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Lessons from the Mauritius Case study in the Global Context

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Working Paper

Lessons from the Mauritius Case Study in the Global Context

Wolfgang Lutz

WP-93-15
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ABSTRACT

This Working Paper constitutes the epilogue of the book manuscript, *Understanding Population-Development-Environment Interactions: A Case Study on Mauritius*. It is an attempt to summarize the findings from the Mauritius case study and put them into the context of the global population-environment debate. The Mauritius case study was carried out by IIASA in scientific collaboration with the University of Mauritius and funded by the United Nations Population Fund (UNFPA).

The paper presents findings from the multidisciplinary historical description of population, economy and environment in Mauritius and from the interdisciplinary computer model simulating future population-development-environment interactions.

The material is structured around five broad questions that figure prominently in the population-environment debate and to which the Mauritius case study can make a contribution.

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LESSONS FROM THE MAURITIUS CASE STUDY IN THE GLOBAL CONTEXT ¹

Wolfgang Lutz

This last chapter of the book is an attempt to synthesize the information provided in Sections II ("Understanding through History") and III ("Understanding through Modeling") and to relate it to the present global population-environment debate. For doing so, five relevant questions have been singled out that on the one hand capture some of the main arguments stressed in the debate, and on the other belong to areas where our empirical work on Mauritius can make real contributions. These two criteria exclude questions of a purely conceptual nature, and questions to which the answer is already known beforehand.

Part of the problem in the population-environment debate is that in many cases, the models chosen already predetermine the answer. If certain variables are not included in the model (be it conceptual or on computer) the results can never attribute those variables any significance. Similarly, the structure of the model and the way in which variables are being linked may exclude some relevant mechanisms. As discussed in Chapter 1 of this book, the Ehrlich identity in its simple multiplicative form assuming independence between population size, affluence and technology does not cover the case in which population growth has a positive effect on technology (the Boserup/Simon argument) or the cases in which population growth diminishes affluence (the Malthusian argument) or increasing affluence brings down population growth (the usual development argument).

It is never possible to design a model that is entirely free from personal views or views dominant in scientific disciplines as well as society. Certain basic approaches to analysis always predetermine our questions, our data categories, and the structure of our models. The only thing we can do is to take advantage of the multitude of differing scientific views expressed within disciplines and across disciplines, and try to develop approaches that do not already predetermine apparently controversial issues.

The major challenge for the above described PDE model for Mauritius was to define such an interdisciplinary and intersubjective model that can be accepted in its basic structure by the bulk of serious participants in the population-development-environment debate and is quantitatively operational, i.e. consists of more than general words. The approach chosen was to have two parts of the model, the "hard-wired model" which only includes unambiguous relationships on which scientific consensus can be expected, and the "soft model" which can quantify all kinds of feedbacks and interactions that the user wants to define. This way differences in assumptions and results can be nailed down and evaluated in a specific and clear form.

¹Epilogue from the forthcoming book, *Understanding Population-Development-Environment Interactions: A Case Study on Mauritius*, edited by Wolfgang Lutz.

The emphasis of this book is on the process of better understanding the complex mechanisms that link population, development and environmental variables. This understanding has been approached both through the analytical description of man-environment interactions in the history of Mauritius as well as through quantitative modeling. When discussing the following five questions, reference will be made to both approaches as well as to international statistical data.

1. HOW DID POPULATION DENSITY AFFECT THE ENVIRONMENT AND HUMAN LIFE OVER THE LAST CENTURIES?

The popular argument to this question is that with limited agricultural space and limited natural resources, increasing population density will result in increasing stress on food supplies and damage to the environment. The food argument goes essentially back to Malthus, whereas the explicit environmental concerns are of a much more recent date. Here the most frequently stated argument is that higher density forces people to utilize marginal lands resulting in deforestation, species extinction, soil erosion, even desertification and ultimately war or starvation. Support for this density stress argument comes from animal ecology, where the basic concept of a limited carrying capacity is self-evident.

