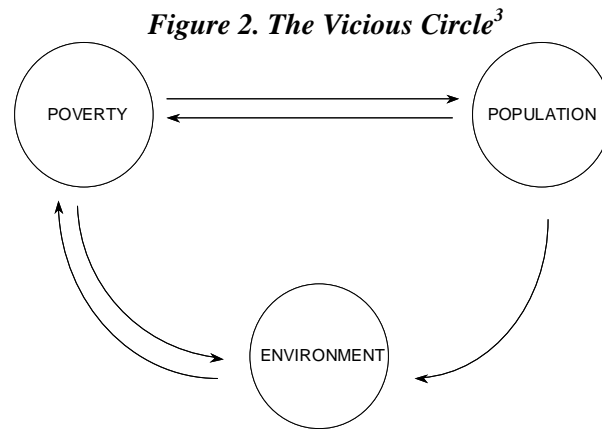
is hypothesized that there are a number of positive feedback loops that contribute to a 'downward spiral' of resource depletion, growing poverty, and high fertility. In its simplest version, *poverty* contributes to *high fertility* through factors such as:

- demand for children due to high infant mortality, farm and household labor requirements, and old-age security in the absence of social security programs;
- lack of education and future orientation, which implies less awareness of family planning services, and less confidence in an ability to control one's future, which is a pre-requisite to use of such services; and
- low status of women and disempowerment over fertility decision-making.

High fertility affects *poverty* through:

- unemployment, low wages, and increasing landlessness in the agricultural sector; and
- overstretching of social services, schools, health centers, and water and sanitation services.

Poverty contributes to *environmental degradation* due to:

- a short-term orientation in which current needs take precedence over long-term stewardship of resources (owing to high discount rates); and
- lack of access to technologies to mitigate the environmental damage.

---

[3] This diagram is loosely adopted from UNICEF, *The State of The World's Children* (1994). For a more sophisticated diagram, see Poverty-Environment Partnership (2005), *Investing in Environmental Wealth for Poverty Reduction*, pp. 64-71, available at http://www.povertyenvironment.net/pep/.

Environmental degradation contributes to *poverty* and *population growth* through:
- inadequate soil fertility management (erosion, salinization, and short-fallow cycles) that contribute to declining yields;
- increased vulnerability to natural hazards such as flooding and landslides;
- poor environmental sanitation, contributing to disease and income loss; and
- declining *per capita* availability of water, forest, rangeland and other 'commons' that, perversely, increases the demand for household labor to 'capture' them.

And, *population growth* adversely impacts the *environment* because of:
- increasing pressure on marginal lands, soil erosion, siltation, and flooding;
- increasing use of fertilizer, pesticides, and water for irrigation leading to water pollution and impacts on fisheries;
- migration to peri-urban squatter settlements, and attendant problems of water supply and sanitation, proximity to industrial effluents, indoor air pollution, and mud slides.

In terms of their theoretical underpinnings, VCMs build on intergenerational wealth flows theory, which holds that high fertility in traditional societies is beneficial to older generations due to the net flow of wealth from children to parents (Caldwell, 1982). In other words, children contribute more than they consume in the household economy. VCMs also borrow from theories that describe fertility as an adjustment to risk, which argue that in situations "where financial and insurance markets are poorly developed, and… there is no tradition of extrafamilial welfare institutions," children serve as old-age security (Cain 1983). In more traditional societies in which children possess a deeply engrained sense of filial obligation, this kind of 'pension plan' often works very well. Some economists have incorporated environmental elements to the above theories by suggesting that children are valued by rural households in part because they transform open access resources (forests, fisheries, and rangeland) into household wealth (Panayotou 1994, Dasgupta 1995). Thus, according to this interpretation, individual responses to resource scarcity lead to problems at the societal level as each household copes with increased risk and uncertainty by maximizing its number of surviving children.

It should be noted that VCMs have been criticized as being oversimplified and as 'blaming the victim' rather than examining deeper political, economic and institutional imbalances that set the context for environmental degradation (Gray and Moseley 2005, Krings 2002, Forsyth *et al.* 1998). A political economy perspective is indeed important for research on fertility-livelihood-environment linkages, but for the purposes of this brief review we will focus on the evidence of linkages between household-level fertility behavior and the quantity and quality of environmental resources rather than on what might be termed 'underlying causes.'

For all the interest in VCMs, there has been surprisingly little empirical research looking at the relationships among natural resources, environmental degradation, fertility and family size preferences. Box 1 provides a summary of the theory and literature based on

Sutherland *et al.* (2004).[4] The remainder of this section will focus on studies published in the past five years.

Box 1. Summary of Relationships Between Various Resources and Fertility

Land and fertility: Land resources can be characterized by size of holding and tenure. The relationship between land holding and fertility is expected to be positive under the land-labor-demand hypothesis advanced by Stokes and Schutjer (1984). They postulate that a larger farm size creates a demand for children as labor to keep land in production. This positive relationship has been observed in studies in Rwanda, Egypt, the Philippines, Iran, Peru and Ecuador (Hiday 1978, Good *et al.* 1980, Schutjer *et al.* 1983, Easterlin and McCrimmins 1985, Clay and Johnson 1992, Coomes *et al.* 2001, Carr *et al.* forthcoming). Alternatively, it has also been proposed that the effects of land tenure can counteract the relationship between farm size and family size. Under this land-security hypothesis, land tenure security creates economic security that lowers the need to invest in large numbers of children (Stokes and Schutjer 1984). Greater security is associated with higher living standards, access to health care, and greater educational opportunities, all of which promote lower fertility. Studies in the Philippines, Egypt, Ecuador, Iran, India and Mexico provide evidence for the negative relationship between tenure security and fertility (Hiday 1978, DeVaney and Sanchez 1979, Good *et al.* 1980, Vlasoff and Vlasoff 1980, Schutjer *et al.* 1983, Coomes *et al.* 2001, Carr and Pan 2003). Easterlin proposed that in frontier settings it is not the size of farm that predicts family size, but the perception of availability of land for one's children. In frontier areas, he argues, land is abundantly available, and therefore parents opt for higher fertility in expectation that land will be available for their children. As the frontier becomes settled it is expected that fertility would decline in response to the perceived scarcity of land to settle. This hypothesis has not been tested with household-level data, but macro-level studies have supported this hypothesis in Thailand, the United States and Brazil (Easterlin 1976, Merrick 1978, VanLandingham and Hirschman 2001).

Cattle and fertility: Cattle are an important asset in many parts of the world. Unlike land, they are uncomplicated by tenure issues; they are easy to liquidate and transport; they provide a stream of income from dairy products; and they represent a status symbol (Loker 1993, Faris 1999). Cattle grazing requires little labor and they can be sustained on land that is too poor for crops. Thus, it could be expected that cattle, like land, might have an impact on fertility decision making. Cattle could be seen as a retirement account that could reduce demand for children. However, Perz (2000) asserts that cattle tend to be acquired later in life, after child bearing is completed, when households have acquired sufficient capital to invest in cattle. In this hypothesis, children are in demand by parents because they provide labor needed for early agricultural production and later, when they migrate out, remittances needed for acquisition of cattle.

Natural resources and fertility: Fuelwood and water are necessary for every day life. In rural areas these tend to be collected from ungoverned commons, such as forests and rivers. Gathering these resources is often left to women and children. Dasgupta (2000) hypothesizes that as these resources become scarce each additional child provides a marginal benefit through his or her labor. This suggests that resource dependency will result in higher fertility. There is empirical evidence supporting this hypothesis from Pakistan, Nepal, and South Africa (Biddlecom *et al.* 2000, Aggarwal *et al.* 2001, Filmer and Pritchett 2002).

