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# malthus revisited:
## people, population and the village commons in colombia

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# EXECUTIVE SUMMARY

Traditionally, communities in the developing world have been labelled as the source of environmental problems as they extract and use goods and services from the environment, sometimes beyond the natural regeneration rates of eco-systems. Usually this is attributed to population densities growing at an unsustainable rate.

This paper argues against the common proposition that population growth alone is a threat to natural resources. It contends that technological and structural factors play a role in determining the net effect of population density on the conservation of key local environmental public goods (called village commons in this paper) such as soil, watershed regulation or natural vegetation, that affect the flow of ecological benefits to the community. Such an effect takes place through household decision-making about farming choices such as land and input use. The interaction between certain farming practices and social relations such as the distribution of land may create positive or negative net effects of population in the provision of environmental public goods or degradation from these village commons.

The paper illustrates these ideas with empirical and statistical evidence from Colombia, where a long term study using a combination of remote sensing and participatory research built up a detailed data set for 164 villages. Analysis of these findings showed that villages with more equal access to resources and the distribution of benefits have more sustainable farming systems and show a lower negative, perhaps even a positive relationship between population density and local natural resources. Case studies of individual villages demonstrate that despite high population densities, equality of access to resources can support good environmental- management. In terms of policy, there are several implications, depending on the level of inequality present in an area. Options range from wealth redistribution to supporting participatory and communal management of resources. However, in all situations, policy will be most effective if underlain by the assumption that communities can co-operate to sustain, rather than destroy, ecosystems when the conditions are right.

# MALTHUS REVISITED: PEOPLE, POPULATION AND THE VILLAGE COMMONS IN COLOMBIA[1]

Juan Camilo Cardenas

## Introduction: people and sustainable farming systems

The puzzle over the connection between natural resource degradation and population levels remains unsolved. The debate still rages over whether population growth is by itself a threat to the conservation of the planet's resources. Unfortunately, the discussion has not seen major changes in the last decades. In his most recent book, Daly (1996) states: "*It is frankly discouraging to see how little the population discussion has advanced during the last thirty years.*"

The relevance of the population-environment debate for sustainable agriculture is central. At the heart of a sustainable agriculture is the basic relationship between people and their farming systems and how this affects natural resources of importance to wider society (defined here as village 'commons'). This paper attempts to broaden the debate by adding a third factor to the equation. The hypothesis that I develop here is that the net effect of population density on a village's natural resources, at least for agrarian societies in Colombia, is determined by the degree of inequality in access to land within the village.

Based on an in-depth study of a large region in the Colombian Andes, I will show that as land inequality worsens, high population density has a detrimental effect on the village's natural resources. In other words, in villages where there is a more equal access to land, population density does not have such an impact on natural resources, and can, in some cases, have a positive impact. The main explanation for this finding lies in households' decisions to adopt farming systems that are more suitable for the institutional setting of the village, particularly labour and land. When labour is available at lower costs, for instance because of higher village population, farmers switch to more labour intensive practices which in many cases have less damaging effects on water, forest and soil resources because of lower use of chemicals and higher soil conserving activities.

1. An earlier version of this paper was presented at the Latin America Regional Meeting on Population and the Environment, American Association for the Advancement of Science (AAAS). Merida, Mexico – April 23-25, 1997.

# Introducing a third dimension to the population-environment debate

## The problem in two dimensions

The famous "*Essay on Population*" by Malthus at the end of the eighteenth century, and much later Hardin's (1968) widely discussed work "*The Tragedy of the Commons*" determined a great deal of what has become the Neo-Malthusian view of the population problem on the environment. However, rather simplistic answers to the problem have been derived from oversimplifications of these authors. Most of the propositions arising from the Neo-Malthusian argument suggest that the growth of population will inevitably bring over-exploitation of natural resources. In other words a two dimensional (negative) relationship is suggested between these two variables. Furthermore, these oversimplifications have yielded policy recommendations that have affected many developing nations and their internal cultural and economic systems. For instance, the elimination of communal property regimes to manage natural resources such as forests, fisheries or water and the reduction of options to individual (private) holdings have eradicated the possibilities to internalise collectively the externalities derived from the use of natural resources (Ostrom, 1990; Berkes, 1989). Likewise, public programs have devoted and, in several cases, wasted scarce resources in birth control programs that clash with local values and social processes.