This density argument, however, is challenged by scholars mostly from the field of economics. Boserup (1981) and Simon (1982) even say that under certain conditions increasing density is conducive to technological advance because societies are pressed for innovations. A somewhat different argument is that of economies of scale, which points to the benefits of higher density because of a larger market, better infrastructure and greater division of labor.

The history of a small, densely populated and very remote island seems to be an ideal setting for checking the empirical validity of those arguments.

1.1. Population Density and Deforestation

When the first Dutch merchant ships came to Mauritius in 1638 the uninhabited island was almost completely covered with lush tropical forests in which a large variety of unique species lived. By the end of the 17th century 200 Dutch and some hundred slaves had managed to strip the island of most of its valuable ebony trees. The composition of the forests already changed during that time.

As can be seen in Figure 1 a sizeable deforestation only started during the French rule in the late 18th century. The French, aiming at permanent settlement of the island, were interested in food self-sufficiency and also started to expand sugar cane production. Hence there were three different sources of deforestation: land required for food production, land required for sugar cane and wood required for construction and cooking including the refining of sugar. Population density increased only very slowly during that period.

The most significant deforestation in Mauritian history happened during the 1840s. Within a decade almost two-thirds of the remaining forest disappeared. This event

coincided with the abolition of slavery in 1833 and the immigration of large numbers of indentured laborers from India, but the peak of Indian immigration was more than a decade after this massive deforestation. Because of this timing, deforestation can hardly be explained by the subsistence needs of the immigrants. However, the first arriving Indians were probably instrumental as laborers in clearing the woods. Around this time also the first modern sugar factory was built requiring more firewood.