Source: Adapted from Sutherland et al. *2004.*

---

[4] For a discussion of historical links between land and fertility see Desantis *et al.* (2000).

A carefully designed study in the Western Chitwan Valley of Nepal (Biddlecom *et al.* in press) found that three measures of environmental constraint – the time to collect fodder, the increase in time required to collect fodder in the prior three years, and household's dependence on public lands for fodder – were significantly and positively correlated with desired family size, even when controlling for household wealth and numerous other factors found to influence desired fertility. Furthermore, women in households where the time to collect firewood had increased by more than an hour in the three years prior to the initial survey were more likely to have had a pregnancy in the three years after that survey. Both of these findings seem to confirm the vicious circle hypothesis, in which declining environmental resources lead to increases in fertility. Yet several other indicators of environmental decline had no significant relationship to either desired fertility or pregnancy outcomes, and the actual relationship to desired fertility depended in part on whether the respondents were men or women.[5]

Economists Filmer and Pritchett (2002) found qualified support for the vicious circle hypothesis using detailed data from Pakistan on child time use, firewood collection activities, and recent fertility. They find that collection activities do absorb a substantial part of household resources and that children's tasks are often devoted to collection activities. In comparison to the time spent by other household members, child time is a significant but not dominant. The presence of older children in the household was found to reduce the time that women devoted to household tasks. Exploratory multivariate regressions showed a partial correlation between indicators of firewood scarcity and the probability of a birth in the past five years – a relationship that varies across regions of Pakistan, and may be partially explained by the evolution of property rights in different provinces. However, they conclude that the results "support the notion that there is a stage in the relationship between environmental degradation, fertility, and land ownership rights in which children are in relatively high demand," even if it cannot be said unequivocally that environmental changes lead to changes in the perceived costs of children.

In a study of Guatemala's Petén, an agricultural frontier, Sutherland *et al.* (2004) utilized a specially designed Demographic and Health Survey (DHS) that asked questions regarding land ownership, land use, fuelwood and water gathering, and attitudes towards conservation.[6] Using number of living children as the dependent variable ('family size'), and controlling for maternal age, education and living standards, they found that neither farm size nor tenure security had significant effects on family size. Those perceiving land to be available for their children had significantly fewer children than those who perceived land to be scarce, which partially supports the notion that children may be seen as an economic safety net for those who perceive resources to be scarce.[7] The authors

---

[5] For example, the dummy variable indicating that fodder collection times increased by more than an hour in the past three years yielded a 1.27 child increase in the desired family size among women, but for men there was a statistically insignificant decrease of -0.29.

[6] Grandia (2005) describes the lessons learned from implementing this unique DHS.

[7] The perception of land availability question was only asked of land holders and not of landless families. On average 78% of respondents reported that they felt land was available for their children, which may simply suggest an overall "optimistic" attitude with regards to land availability in the future, despite the fact that 28% of families are landless.

posit, however, that this may actually reflect a reverse causality – that those with smaller families are more likely to report that land is available for their children. Ownership of cattle was strongly and positively associated with family size. Here again, reverse causality is more likely, since larger families are more likely to have accumulated the resources necessary for cattle ownership. The time required to collect water was not significantly related to family size, nor was household reliance on fuelwood collection – perhaps because the average water collection time is relatively low (only 13 minutes), and only one-third of households actively collect fuelwood.

Carr *et al.* (forthcoming) take advantage of a subset of longitudinal data collected in 1990 and 1999 to explore land-fertility relationships in the Ecuadorian Amazon. By using longitudinal data they were able to follow families and plots over time and analytically describe the relationship between landholdings and fertility. The data confirm the land security hypothesis (Stokes and Schutjer 1984), with women in households with secure title having two-thirds fewer children then those without such titles. Consistent with the VCM hypothesis, women on the smallest farms in 1990 had more than double the number of children than did women on the largest farms. Large cattle and coffee holdings during the time period were associated with lower fertility. Generally their findings confirm hypothesized links between poverty and fertility - better off households that are more centrally located, with good access to markets and services, choose to limit fertility more than poorer households.

Discussion and Policy Relevance

Given the emphasis of population policy on fertility, these research results are briefly examined in terms of their policy relevance. Overall, the research suggests that although fertility decision-making may indeed be related to household livelihood strategies, the actual empirical evidence of fertility choices being based on resource abundance or scarcity is fairly slim. The evidence for environmental degradation feeding higher fertility is also spotty. Thus, the VCM hypothesis cannot be fully supported, but nor can it be wholly 'debunked,' as some would prefer.

The research in this field is predicated on the notion that childbearing decisions are largely an economic calculus, and that in rural subsistence-based societies the returns to childbearing are higher than the net costs. Evidence from Zambia suggests that the age at which children change from net consumers to net producers is about age 12 (Barrett and Browne 1998). In Pakistan female children are judged to be net contributors to hours of household activities between the ages of 11-16, and by age 18 female children effectively 'repay' the child rearing time allocation by mothers (e.g. child care and other household tasks) (Filmer & Pritchett 2002). These findings suggest that even where children are resource gatherers, households do not begin to experience net benefits until they reach age 11, and in societies where girls marry early, the actual period of net contribution to a household's income is potentially very short. On the other hand, it may be that the *perception* of benefit still exists, even when the actual evidence of such a benefit is minimal. In any case, theory and research suggest that there is a complex array of factors affecting fertility decision making, and the economic calculus is only one of them – with

cultural, emotional, religious and other factors often being predominant (e.g. van de Walle and Meekers 1992, Caldwell and Caldwell 1987).

Nevertheless, some researchers have made impassioned appeals for greater policy attention to fertility-environment linkages. For example, Clay and Reardon (1998) argue, based on research in Rwanda and Madagascar, that intergenerational wealth flows from children to parents means that it is economically rational for household heads to create a large pool of household labor through high fertility. They state:

> Reducing fertility, for households in sub-Saharan Africa facing land constraints, is not perceived to be an alternative to other strategies such as income diversification, cash cropping, and intensification. Indeed, to make these income strategies work, households often see the need for even greater household labor through higher birth rates.

In the absence of a change in the direction of wealth flows from parents to children, they argue that fertility is unlikely to decline in the rural African context because households tend to 'externalize' the costs of excess fertility by sending children away who are unable to contribute to household income. In terms of policy, they make the case that the common practice of separating out population factors as 'exogenous' to natural resource and environmental policies is mistaken, and that an understanding of household demographic responses to constraints and opportunities is fundamental to improved resource management. Though demographic trends are often taken as a 'given' owing to population momentum, they point out that reversing long-term environmental degradation is no easier than instituting policies and programs to reduce fertility.

One finding that bears policy attention is the importance of improving women's status, and engaging women in activities aimed at improved natural resource management (Tukahirwa 2002, UNFPA and IUCN 1999). This can shift the economic calculus, as women consider the opportunity costs of having children versus engaging in income generating activities. It also results in their greater involvement in and control of fertility decision making. Improving women's status has long been heralded as a 'win-win' strategy for reducing fertility rates while improving incomes and the environment.