However, there are signs that the two dimensional Neo-Malthusian perspective is being questioned. For example, the Rome Declaration on World Food Security signed at the recent FAO World Food Summit in 1996 does not mention in any of its eleven items that population growth is a barrier to the goal of increasing food security worldwide, despite the present severity of the malnutrition, hunger and food distribution problems. Furthermore, The subsequent Plan of Action stated in its fifth item that "*the 5.8 billion people in the world today have, on average, 15 per cent more food per person than the global population of 4 billion people had 20 years ago*".[2] (FAO, 1996).

## Inequality and community co-operation: revisiting Malthus

Malthus himself provides some keys for expanding the analysis of such a simplistic relationship in his reference to the distributional problem:

> "*It is unquestionably true, that in no country in the globe have the government, the distribution of property, and the habits of people, been such as to call forth, in the most effective manner, the resources of the soil. Consequently, if the most advantageous possible changes in all these respects could be supposed at once to take place, it is certain that the demand for labour, and the encouragement to production, might be such as for the short time, in some countries, and for rather a*

2. However, this average does not reflect the actual distribution of the benefits of such an increase in food production efficiency if one looks at the basic indicators on nutrition, e.g., calories and protein intakes by different groups or regions in the world.

> *longer time in others, to lessen the operation of the checks to population which have been described*." (Malthus (1830), my emphasis)

Thus Malthus implied that institutional factors such as inequality, social norms and governance structures may delay or hasten the appearance of what he called the positive and preventive checks on population as a result of the difference between the rates of population growth and land productivity. Later on he argues:

> "*An unfavourable distribution of produce, by prematurely diminishing the demand for labour, might retard the increase of food at an early period, in the same manner as if cultivation and population had been further advanced*;" Malthus (1830)

Whether the appearance of those checks was in fact taking place then or today, the suggestion that distribution of wealth between the poor and the rich may determine the speed and severity of those checks seems to arise as an important factor. Despite these statements, there is scarce reference to such items later by those using Malthus' ideas to support the population evil hypothesis in the so-called Neo-Malthusian literature. Malthus himself was apparently more interested in tackling the demographic problem from the ethical and cultural points of view while leaving the distributional issue as an exogenous or given issue.

## A new hypothesis about population and environment

To develop the argument of a more complex interaction of factors in the population-environment relationship, I suggest a new hypothesis composed of four interlinked arguments (Table 1).

Let us develop this hypothesis in more detail by explaining how social systems and technology interact to determine the population-environment relationship. Some of the factors are endogenous to rural households, such as the type of farming practices (e.g., inputs use, crop selection and rotation), whilst others are more village-wide and exogenous, such as rights over resources, land distribution, or access to credit, land or labour.

Table 2 shows the four different outcomes and the evolution of scenarios according to the conditions and options that households face when deciding to conserve or exploit their natural resources. The matrix should be thought of in three dimensions. The *vertical axis* lists the different social characteristics of a village. I have grouped these into two major categories, 'sustainable and 'unsustainable', according to the conditions conventionally recognised in the literature. Clear property rights and the internalisation of externalities are often recognised as necessary for a rational use of resources from an economic view. Others less frequently mentioned or less unanimous include the existence of social values that enhance co-operative behaviour or the degree of inequality in wealth.