Further Research Questions

- Given that fertility remains high in most rural/frontier areas with respect to urban/core areas, are there environmental or resource conservation rationales for family size limitation that might actually be sensible to household heads?
- Famiily sizes in the Brazilian Amazon are generally quite small in comparison to those in frontier zones of other countries. What are the reasons for this? Are there any generalizable recommendations can we learn from the Brazilian case?
- In what ways can a political economy perspective enhance the understanding of household fertility and the environment, or at least the policy implications of the findings?
- Can it be proven that households 'externalize' their excess fertility by sending children away who cannot contribute to (or be supported by) the household economy? If so, do high resource constraints favor such externalization?

3.b) *Morbidity and Mortality, the Environment and Natural Resources*

The research on the impact of environmental contaminants (e.g. air and water pollution) on human health and the resulting burden of disease is quite extensive, and is beyond the scope of this paper.[8] There is also a growing literature on the disease impact of land-use transformations resulting from frontier migration, with recent studies focusing on growing malaria prevalence in Amazonia (e.g. Castro 2006). The focus here is on how changes in the morbidity and mortality at the household level influence livelihood strategies that can impact the environment and natural resources. This section builds on a relatively undeveloped body of research – one which has nevertheless become important in light of the AIDS crisis in sub-Saharan Africa.

Research by Barrett and Browne (1998) suggests that environmental shocks and AIDS-related mortality can have had an impact on the valuation of children. The research was carried out in Eastern Province, Zambia, an area where women bear an average of about seven children. The region has been badly hit by drought and HIV prevalence has increased, increasing poverty rates. They found that the importance of labor and cash transactions for rural households is intensified in periods of environmental and social change, with children's labor increasingly being redefined in cash terms. They further found that children are increasingly being viewed as assets to be negotiated between rival parents and families. The implication of this research is that children provided needed household labor during times of high mortality, though the environmental implications were largely untested.

In another study in South Africa's South Limpopo Province, Hunter *et al.* (2005) examined the impact of AIDS mortality on household's fuelwood provisioning strategies. This province has been hard hit by AIDS, which accounted for 21.5% of deaths in the year 2000. Furthermore, even with relatively high levels of electrical connections, 92.3% of households utilize fuelwood for some portion of their energy needs. Paradoxically they found little relationship between household socioeconomic and demographic characteristics and the amount of fuelwood consumed, but village location did have a significant impact on wood consumption. They did find that households with a young age structure (>1/3 of members below age 15) are less likely to purchase wood, and therefore more likely to gather their own wood. They found no statistical evidence that households experiencing a death in the prior two years consumed different amounts, or used fuelwood differently, than other households. But through interviews with household members they found that loss of a family member resulted in important though often subtle changes in household labor and fiscal allocations, including increasing dependence on children for resource gathering tasks. They found that mortality exacerbates poverty, with natural resources serving as a buffer against poverty, and sometimes a means of generating income.

The notion that open access natural resources offer an important economic buffer for families experiencing crises of morbidity or mortality has been tested in Central America

---

[8] For those interested in this topic, a PERN cyberseminar was held on the topic of "air pollution and health linkages" in December 2003. Visit http://www.populationenvironmentresearch.org/seminars.jsp#sem2003.

as well. In research among Amerindians in Honduras, Godoy *et al.* (1997) found that the area of old-growth rainforest cleared for farming increased with the number of days family members were ill during the previous growing season, suggesting that households may engage in more forest clearing in order to pay off debts incurred during illness. Unexpectedly, household size was also negatively correlated with forest clearance, suggesting perhaps that larger households dedicate more workers to off-farm employment.

Discussion and Policy Relevance

The primary conclusion of this research, limited though it may be, is that natural resources can play an important cushioning effect when households experience morbidity and mortality by providing a supplementary source of income, or replacing goods that might otherwise be purchased. Similar natural resource dependence is observed to occur during times of drought and famine. Morbidity and mortality are likely to increase the stress on household finances, pushing families into poverty, with concomitant increases in natural resource dependence (e.g., substitution of electricity or gas with local fuel wood).

There is a growing literature on forest resources as a 'safety net' in the context of household illness (McSweeney 2004; Takasaki *et al*. 2004). This literature finds that where epidemiological risks are high, and formal insurance markets thin to non-existent, then some households are likely to sell forest products to cover the costs of illness. Young, undercapitalized households are more likely to self-insure this way, though only for their women and children that are sick, and not the adult males, because they are the ones who actually do the extractive activities.

The impact of loss of household members due to AIDS mortality has had important impacts on natural resource management. According to a study commissioned by the FAO (Drimie 2002):

> Conservation and resource management are also dependent on human factors such as labour, skills, expertise and finances that have been affected by the epidemic. Therefore the reduction in the number and capacity of 'willing, qualified, capable and productive people' who have managed natural resources has negatively impacted on sustainable utilisation of these resources (Dwasi 2002). In addition, the epidemic can impact natural resource conservation and management by accelerating the rate of extraction of natural resources to meet increased and new HIV/AIDS demands.

This has been something of an unforeseen and largely neglected aspect of the AIDS epidemic. However, since the impact of mortality and morbidity on the environment is mediated through household poverty, the primary policy response would seemingly be to bolster ongoing public health and poverty reduction interventions.

Further Research and Policy Questions

- Are elevated levels of morbidity/mortality at the household level likely to increase poverty-induced over-exploitation of public access natural resources such as fuel wood or water, at the expense of longer term stewardship?
- If under certain circumstances children are more highly valued in households impacted by HIV/AIDS morbidity and mortality, in what ways is child labor utilized, and to what degree is it for natural resource gathering activities? Are children in HIV/AIDS impacted families more likely than their counterparts to be engaged in gathering activities and less likely to be attending school?
- To what extent might investments in rural health care or microcredit lending programs lessen the need to exploit forest products during health crises?
- How might investments in preventative health care be reflected in a healthier labor force with positive outcomes for agricultural investments in sustainable practices?

3.c) *Migration, the environment and natural resources*

Much of the research on the impacts of migration on the environment looks at migration in the aggregate or societal level, divorced from household livelihood strategies, with a particular emphasis on impacts in destination (especially frontier) areas. While widely considered to be one of the most important demographic factors affecting the environment, because the types of migration (including return, repeat, circular, permanent, and temporary) are as many and varied as the intervening variables (socioeconomic status, migrant selectivity) and environmental outcomes (deforestation, fisheries depletion, etc.), it is also one of the most difficult to adequately assess (Curran 2002). The focus here will be on household migration strategies and their relationships with the environment and natural resources at places of origin rather than places of destination. This does not preclude an assessment of frontier areas, since established households in these areas often employ a number of migration strategies to supplement their livelihoods.

One of the theoretical approaches to research in this area has been the multiphasic response (Bilsborrow and Okoth-Ogendo 1992). Modeled on the multiphasic response theory of fertility regulation (Davis 1963), its application in the area of population and land-use change suggests that in response to population growth societies adopt several strategies: tenure regime change, extension of the cultivated area (extensification), technological innovation (intensification), and outmigration. Although the strategies are presented consecutively, outmigration is not necessarily the last response in a series (e.g. after all others have been implemented), but is a strategy that may complement other responses.