**Table 1. Four elements of a hypothesis on the population-environment relationship**

| |
|---|
| 1. There is no clear relationship between population levels and the environment. The relationship between population density and the degradation of the environment is defined by technological and social factors which govern the relations among households, and between them and the environment. |
| 2. Farming practices and land use patterns largely determine the positive or negative impact that people have on their ecosystems, and such technological choices are directly determined by the social institutions that constrain the household's decisions about inputs use and production processes. |
| 3. Inequality in access to basic resources and technology, e.g., land distribution in agrarian regions, affect the relationship between population and environmental degradation as it impedes or allows communities to balance their immediate needs for energy, food and fibre with their longer term objectives to maintain the productive capacity of land for the community and next generations. |
| 4. Therefore, social institutions and technology create the conditions for communities to either manage or over-exploit their natural resources. |

The *horizontal axis* lists the types of technological systems, with an emphasis on farming practices. Again the variety of options that the household faces regarding input use, production processes and by-products or side effects may be roughly grouped into 'sustainable' and 'unsustainable' practices.

As a result of the different combination of these social and technological conditions, the inner matrix shows four possible scenarios (A,B,C,D). The *third dimension* of the matrix would rise from the matrix as the net outcome on the use of natural resources and ecosystems for each of the combinations. As an additional hypothesis, two of the scenarios may be stable (A and D) while two are unstable (B and C).[3] The stability of the former is based on the argument that changes in inputs use (chemicals, labour) can be – at least in the short run – more plausible than changes in structures such as land distribution. Therefore, horizontal shifts in the matrix should be more likely than vertical ones.

3. The reason for suggesting the shifts from unstable to stable scenarios horizontally and not vertically is based on the fact that farming systems choices, e.g., hire more labour or purchase more pesticides, can be made more rapidly than social structure changes

**Table 2: Four scenarios in the interaction between technological and social systems**

| | | TECHNOLOGICAL SYSTEMS *(inputs, outputs, practices, land use)* | |
|---|---|---|---|
| | | • Unsustainable<br>• High use of pesticides and chemical fertilisers<br>• Residual effects on soils and water<br>• Monoculture practices in crops and pastures<br>• Elimination of natural life in soils and vegetation<br>• Extensive (grazing) livestock systems<br>• Soil compaction and natural pastures exhaustion | *Sustainable*<br>• Biological control and IPM practices<br>• Low impact on soils, water streams and deposits<br>• Organic by-products recycled<br>• Crops and land rotation<br>• Rotation of crops and managed pastures<br>• Multipurpose livestock systems |
| SOCIAL SYSTEMS | *Unsustainable*<br>• Unclear definition of property rights<br>• Unequal distribution of land and landlessness<br>• Restricted access to rural credit<br>• Free riding yields high individual benefits | *Scenario A: (Stable)*<br>• Tragedy of the Open Access Resources" scenario<br>• Property rights undefined or unclear<br>• Free riding on public (open access) lands to over extract forest products and services.<br>• Low use of local labour inducing migration | *Scenario B: (Unstable)*<br>• Sustainable farming systems cannot persist since restricted access to land and other resources induce shifts to technologies that yield short run returns for subsistence<br><br>May evolve to scenario A<br>? |
| | *Sustainable:*<br>• Access to land and credit<br>• Co-operation and community participation is socially valued and recognised<br>Free riding is socially punished | *Scenario C (Unstable)*<br>• Higher (cheaper) supply of community labour induce substitution of external (chemical) inputs for labour and other local resources.<br>• Social valuation of co-operation and access to resources may induce a shift to technologies that encourage conservation and higher provision of environmental goods and services.<br>May evolve to scenario D ? | *Scenario D: (Stable)*<br>• Collective action for conservation is achieved.<br>• Common Property Regimes evolve and succeed Co-operation among and within villages<br>• Social and biological diversities empowered<br>• Higher use of community labour<br>• People's co-operation for conservation offsets pressures over environment from people's needs for food, fibre and energy |

## Empirical evidence from the Chicamocha (Northern Boyaca) watershed, Colombia

Colombia presents several interesting features for an analysis of the relationship between population, farming systems and the environment in rural areas. This is especially true of the Andean region, where after more than 25 centuries of human occupation, rural production systems which range from very traditional subsistence farming practices in the hillsides to state of the art modernised agriculture in the inter-Andean valleys today coexist. Of even more interest, densely populated communities have been supported along the Andes for centuries, particularly in the Pre-Columbian periods. By the time the Spaniards arrived in the middle of the fifteenth century, there was already a well established settlement of the Muisca group whose first permanent settlements date back to 1500 years B.C.