Utilizing a rich multi-level longitudinal data set, Henry (2005) examines the push and pull factors affecting migration decisions in Burkina Faso, including three environmental variables among several others: average agro-climatic conditions (precipitation levels),

drought, and water conservation technologies. Overall, the risk of leaving places with favorable agroclimatic conditions is higher than the risk of leaving unfavorable places. This was contrary to the author's expectations, but is consistent with the hypothesis that households in resource-poor areas may lack the resources necessary to send migrants (Curran 2002). When disaggregated by long- and short-distance migration, low precipitation levels in source areas tended to be associated with a higher propensity for long-distance (inter-provincial) migration but decreased the propensity for short-distance moves. By contrast, short-term drought in source areas had the effect of increasing the likelihood of long-distance outmigration but decreasing the likelihood of short-distance migration. Increased local water conservation technologies only had a significant (negative) effect on short-distance migration. These results suggest that if agroclimatic conditions and/or drought are severe enough it may impel people to move longer distances, but that a short-distance move would not make sense because the same conditions would likely prevail in the destination area. They also suggest that local water conservation technologies may serve to keep migrants in place.

In a longitudinal study of household migration strategies in the Ecuadorian Amazon, Barbieri and Carr (2005) find significant gender differences in migration patterns, with men typically going to other rural frontier areas, and women preferring incipient frontier urban areas. The survey instrument covered approximately 250 households in 1990 and 1999, 147 of which had at least one member permanently migrate during this period. Fifty-five percent of all migrants were between the ages of 12 and 19. On-farm natural resource constraints appear to be significant drivers of migration, with higher population density and declines in areas under forests and crops associated with higher levels of male outmigration. Overall, both male and female migrants had a higher probability of moving to rural frontier areas than to urban areas, leading the authors to suggest that a 'vicious cycle' may be in place whereby households that settled in the first wave of frontier migration use up resources and then send younger members to settle more distant areas, with the potential for the same pattern repeating itself in the next generation.[9]

In their study of communities in Nang Rong, Thailand, Entwistle *et al*. (1998) linked household survey data to remote sensing imagery from the 1970s and early 1980s for the areas surrounding those communities. In this area land is cleared to establish cultivation rights. For young farmers, access to land is vital if they are to be gainfully employed. A more fragmented landscape, with a large number of small forest patches, would suggest that there is a scarcity of land for the introduction of new crops. Their research found that forest fragmentation was associated with out-migration of young adults during the period from 1984-1994. Stated differently, districts with higher proportions of land in forest were less likely to experience out-migration.

Any discussion of household migration-environment linkages without an assessment of the role of remittances would be incomplete. Remittances may have beneficial impacts on the local environment by reducing resource dependency through the substitution of

---

[9] Similar to the criticism of the VCM hypothesis, some reject the notion that environmental scarcity is a significant cause of migration. This work, based on a political economy framework, suggests that local power/knowledge relationships are more important (Carr 2005).

purchased goods (such as electricity or imported food) for locally produced goods. They may also be invested in resource-conservation (e.g. fertilizers to improve soil fertility) or environmental activities. On the other hand, remittances may have negative impacts on the environment by increasing investment in environmentally destructive practices, or by cultivating unsustainable tastes. Case studies examined during a 2001 PERN cyberseminar on coastal p-e linkages illustrate some of these dynamics. One study of the Micronesian Island of Kosrae (Naylor *et al.* 2001) found that 15% of the island's population was living abroad, primarily in Hawaii and the mainland United States, and remittance income was important to all households, especially subsistence households. In another study of coastal Vietnam, remittance income comprised 9% of household income (Adger *et al.* 2001). Finally, in a mangrove area of El Salvador, 73% of farming families and 56 % of rural families have family members who have migrated and are sending remittances (Gammage *et al.* 2001). The case studies demonstrate that the financial capital available to rural households from remittances has demonstrable impacts on the environment. In the case of Vietnam they were negative, insofar as they enabled local farmers to purchase more land for aquaculture, which resulted in mangrove clearance. In the case of El Salvador they were mixed, because remittances were used by some households to purchase firewood (increasing pressure on forests) and others to purchase alternative fuels (decreasing pressure).

On Kosrae, the authors suggest that there is no clear relationship between migration status of households and mangrove resource consumption, yet this case study revealed another potential impact of remittances, which is that they may serve to erode indigenous knowledge systems that have traditionally governed the management of natural resources. Naylor *et al.* posit that continued or increasing economic dependence on the United States could result in increased degradation of the mangrove resource base as the local environmental knowledge is lost. This suggests that communities that are heavily dependent on local resources will be more likely to maintain the institutions and practices necessary to manage them for sustainable yields, whereas those communities that no longer depend upon ecosystem services for survival may lack the traditional knowledge that would ensure the ecosystem's survival, and may also be more likely to exploit them for short-term gain.

Discussion and Policy Relevance

Decisions by households to send migrants to urban or other rural areas are generally part of a household income diversification strategy. The environmental impact on the sending area depends heavily on who is sent, whether the siphoning of labor to other areas reduces pressures on land or other resources, and how remittances are allocated. The impact of resource scarcity or other environmental factors on a household's decision to send migrants is not well studied, except perhaps in the case of land resources. There is ample historical evidence to suggest that scarcity of land resources has led to waves of outmigration to new lands, as occurred in European history and is repeated from the cores to the peripheries of many developing countries (e.g. from other regions of Brazil to the Amazon, or from the highlands of Guatemala to the Peten). Tukahirwa (2002) finds that land scarcity is the number one factor prompting migrants to move in three regions of

Uganda. The Burkina Faso study suggests that if resource scarcity is severe enough in certain source areas, household poverty levels may actually preclude the possibility of a move to more favorable regions.

To the extent that migration may be a strategy to 'externalize' unsustainably high fertility by sending excess household labor elsewhere, there may be opportunities to reduce fertility through policy interventions. Barbieri and Carr suggest a number of policy strategies to stop the 'vicious cycle' of successive waves of migration into more distant frontier areas of the Ecuadorian Amazon. Among them are the provision of family planning services, to improve living conditions in long-settled areas, and to improve infrastructure and labor opportunities in urban areas, especially for young women.

Further Research Questions

- What empirical evidence exists to link household outmigration to environmental degradation or resource depletion in sending areas?
- What are the gender differences in migration types, migration destination areas, and propensity to remit money?
- What evidence exists for the expenditure of remittance income in environmentally beneficial or damaging ways?
- How does a political economy perspective, understanding entitlements to resources (or lack thereof) and power imbalances, help to illuminate the decision to migrate (e.g., Carr 2005)?

3.d) *Household lifecycle and the environment*

Household lifecycles can be viewed as the result of the previously documented household-level dynamics – fertility, mortality, and migration – over time. Household formation generally signals the establishment of a new residence by a married couple. The household then goes through a cycle as children are born and are reared to the point where they become economically contributing members of the household, eventually marrying and either leaving or staying within an extended family home. Different points in the lifecycle are characterized by different household age and sex compositions, dependency ratios, etc., and these lifecycle dynamics can have important consequences for labor availability and household livelihood and land use strategies. Societies in the rural developing world differ in the degree to which the extended family model is the norm. In much of Africa and Asia wives may be expected to join the husband's household, and children are reared in this context. In Latin America, the extended household is less common, and in some rural areas such as the Brazilian Amazon a small nuclear family is increasingly becoming the norm (Moran *et al.* 2005).

The foundational theory upon which much research on household lifecycles and the environment is built is Chayanov's household economy framework. Chayanov was an economist in the former Soviet Union who observed that peasant farming households possessed farms of different sizes, and that well endowed households with many family

workers typically possessed larger holdings than those constrained by labor shortages. Although not explicitly developed for frontier situations, his theory suggests that household size and lifecycle may be related to the amount of land that would be cleared for cultivation in forest frontier environments (Walker *et al.* 2002). This hypothesis has been tested in the Amazon and other tropical forest regions.