The distribution of land and property rights regimes have evolved towards higher concentration of land in the hands of large landlords, the disappearance of community-managed resources, generalisation of individual property as well as weakly enforced state property rights over ecologically rich areas. With respect to agrarian structures, today Colombia's land distribution pattern is one of the most unequal in Latin America. The process is aggravated by including the recent disturbing phenomenon of the concentration of more than three million hectares of highly productive land in the hands of drug traffickers.

Within regions, however, there is great variability in ecological and socio-economic factors which are useful for illustrating the arguments presented here. Along one of the corridors of the Andes lies the Chicamocha major watershed in the eastern Colombian Andes, ranging from 800 to 5,000 metres above sea level. A group of 17 municipalities is spread along this watershed which is incredibly diverse with respect to resources, climates and geography.

A five-year participatory and interdisciplinary research project in this region conducted by the *Instituto de Estudios Ambientales para el Desarrollo* (IDEADE) at the Universidad Javeriana yielded a detailed spatial data base built from a combination of research techniques such as remote sensing and GIS, field work and community workshops (See Box 1 and IDEADE, 1995).

One of the most important initial tasks in the study was to characterise the different factors associated with each farming system: on the one hand the prevailing social conditions for each system such as land access and tenure forms or labour use, and on the other, the specific practices regarding input use, processes and output (side) effects (Box 1).

About 40 different farming systems were identified in the region according to the following criteria: elevation, crops and area used, livestock and area used, farm sizes range, land tenure, destination of harvest (markets, self consumption, exchange), tech-nology used (inputs), parallel economic activities for complementary income (e.g. labour market, tourism), ownership of land elsewhere, landscape unit.

**Box 1. Exploring farming systems in the Chicamocha middle basin**

The Chicamocha middle basin region where the project collected the data is formed by 17 municipalities. The unit of analysis is the vereda or village. A municipality is composed of about 10 veredas on average. Each vereda can be considered as an homogeneous area in social, cultural, economic, and ecological terms, yet the household level presents high variability in the adoption of farming practices. Most of the villages are located within the same micro-water-shed, since historically vereda boundaries were defined either by streams or mountain peaks. The entire data set region is formed by 164 villages.

The research project created a spatial database using a combination of remote sensing (aerial photographs and satellite images), field work using participatory research and rapid rural appraisal; and secondary sources. I was involved in the project during its first years in both the collection of economic field data using participatory research techniques and undertaking community workshops for discussing environmental issues. Meanwhile, the ecological team gathered field data from plant collections, soil samples and the processing of aerial photography and satellite imagery. The participatory nature of the process meant that it took more than three years (approximately between 1990 and 1993) to yield diagnostic results collectively agreed with the communities. The project evolved into a second major stage financed mainly by the European Commission (EC) for setting up pilot projects of conservation and natural resources management in the most critical areas identified by the study, or where the level of community organisation and local leaders and authorities were interested enough to embrace such actions.

## The population-environment relation in three dimensions: statistical evidence

One major finding from the field work in this region was the variability across villages between population density, levels of land productivity and ecological degradation. No common pattern between population density and the other two conditions emerged. This region presents, for instance, highly populated villages with both high and low levels of productivity and more interestingly, with both high and low levels of environmental degradation. However, if the hypothesis put forward above is correct, the variability in social conditions may explain such differences. Thus we set out to explore this.

Using the spatial database constructed from the remote sensing and field work, several village-level variables were selected to relate environmental health to population and inequality:

- Environmental quality
- Population density
- GINI coefficient

Each of these are described in more detail.

1. *Environmental quality*. To measure environmental quality, we focused on three main factors: vegetation loss, soil erosion and water variability and availability. For each village we assigned positive points (0.5, 1) to the presence and degree of valuable areas and negative points (-0.5, -1) when degradation was an issue. There-fore, a village's area is divided into positively and/or negatively valued pieces. The sum of areas weighted by the values and divided by the entire area results in an Index of Environmental Goods and Services (BSAINDX). The index thus ranges from -1 (worst negative externalities) to +1 (maximum environmental benefits), and was calculated for 164 villages in the region.

The next step was to overlay two maps for each village:

- a map of the village boundaries, which usually followed the watershed; and
- a map of 'critical and valuable areas' which identifies the areas suffering from severe environmental degradation, as well as the most valuable areas because of their level of conservation (Etter, 1990; Zonneveld, 1979). The approach is based on the ecosystem and therefore integrates vegetation, soils and water resources.

2. *Population density*. Using GIS we could estimate the average number of households per hectare in the village.

3. *Land inequality*. The GINI coefficient was calculated using GIS techniques to estimate the area of land for each household in the village, and then to calculate the GINI index. A gini of zero implies that everyone owns exactly the same, and a gini of one means that one single person owns all the wealth and the rest of the group nothing.

For both the population density and the GINI coefficients, we adjusted the estimated area by giving higher weights to farms that were flatter, better irrigated and closer to main or secondary roads.

Figures 1 and 2 illustrate the main findings. The vertical axis shows the environmental goods and services index (BSAINDX) from -1 to +1 depending respectively on the net negative or positive level of environmental quality of the village commons. The horizontal axes show the level of population density (POPDENS) in number of households per hectare, and the level of inequality (GINIADJ) measure between 0 and 1 (again, higher values imply higher levels of inequality). Figure 1 shows the plotting of the actual observation values for the sample in the study with a smoothed surface generated across the points (villages). Figure 2 shows a surface generated with the estimated coefficients from an econometric regression for the 164 villages with sufficient statistical robustness. The reason for showing the two surfaces is to illustrate that a smoothing of a surface among the actual data points, where each point has the 3 coordinates BSAINDX, GINI and POPDENS, shows the same relationships created by a surface generated from the estimated regression coefficients.

Both graphs show basically the same finding, that as inequality worsens (i.e. as the GINI coefficient increases), the marginal effect of population (slope of the surface looking at the POP–BSAINDX axes) changes with the level of inequality. For instance, the lower levels of the surface (i.e., worst environmental scenarios) are located where a bad combination of

high population density and high levels of inequality create conditions which encourage the unsustainable use of natural resources. However, as the level of distribution of land improves, the effect of population on BSAINDX becomes less negative and eventually reaches a positive slope.

This statistical evidence confirms the basic foundation of the argument, namely, that *the marginal effect of population density on the environment depends on the level of inequality*. Moreover, the regression results confirm that if a negative effect of population density on the environment exists, the size of such effect worsens as inequality increases.

**Figure 1: Surface generated from the actual points (quadratic smoothing method)**

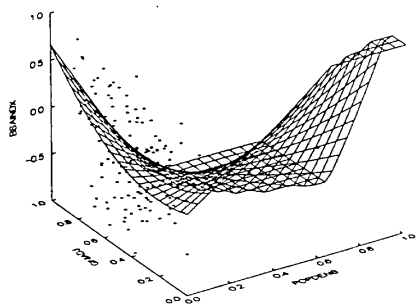
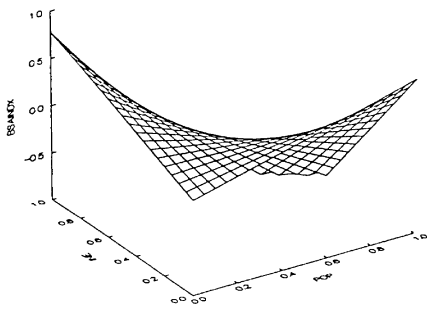


**Figure 2: Surface generated with the estimated coefficients from the regression**



## A case study of contrasting farming systems

To illustrate the argument in more detail, we have chosen two farming systems which represent the extremes of technological sustainability despite having the same type of ecological constraints and elevation. Table 3 summarises the main characteristics of these two farming systems.