Walker *et al.* review a large number of studies conducted in the Amazon for evidence of household size and lifecycle impacts on land use and, deforestation, among other outcome variables. Out of 20 studies reviewed, they only identified a few studies that found statistically significant relationships between lifecycle variables such as age of household head, duration of residence, family size and number of children and dependent land use and environmental variables. The results were as follows: Godoy *et al.* (1997b) found a positive correlation between duration of residence and family size and the probability of cutting old growth forest in one of three sites; Godoy *et al.* (1998a) found a positive correlation between duration of residence and hectares of primary forest cut, but (surprisingly) negative relationships for age of household head and number of males present; Godoy *et al.* (1998b) found a positive correlation between duration of residence and hectares of primary forest cut; Jones *et al.* (1995) found duration of residence was positively correlated with coffee production; Pichón (1997) found the duration of residence was positively correlated with % of land in pasture and that duration, family size and number of kids was negatively correlated with % of land in forest; Rudel and Horowitz (1993) found that family size was positively correlated with the % of land deforested; and Sydenstricker-Neto and Vosti (1993) found that number of adult males and females was positively correlated with hectares deforested. Confirming the Chayanovian hypothesis, duration of residence is generally positively correlated with % land deforested, and in selected instances with % land in pasture and perennial crops.

These statistical 'snapshots' do not do justice to the depth of the studies, however. Here I review a sub-set of longitudinal studies published in the past five years that provide greater depth of insight into land use patterns over time as they relate to household lifecyles.

Similar to the studies above, the fundamental question asked by a team of researchers at the Anthropological Center for Training and Research on Global Environmental Change, Indiana University, in research spanning 30 years in the Altamira region of the Amazon, is how does household lifecycle affect patterns of land use and deforestation (Moran *et al.* 2002, 2005)? Their research has uncovered a cyclical pattern of deforestation. In the first five years of settlement, households in the region begin their occupation with a rapid spurt of deforestation necessary to establish rights to the land and to produce crops. After this the rate of deforestation declines as households seek to manage the areas already cleared, and try to control the aggressive regrowth of native species. Households begin to shift from largely annual crops to pasture and perennial crops, which is facilitated by increased labor availability as children become teenagers. Within this seemingly orderly progression, there was significant variation, with factors such as soil fertility playing a major role in influencing paths of land use, and prior farm management experience also affecting to a large degree the success of household livelihood strategies. A subsequent

18

phase of research, involving several new study sites in other parts of the Amazon, focused on what factors explained the differential rate of secondary succession forest regrowth. Within geographic regions farmer land use strategies predicted the degree of forest regrowth, but between regions soil fertility had the greatest impact – with secondary growth being fastest in regions with the best soils.

A team of researchers at the Carolina Population Center (CPC)/University of North Carolina (UNC) conducted research in the northern Ecuadorian Amazon between 1990 and 1999 (Barbieri *et al. In Press*). In contrast to what they term the 'Brazilian model' of extensification, land resources are more constrained in the Ecuadorian Amazon, and thus land is often sub-divided to accommodate the next generation or sold to new settlers, resulting in greater fragmentation of holdings. Comparing households surveyed in both 1990 and 1999 versus those that arrived on the frontier subsequent to 1990, the former tended to have more land per household member (6.5 vs. 3.2 ha), to have a significantly older age structure, and to experience more off-farm employment. The proportion of land in three classes – forest, pasture and cropland – among later settlers is almost identical to the proportions for the earlier settlers surveyed in 1990 (59%, 22%, and 19% respectively), reflecting similar strategies at similar lifecycle stages even if their landholdings are less than half as large (46 ha in 1990 vs. 18 ha among recent settlers in 1999). Forest land as a percent of total land use did not decline significantly among the early settlers in the 1990/1999 surveys, but the percent of land in forest for the entire 1999 sample did decline from 59% to 45% between the two survey dates.

The researchers created synthetic cohorts over time to track allocation of land use over the 20 years since settlement began, and found that farm size plays a significant role in land use allocation decisions – with farms under 25 ha deforesting faster and a far greater proportion of land than larger farms. These farms also tend to have the highest percentage in crops. Farms greater than 50 hectares deforest little land at first, but the pace picks up over time, ultimately leaving a smaller proportion of land in forest after 20 years (~40%) than for mid-sized farms (~60%). All three groups end up, after 20 years, with approximately 20% of their land in pasture. They find that the pattern identified elsewhere in the Amazon – of a trend from subsistence farming to cash crops to cattle ranching (reflecting changes in household labor and capital accumulation) – was not mirrored in their study area because of land shortages and household's need to use land more intensively. Because of a more diversified portfolio of land uses over time, and less reliance on cattle ranching as the 'end point', deforestation was not as high as might be expected in this frontier area. Confirming the aforementioned research on the importance of natural resources as a cushion for emergencies, farmers reported keeping some land in forest as an insurance policy – ready to be harvested should the household be in need of quick cash.

With survey data going back to the mid-1980s, another team of researchers at the CPC/UNC have studied an even more constrained setting in terms of land availability: Nang Rong District of northeast Thailand (Walsh *et al.*2005). This region represented a forest frontier up until the 1950s, but has become progressively settled since then, with clustered village settlement and farmers walking as far as 3 km to reach their fields. The

researchers used a 'life course perspective', which focuses on individual's role states, transitions and trajectories, recognizing that individuals are connected to one another through households and families. The greatest number of transitions occur in early adulthood, when young people make decisions about migration, marriage household formation and childbearing. This suggests that young people are central to the population-environment relationship. They have found that as patterns of land use and land cover become more fragmented, that young adults engage in more off-farm employment, suggesting that the landscape has exceeded a perceived threshold of land availability/contiguity, and that outmigration is preferred over new household formation within the district. In a finding somewhat consistent with Moran *et al.*, finer-scale research at village level found stronger relationships between social variables such as number and density of households and plant biomass patterns, whereas broader scale studies (with pixel sizes of ~1km) found that these patterns were largely a function of biophysical measures such as slope. Research linking individual households to plots is a challenge in this environment, where households may own several plots of different types of land in different locations. But land cover change analyses have found that regardless of temporal scale (seasonal, inter-annual, and decadal), mean elevation, mean slope angle, as well as mean distance to water with a village territory are all positively correlated with the percentage of land cover change. Growth in the number of households between 1994 and 2000 was a significant predictor of forest to rice land conversion, as was village density. As in the Ecuadorian Amazon, off-farm employment is increasing, particularly in villages that are close to Nang Rong town, the central market and service center of the district.

Discussion and Policy Relevance

This section has only been able to scratch the surface in describing the results of ambitious research projects involving teams of researchers from many disciplines, employing varied theoretical frameworks and methodologies. These projects have helped us to see that population-environment relations that in the past were viewed in the aggregate – using county-level population and deforestation data – are considerably more complex the closer one gets to where the machete meets the underbrush or the hoe meets the ground. Understanding incentives for production and reproduction at the household level sheds light on the policy levers that might be employed in an effort to improve household livelihood security while preserving as much forest land as possible. This does not mean, however, that the policy solutions are simple. And there is a risk that focusing on households may result in the neglect of other actors – such as illegal loggers, corporate soy farms, or oil prospecting – that have a far more devastating impact on tropical forests.