Labelling these two farming systems according to the stable scenarios A and D in Table 2, we can continue the line of argument introduced above. First there is the 'unsustainable' Scenario A, where free-riding dominates, given the incentives and conditions that house holds face regarding technology choices and social conditions. This production system predominates in the highlands, where open access to, and poor enforcement of, state national parks is prevalent. The vicious cycle decreases both the stock of natural capital and the satisfaction of households' needs from decreasing productivity of land over time, inducing the scattering of new marginal lands within fragile ecosystems, confirming Hardin's tragedy.

The lands where these types of farming systems prevail showed higher occurrence of soil erosion, less presence of native plant species within and around the farming systems, lower availability of water, and higher variability in the hydrological cycle over time.

**Table 3. A comparison of two Andean farming systems**

| **Factors** | **Scenario *A - Extensive livestock grazing and small potato monoculture (3,000-3,600m elevation)*** | ***Scenario D - Intensive dairy livestock and crop rotation of potato, wheat, maize, beans and barley* (3, 000-3, 600m *elevation)*** |
|---|---|---|
| Description of the farming system (land use) | Crops monoculture (potatoes and beans) (5% area) Semi-extensive overgrazing livestock (95% area) | Intensive dairy livestock (cattle and sheep) (10-30% area)<br>Crop rotation of potatoes, wheat, maize, beans, barley (70-90% of area) |
| Land tenure forms | Land operated by owner or given in rent and other arrangements to others. | Owner operates 100% of land, sometimes in partnership with neighbours |
| Inputs use and production practices | Farm size: 10-50 ha.<br>High dependence on external inputs<br>More capital intensive<br>Low use of labour<br>No diversification of activities and scarce resting (fallow) periods for land<br>No use of organic residuals | Farm size: 1-10 ha.<br>Low dependence on chemical fertilisers and pesticides<br>Labour intensive<br>Rotation of crops and resting (fallow) periods<br>Recycling of organic matter<br>Biological pest control |
| Side effects on environment | Soil compaction and erosion<br>Loss of natural diversity in soils and natural grazes | Low contribution to soil and water erosion and contamination by chemicals. |

Scenario D represents a more sustainable situation. Here we have a multi-crop farming system, where the use of external inputs (e.g. chemical fertiliser or pesticides) is low, while the use of local labour, particularly household members, is higher. Better definition of property rights is accompanied by more equal distribution of land and stronger community relations at the village level. These in turn provide better incentives for the sustainable management of local public goods such as water sources, forests or soil. The higher supply and demand for labour prove more attractive for supporting integrated (biological) pest management, soil erosion control, and crop div-ersity conservation than the external chemical inputs option. Thus natural capital can be maintained while levels of income, nutrition and productivity can sustain even more densely populated villages.

# Conclusions for policy and research

## Thinking in more than two dimensions

I have argued that the net effect of population on the environment is far from being simple and monotonic. Instead, these effects are the result of different institutional and technological factors affecting the relationship between people and their ecosystems. One example is the interaction between land distribution and the choice of farming systems. I assume that households choose their farming practices or land uses endogenously within an institutional environment constrained by input availability, prices, or government policies,

and that such decisions ultimately determine the level of conservation or degradation of the village commons. Therefore, the exogenous structures (e.g. land distribution) determine the

final environmental quality outcome through endogenous decisions[4]. Thus, we ultimately may find that inequality (which in general is exogenous in the short run from the community standpoint) would determine the impact that people and population have over their natural environments. Therefore, social systems at the village level that promote a more equal access to land and other resources may find conditions for overcoming the 'tragedy of the open access resources' and create community structures to manage their natural resources co-operatively. But by the same logic, if the social structures governing the community create unequal conditions within highly populated areas, an important proportion of the households will put greater pressure on forests, soil or water resources.