Much of the research on household-level determinants of deforestation is aimed at a deeper understanding of the processes driving deforestation, and by extension biodiversity loss. Based on research conducted from 1986-1999 in Machadinho D'Oueste, Brazilian Amazon, Sydenstricker-Neto (2005), suggests that cultural and institutional factors form an important overlay on household's land use decision-making. According to his research, institutions and networks in the Amazon privilege a conventional

production system based on cattle ranching and a single perennial crop such as coffee as the model for becoming a successful '*gaucho*' farmer. He writes:

> The links between entrepreneurship and conventional agriculture, and by extension the 'rancher,' suggests a particular view of a local development project. This project privileges expanding conventional agricultural rather than promoting diversified production systems and environmental management. The perception and social construction of a 'successful farmer' is informed by policies and incentives operating in the region and the outcomes could be different if mechanisms such as a credit for carbon sequestration or stronger incentives promoting agroforestry systems were in place.

Thus, important though household dynamics may be as proximate determinants of deforestation, researchers must not lose sight of cultural and contextual factors that influence household decision-making – everything from what 'success' means on the frontier, to international commodity prices, to land tenure, credit markets, etc. To be fair, most of the research included in this section addresses these issues to greater or lesser degrees.

Walker *et al.* note that there is a sense in which, once the frontier is opened, intergenerational aspects of family relations, especially demands for new land among the second and third generations and capital to open it, take over and operate autonomously. A policy implication is that "endogenous forces emanating from families are unleashed once a region is settled, and it may not be possible to turn the conservation clock as far back as one would like through top-down interventions, such as reduced expenditures on highway construction or improvement."

Research questions

- With the progressive closing of many frontier areas, of what relevance is this research on household lifecycles and land use change once the frontier 'closes'?
- What are the biophysical constraints to household decision-making with regards to land or resource use?
- To what degree to biophysical variables (e.g., soil quality, hilliness, water access, drought) affect household demographic decision-making (use of family planning, migration strategies), or the form of the household (either nuclear or extended)?
- Much of the research on household lifecycles and the environment has been in Latin America. Further investigations are warranted of how these dynamics differ in land-constrained Asia, or in Africa, where forest land in the Congo basin remains relatively abundant, yet political instability grips the region.
- How have the research results from these large and ambitious longitudinal research programs being put to use in policy formulation?

4. Conclusion

This has necessarily been a cursory examination of a large body of literature. As the reference section of this paper attests (which itself is incomplete), there has been an

exponential increase in the amount of research dedicated to household demographics and the environment since these studies began around 1990. There have been many theoretical and methodological advances during this time, and a growing understanding of the complexity and place-specificity of population-environment linkages. In this sense, it will not be possible to 'turn back the clock' and return to simpler mono-causal explanations for environmental change, focused as they were on abstract concepts of an aggregate population impacting on an aggregate environment.

The research also underscores one of the fundamental issues in population-environment research – which is that in studying the connections between humans and their environment, one is really studying *everything*. The question of where to draw the bounding box of what is endogenous to the system and what is exogenous becomes increasingly difficult. As Moran *et al.* (2005) write:

> The reality is that people are interacting with the physical environment in a myriad of ways – from the cognitive act of choosing where to settle, whom to migrate with, whether they pick flat or steep terrain, whether they give priority to proximity to a water supply or not, to soil color or not, whether they interact with natives or keep to themselves, whether they collect germplasm regularly from neighbors or import it from areas of origin, whether they have the knowledge and the means to practice contraception, and how the timing of contraception fits with views they may have of desirable family size and long-term goals for those children and themselves. This complexity of human-environment interactions requires multi-disciplinary research involving theoretical flexibility and a multiplicity of data collection tools that can capture the variety of sources of change and the variety of responses by the population.

The political economy perspective would draw the bounding boxes even more broadly to include local, national and even global scale political processes and power imbalances. This perspective is important, illuminating as it does the wrong assumptions underlying some population-environment research that households and their members are free to choose among a wide range of demographic responses and livelihood strategies, or that the environment is a bigger predictor of household livelihood strategies than the policies and institutions that govern household entitlements (Forsyth *et al*. 1998).

Nevertheless, there have been admirable advances in teasing out the linkages, and this has contributed to our collective understanding of how humans, bound together in economic units called households, alternately modify their environment and respond to environmental changes and resource constraints in some of the poorest and least developed corners of the world. This research can plan an important role in informing strategies for achieving the Millennium Development Goals, and for the work of the Poverty-Environment Partnership, a group of major donors seeking to reconcile poverty alleviation goals with environmental stewardship.[10]

---

[10] See www.povertyenvironment.net/pep.

References and Bibliography

Adger, N., P.M. Kelly, C. Locke, A. Winkels and L.Q. Huy. 2001. "Migration, Remittances, Livelihood Trajectories and Social Resilience in Coastal Vietnam," Background paper for a PERN cyberseminar on population dynamics in coastal regions, June 2001.

Aggarwal, R., S. Netanyahu, et al. 2001. Access to natural resources and the fertility decision of women : The case of South Africa. *Environment and Development Economics,* 6: 209-236.

Barbieri, A.F., R.E. Bilsborrow, and W.K. Pan. In Press. Farm household lifecycles and land use in the Ecuadorian Amazon. *Population and Environment* forthcoming.

Barbieri, A.F., and D.L. Carr. 2005. Gender-specific out-migration, deforestation and urbanization in the Ecuadorian Amazon. *Global and Planetary Change,* 47: 99-110.

Barrett, H. and A. Browne.1998. "Environmental and Social Change in Zambia: the Value of Children to Rural Households," *Global Environmental Change Programme Briefs*, Number 22, ESRC Global Environmental Change Programme, July 1998.

Biddlecom A.E., W. Axinn and J.S. Barber. 2005. "Environmental Effects on Family Size Preferences and Subsequent Reproductive Behavior in Nepal," *Population and Environment*, 26(3):583-621.

Biddlecom, A.E., W.G. Axinn, et al. 2000. *Environmental effects on reproductive preferences: A case study in Nepal*. Population Association of America, Los Angeles, CA.

Bilsborrow, R. and H.W.O. Okoth-Ogendo. 1992. Population-driven changes in land-use in developing countries. *Ambio*, 21(1): 37-45.

Cain, M. 1983. Fertility as an Adjustment to Risk. *Population and Development Review* 9(4): 688-702.

Castro, M.C.d., R.L. Monte-Mor, D.O. Sawyer, and B.H. Singer. 2006. Malaria risk on the Amazon frontier. *Proceedings of the National Academy of Sciences*, 103(7): 2452 - 2457.

Caldwell, J.C., and P. Caldwell. 1987. The cultural context of high fertility in sub-Saharan Africa. *Population and Development Review*, 13(3): 409-437.

Caldwell, J.C. 1982. *Theory of Fertility Decline*. London: Academic Press.

Carney, D. 1998. *Implementing the Sustainable Rural Livelihoods Approach*, London, UK: Overseas Development Institute. Available at: http://www.dfid.gov.uk/public/what/advisory/group6/-rld/dianakey.html

Carr, D.L., W. Pan, and R.E. Bilsborrow. Forthcoming. Declining fertility on the frontier: The Ecuadorian Amazon. Under review by *Population and Development Review*.

Carr, E. 2005. Placing the environment in migration: environment, economy, and power in Ghana's Central Region. *Environment and Planning A*, 2005, volume 37, pages 925-946.

Chayanov, A.V. 1966. *The Theory of Peasant Economy*. Homewood, IL: Richard D. Irwin.