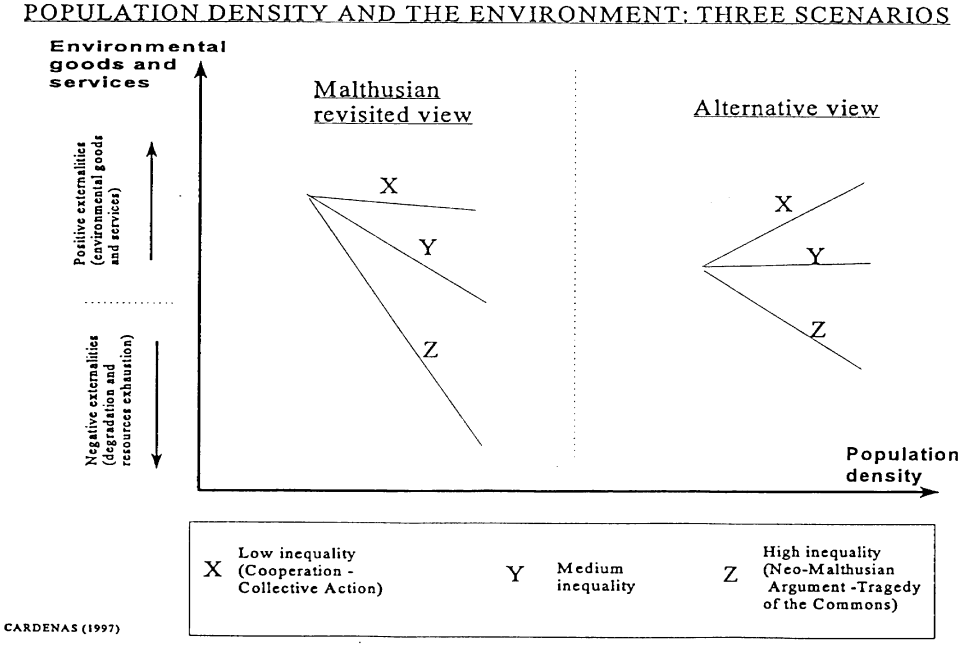
Figure 3 replicates the statistical results above, and summarises these ideas by illustrating two ways of enriching the population-environment debate. In both cases, social institutions and, in particular, inequality introduce a third dimension to the problem. Three scenarios are considered in each diagram, X,Y, Z which reflect low to high levels of inequality. For each of these a different level of impact of population on the environment is presented. The more conservative view in the diagram on the left hand side revives Malthus' concern of the distributional factor which may accelerate or attenuate the appearance of the checks that arise when increasing populations put pressure on scarce natural resources. Or conversely, a fairer distribution of wealth may postpone the occurrence of the population checks on the environment.

The alternative view suggests that under certain conditions of wealth distribution and technology, the net effect of population on the environment can become positive. This has been shown by some empirical research and case studies, such as the Machakos District experience over the last six decades in Kenya (Tiffen, et al., 1994). There was also evidence for this situation found in the Colom-bia study (Box 2).

In this case, the cross-sectional nature of the study, being a snapshot in time, cannot be used to argue that such processes occurred over time for each of the villages. This type of data does not allow for testing causality or the direction of the effects between the variables. However, the results do show that for some of the villages, and after controlling for other variables involved, the Neo-Malthusian predictions may not apply when fair access to land and the adoption of more sustainable farming systems have created a more balanced relationship with the village commons despite high population densities. Such results are closely related to the debate surrounding the 'Boserup hypothesis' (Heath and Binswanger, 1995), named after Esther Boserup's (1965) work on how agrarian societies, when facing resources constraints, adapt themselves to use their available resources more wisely.

4. In the full econometric analysis, I created a system of equations where BSAINDX is a function of the land use patterns and farming practices; the land use and farming practice decisions are in turn functions of institutional variables such as population density, inequality, tenure and others. The results (Cardenas, 1995), show robust and logical explanations for the findings described here, which in fact represent only part of the calculation, ie where BSAINDX is a function ultimately of the population density and the land inequality.