Clay, D.C. and Reardon, T. 1998. "Population and sustainability: Understanding population, environment, and development linkages." Food Security II Cooperative Agreement, Michigan State University. Available at http://www.aec.msu.edu/agecon/fs2/rwanda/sust_pop.pdf

Clay, D.C. and N.E. Johnson. 1992. "Size of farm of size of family: Which comes first?" *Population Studies* 46: 491-505.

Coomes, O.T., F. Grimard, et al. 2001. *Peasant farm size and family size : a causality analysis from the Peruvian Amazon.* NEUDC Conference, Boston, MA.

Curran, S. 2002. Migration, Social Capital and the Environment: Considering Migrant Selectiveity and Networks in Relation to Coastal Ecosystems. In: W. Lutz, A. Prskawetz, and W. Sanderson eds., *Population and Development Review*, Supplement to Vol. 28.

Dalton, M.G., B.C. O'Neill, A. Fuernkranz-Prskawetz, L. Jiang, and J. Pitkin. 2005. *Population Aging and Future Carbon Emissions in the United States.* IIASA Interim Report IR-05-025, Laxenburg, Austria: International Institute for Applied Systems Analysis.

Dasgupta, P. 2000. Population and resources: An exploration of reproductive and environmental externalities. *Population and Development Review*, 26: 643-689.

Dasgupta, P. 1995. Population, Poverty and the Local Environment. *Scientific American*. (February 1995).

Davis, K. 1963. The theory of change and response in modern demographic history. *Population Index*, 29: 345-366.

De Santis, G.; Doveri, A.; Livi Bacci, M. 2000. An overview of the connections between land, fertility, and family in pre-industrial times. Fourth European Union Research Programme, 1998-2001. Available at http://www.ds.unifi.it/ricerca/interessi/demografia/poverty/papers/-desantis/desantis.htm (accessed March 2006).

de Sherbinin, A. 2000. "Population, Development and Human Security: A Micro-level Perspective," *Aviso: An Information Bulletin on Global Environmental Change and Human Security*, Issue No. 7, October 2000, available at http://www.gechs.org/Aviso/seven_lg.shtml#Anchor-Populatio-52746 (accessed January 2006).

DeVaney, A. and N. Sanchez. 1979. Land tenure structures and fertility in Mexico. *Review of Economics and Statistics*, 61: 67-72.

Drimie, S. 2002. "The Impact of HIV/AIDS on Rural Households and Land Issues in Southern and Eastern Africa." A Background Paper Prepared for the Food and Agricultural Organization, Sub-Regional Office for Southern and Eastern Africa, available at ftp://ftp.fao.org/docrep/nonfao/ad696e/ad696e00.pdf (accessed March 2006).

Dwasi, J. 2002. "Impacts of HIV/AIDS on natural resource management and conservation in Africa: case studies of Botswana, Kenya, Namibia, Tanzania and Zimbabwe." (cited in Drimie but no longer available on the internet).

Easterlin, R.A. and E.M. McCrimmins. 1985. *The Fertility Revolution: A Supply-Demand Analysis.* Chicago, IL: University of Chicago Press.

Easterlin, R.A. 1976. Population change and farm settlement in the Northern United States. *The Journal of Economic History*, 36: 45-75.

Entwisle, B. and P.C. Stern (eds). 2005. *Population, Land Use and the Environment*. Washington, DC: National Research Council.

Entwisle, B., S. Walsh, R. Rindfuss and A. Chamratrithirong. 1998. "Land-use/land-cover and population dynamics, Nang Rong, Thailand." In Liverman, D., Moran, E., Rindfuss, R. and Stern, P. (eds.). *People and pixels*. Washington, DC: National Academy Press.

Faris, R. 1999. Deforestation and land use on the evolving frontier: An empirical assessment, Harvard Institute for International Development.

Filmer, D., and L.H. Pritchett. 2002. Environmental degradation and the demand for children: searching for the vicious circle in Pakistan. *Environment and Development Economics*, 7 (2002): 123–146

Forsyth, T., M. Leach, and I. Scoones. 1998. *Poverty and Environment: Priorities for Research and Policy*. Sussex, UK: Institute for Development Studies.

Fox, J., R. Rindfuss, S. Walsh, and V. Mishra (eds). 2003. *People and the Environment: Approaches for Linking Household and Community Surveys to Remote Sensing and GIS*, Boston: Kluwer Academic Publishers.

Gammage, S., M. Benítez, M. Machado. 2001. "Population, Consumption and Environmental Degradation in a Mangrove Ecosystem in El Salvador" Background paper for a PERN cyberseminar on population dynamics in coastal regions, June 2001.

Godoy, R., M. Jacobson, J. DeCastro, V. Aliaga, J. Romero, and A. Davis. 1998a. The role of tenure security and private time preference in neotropical deforestation. *Land Economics* 74: 162-70.

Godoy, R., S. Groff., and K. O'Neill. 1998b. "The role of education in Neotropical deforestation: household evidence from Amerindians in Honduras." *Human Ecology* 26(4): 649-675.

Godoy, R., K. O'Neill, S. Groff, P. Kotishack, A. Cubas, J. Demmer, K. McSweeney, J. Overman, D. Wilkie, N. Brokaw, and M. Martinez. 1997a. Household determinants of deforestation by Amerindians in Honduras. *World Development,* 25(6): 977-987.

Godoy, R., D. Wilkie, and J. Franks. 1997b. The effects of markets on neotropical deforestation: a comparative study of four Ameriindian societies. *Current Anthropoloty* 38: 875-78.

Good, M.D., G.M. Farr, et al. 1989. Social status and fertility: A study of a town and three villages in Northwestern Iran. *Population Studies*, 34: 311-319.

Grandia, L. 2005. "Appreciating the complexity and dignity of people's lives: Integrating Population-Health-Environment Research in Petén, Guatemala." *Focus on Population, Environment and Security*, Issue 10, November 2005, Environmental Change and Security Project.

Gray, L.C., and W.G. Moseley. 2005. A geographical perspective on poverty-environment interactions. *The Geographical Journal*, Vol. 171, No. 1, March 2005, pp. 9–23.

Henry, S. 2005. *The choice of migration destination in Burkina Faso*. Paper presented at the XXV International Population Conference of the IUSSP, 18-23 July, Tours, France.

Hiday, V.A. 1978. Agricultural organization and fertility. *Social Biology.* 25: 69-79.

Hunter, L.M., W. Twine, and A. Johnson. 2005. Population Dynamics and the Environment: Examining the Natural Resource Context of the African HIV/AIDS Pandemic. Paper presented at the XXV International Population Conference, 18-23 July 2005, Tours, France.

Jones, D.W., V.H. Dale, J.J. Beaucamp, M.A. Pelowski, and R.V. O'Neill. 1995. Farming in Rondonia. *Resource and Energy Economics*. 17: 155-88.

Krings, T. 2002. A critical review of the Sahel Syndrome concept from the viewpoint of Political Ecology. *Geographische Zeitschrift*, 90(3-4): 129-141.

Liu, J., G.C. Daily, P.R. Ehrlich, and G.W. Luck. 2003. "Effects of household dynamics on resource consumption and biodiversity." *Nature*. 421, 30 January 2003.

Loker, W.M. 1998. The human ecology of cattle raising in the Peruvian Amazon: The view from the farm. *Human Organization*, 52: 14-31.

Lutz, W., L. MacKellar, and B. O'Neill. 2000. *Population and Climate Change*. Cambridge, UK: Cambridge University Press.