**Figure 3: Two ways of introducing a third dimension in the population-environment relation**




**Box 2. The CHIPA ALTO village**

One of the cases where population is not a constraint for preserving the village commons is CHIPA ALTO, located in the municipality of Chita. This village has more than 150 households and a population density of 0.28 households per hectare. This population density, when adjusted for land quality (slope, water access and road access) increases to 0.61 households per ha (i.e. about 1.6 hectares per household). This makes it the sixth most densely populated village in the region (the highest three being 1.59, 1.05 and 0.91 households per hectare). The distribution of land, on the other hand, shows a gini coefficient of 0.5835, amongst the lowest in the region.

About 31% of the land use is in crops, 22% in natural coverage and the remaining fraction in managed pastures. Compared to neighbouring villages, this village has maintained the traditional farming practices and social relations common amongst the indigenous communities that once occupied the municipality of Chita. Farming is labour-intensive, focusing on key soil preserving activities such as crop rotation, manual weeding, and recycling of biomass in soils. All this occurs despite a reduced availability of land and a high demand for food. The use of chemicals is lower than average, among other reasons due to the restricted access to credit, technical assistance programs and cultural resistance by its members. The livestock activities in this village make a more controlled use of pastures and grazing given the constraints in land. The estimated index of environmental goods and services for this village was of 0.01 which is in the lower third of the village indices.

This village exemplifies the arguments in this paper. Despite a high demand for food and other resources from the ecosystems due to high population density, the fair distribution of land, stronger social ties and availability of labour create conditions under which households find it more efficient to use sustainable farming systems.

## Policy implications

From a public policy viewpoint, there are several implications for both the long and short term.

If regulation and enforcement resources are scarce, there are a number of strategies that government can take depending on the situation. Where higher inequality prevails, closer controls on free-riders in the short run, and a long-term strategy of wealth redistribution should create better conditions for community co-operation and therefore lower the social costs of achieving sustainable management of the village commons. Where communities show better levels of equality, support to participatory and communal management of resources is essential to generate a self-governed system of control within communities, rather than policies based on external regulation or incentives based on individual values that may destroy social cohesion.

In addition, in countries with low policy enforcement, solutions based on the assumption that communities may co-operate rather than destroy ecosystems may prove more feasible than policies based on excluding these communities from using valuable natural resource at all. This is in line with growing calls by local governments and NGOs worldwide for a strong community participation for sustainable development.

However, it is often not clear what 'participation' means. Here it is taken to mean involving members of the community in the efficient provision of environmental public goods in co-operation with local and regional authorities. Thus recent trends toward decentralisation or devolution of power and responsibilities to lower levels including local governments and non-government institutions may present promising possibilities as compared to the traditional approach from the 1970s where impotent national governments in developing countries failed to enforce conservation policies based on prohibiting human access to national parks and other conservation areas (Lutz and Caldecott, 1996). However, the level of inequality in the villages might be the factor determining the success or failure of such approaches.

Yet there are some questions which need deeper exploration if public policy is to be further refined :

- *What conditions support co-operative behaviour*? Which social structures enhance or discourage co-operative behaviour within communities and how does the level of population density in the community affect such co-operative behaviour? How could public policy affect such conditions rather than aiming at demographic control alone?
- *Can high population lead to a positive impact on the environment*? We must explore in more detail and with other data the hypothesis that the net effect of population on the environment may decrease or even change signs as the social structure, particularly distribution, evolves toward a more equitable community.
- *Under what conditions will the negative impacts of population growth be offset by communities developing co-operative arrangements to correct the failures of individualistic behaviour*? Under co-operative and collective action, communities may

take action to reduce their pressure on an ecosystems' carrying capacity, sometimes without a strong policy on population control.

Continuing and broadening the research on population and the environment along these lines will help to answer these important questions.

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