Lutz, W., and S. Scherbov. 1999. *Quantifying Vicious Circle Dynamics: The PEDA Model for Population, Environment, Development and Agriculture in African Countries*. IIASA Interim Report IR-99-049, Laxenburg, Austria: International Institute for Applied Systems Analysis.

McCracken, S., A. Siqueira, E. Moran, and E. Brondizio. 2002. "Land use patterns on an agricultural frontier in Brazil: insights and examples from a demographic perspective." In: *Deforestation and Land Use in the Amazon*. Eds. C. Wood and R. Porro. University Press of Florida. pp162-192.

McSweeney, K. 2004. Forest product sale as natural insurance: the effects of household characteristics and the nature of shock in eastern Honduras. *Society and Natural Resources* 17(1):39-56.

Merrick, T.W. 1978. Fertility and land availability in rural Brazil. *Demography*, 15: 321-326.

Mishra, V. 1995. *A Conceptual Framework for Population and Environment Research*, IIASA Working Paper, 95-20.

Moran, E.F., E.S. Brondizio, and L.K. VanWey. 2005. Population and Environment in Amazonia: Landscape and Household Dynamics. In: B. Entwisle and P.C. Stern (eds), *Population, Land Use and the Environment*. Washington, DC: National Research Council.

Moran, E.F., A. Siqueira, and E. Brondizio. 2003. Household demographic structure and its relationship to deforestation in the Amazon Basin. In: J. Fox, R. Rindfuss, S. Walsh, and V. Mishra (eds), *People and the Environment: Approaches for Linking Household and Community Surveys to Remote Sensing and GIS*, Boston: Kluwer Academic Publishers.

Naylor, R.L., K.M. Bonine, K.C. Ewel, and E. Waguk. 2001. "Migration, Markets, and Mangrove Resource Use on Kosrae, Federated States of Micronesia." Background paper for a PERN cyberseminar on population dynamics in coastal regions, June 2001.

O'Neill, B.C.; MacKellar, F. L.; Lutz, W. 2001. Population and climate Change. Cambridge, UK: Cambridge University Press.

Pan, W.K.Y., S.J. Walsh,, R.E. Bilsborrow, B.G. Frizzelle, C.M. Erlien, and F. Baquero. 2004. Farm-level models of spatial patterns of land use and land cover dynamics in the Ecuadorian Amazon. *Agriculture Ecosystems & Environment*, 101(2-3): 117-134.

Panayotou, T. 1994. "The Population, Environment, and Development Nexus." In R. Cassen, ed., *Population and Development: Old Debates, New Conclusions*. Washington, DC: Overseas Development Council: 148-180.

Perz, S.G. 2000. *Household demographic factors as life cycle determinants of land use in the Amazon*. Latin American Studies Association, Miami, FL.

Pichón, F. 1997. Colonist land allocation decisions, land use and deforestation in the Ecuadorian Amazon frontier. *Economic Development and Cultural Change*, 45 (3).

Poverty-Environment Partnership. 2005. *Investing in Environmental Wealth for Poverty Reduction*. UNDP, UNEP, IIED, IUCN and WRI. Available at http://www.povertyenvironment.net/pep/.

Rudel, T.R., and B. Horowitz. 1993. *Tropical deforestation: Small farmers and land clearing in the Ecuadorian Amazon*. New York: Columbia University Press.

Schutjer, W.A, C.S. Stokdes, et. Al. 1983. Farm size, land ownership, and fertility in rural Egypt. *Land Economics* 59: 393-403.

Sousan, J., N. Emmel, and C. Howorth. 1999. "Freshwater Ecosystems Management and Social Security." A Contribution to IUCN's Vision for Water and Nature in the 21st Century.

Stokes, C.S., and W.A. Schutjer. 1984. Access to land and fertility in developing countries. In: W.A. Schutjer and C.S. Stokes, *Rural Development and Human Fertility*, New York: McMillan.

Sutherland, E.G., D.L. Carr, and S.L. Curtis. 2004. Fertility and the environment in a natural resource dependent economy: Evidence from Petén, Guatemala. *Población y Salud en Mesoamérica,* 2(1): 1-14.

Sydenstricker-Neto, J. 2005. Mediating Factors and Deforestation in Brazilian Amazonia: A Mixed-Method Analysis. Paper presented at the XXV International Population Conference of the IUSSP, 18-23 July, Tours, France.

Sydenstricker-Neto, J., and S.A. Vosti. 1993. Household size, sex composition, and land use in tropical moist forests: Evidence from the Machadinho Colonization Project, Rondonia, Brazil. Unpublished Manuscript.

Takasaki, Y., B. L. Barham, and O. T. Coomes. 2004. Risk coping strategies in tropical forests: floods, illnesses, and resource extraction. *Environment and Development Economics* 9(2):203-224.

Tukahirwa, J.M.B. 2002. Policies, People and Land Use Change in Uganda: A Case Study in Ntungamo, Lake Mburo and Sango Bay Sites. Land Use Change Impacts and Dynamics (LUCID) Working Paper Series No. 17. Available at http://www.lucideastafrica.org/publications/Tukahirwa_Lucid_WP17.pdf

United Nations Population Fund and IUCN-The World Conservation Union. 1999. *Report of the International Workshop on Population-Poverty-Environment Linkages*. 23-25 September 1998, IUCN Headquarters, Gland, Switzerland.

van de Walle, E., and D. Meekers. 1992. The socio-cultural context of family and fertility in Sub-Saharan Africa," *African Development Review* 4(2): 33-62.

Vance C., and J. Geoghegan. 2002. Temporal and spatial modelling of tropical deforestation: a survival analysis linking satellite and household survey data. *Agricultural Economics* 27(3): 317-332.

VanLandingham, M. and C. Hirschman. 2001. Population pressure and fertility in pre-transition Thailand. *Population Studies,* 55: 233-248.

Vlassoff, M. and C. Vlassoff. 1980. Old age security and the utility of children in rural India. *Population Studies*, 34: 487-499.

Walker, R., S.G. Perz, M. Caldas, and L.G. Teixeira Silva. 2002. Land use and land cover change in forest frontiers: the role of household life cycles. *International Regional Science Review* 25(2): 169-199.

Walsh, S.J., R.R. Rindfuss, P. Prasartkul, B. Entwisle, and A. Chamratrithirong. 2005. Population change and landscape dynamics: The Nang Rong, Thailand, studies. In: B. Entwisle and P.C. Stern (eds), *Population, Land Use and the Environment*. Washington, DC: National Research Council.

Walsh, S.J., R.E. Bilsborrow, S.J. McGregor, B.G. Frizelle, J.P. Messina, W.K.T. Pan, K.A. Crews-Meyer, G.M. Taff, F. Baquero. 2003. Integration of longitudinal surveys, remote sensing time series, and spatial analyses: Approaches for linking people and place. In: J. Fox, R. Rindfuss, S. Walsh, and V. Mishra (eds), *People and the Environment: Approaches for Linking Household and Community Surveys to Remote Sensing and GIS*, Boston: Kluwer Academic Publishers.

Zaba, B., and N. Madulu. 1998. "A Drop to Drink? Population and Water Resources: Illustrations from Northern Tanzania," in A. de Sherbinin and V. Dompka (eds.), *Water and Population Dynamics: Case Studies and Policy Implications*. Washington, DC: AAAS, available at http://www.aaas.org/international/ehn/waterpop/zaba.htm.