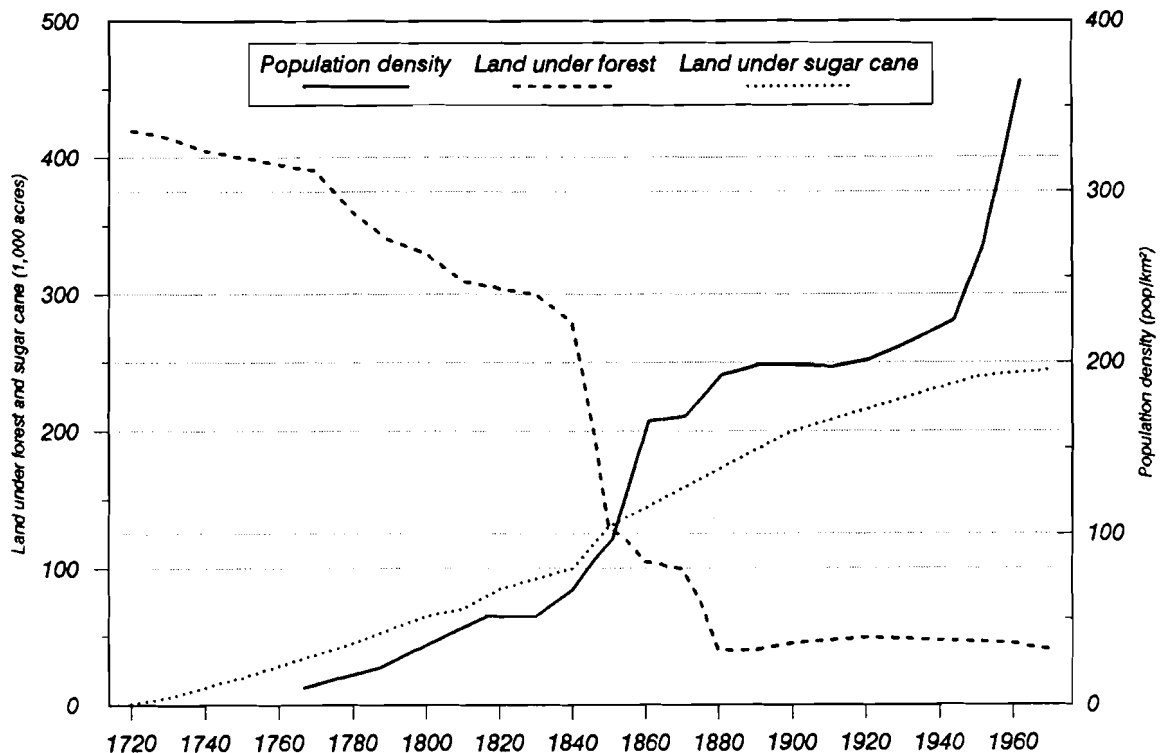


Figure 1. Population density, forest cover and sugar cane in Mauritius since 1720.

By the end of the 19th century almost all of the accessible land had been deforested. Only in some mountainous regions about 3% of the original forest survived. Government efforts of reforestation and the protection of some "crown lands" slightly increased the wood coverage again, which did not change much thereafter. The population explosion since the 1960s has not significantly affected the land area covered by forests. However, recent surveys on energy use indicate that the remaining woods have been partly damaged by uncontrolled use of firewood.

1.2. Population Growth and Loss of Species

No systematic survey of species on Mauritius is available today, not to mention the previous centuries. But there are indications from early descriptions of visitors to the island that the original flora and fauna were plentiful, and a sizeable number of birds and reptiles that existed nowhere outside Mauritius could be found. The most famous of those animals is without doubt the flightless dodo bird that even became an international symbol of species extinction long before the present debate on biodiversity. The dodo

already disappeared during the 17th century most likely through the use of its eggs rather than direct hunting (contemporary reports speak about the bad taste of its meat).

Aside from the extinction of many unique species that was largely the consequence of the destruction of their habitat, the original forest, many other species retreated from Mauritius (most notably the giant turtle) while other plants and animals were brought to the island deliberately (e.g. sugar cane, vegetables, spices and domestic animals) or unintentionally (such as rats). At the moment Mauritius officially lists one mammal species and three bird species as being threatened. In international comparisons considering land area this gives a very high value per 10,000 km² which is a consequence of its remote island status. Concerning the microfauna in the soils there are indications that the original balance still exists in some remote mountain areas but is being threatened by the intrusion of other species.

Since most of the lost species on Mauritius presumably disappeared during the early history of human settlement on the island when population density was still very low, it is difficult to draw direct causal connections between the two variables based on the Mauritian evidence.

1.3. Population Density and Food Supply

For the Dutch settlers in the 17th century that were interested in short term exploitation rather than sustainable agriculture, food supply was a permanent problem. The French, who considered Mauritius strategically important and wanted to sustain their presence for a long period, consequently emphasized the expansion of food production to make the island self-sufficient and robust against crises. The British thereafter opted for cash crops at the expense of food production. Food was partly imported from other British colonies. This, together with the fact that the population had doubled through Indian immigration, made the food supply more vulnerable to external events.

One such event was World War II. But the worst could be avoided on Mauritius because, expecting major problems with food imports, the government ordered sugar plantations to use about one-quarter of their land exclusively for the cultivation of food. Although food production targets were never reached, this quick response showed the flexibility and robustness of the Mauritian system. This strategy, however, cannot necessarily be generalized to other countries. The well developed infrastructure and the small size of the island made this success possible. After the war, however, this food program was ended, despite frequent food supply problems.

To combat the vulnerability to food crises and also to feed the rapidly growing population, Mauritius made another effort for food self-sufficiency in the 1970s as part of a general import substitution policy. Some improvements were achieved with potatoes and other food crops, but because of cheap and often subsidized food imports, the economics of these diversification programs were not favorable. It was simply more profitable to produce sugar and buy cheap food on the world market. If the infrastructure is sufficient for a high volume of international trade, as is the case in Mauritius, and the country is rich enough to pay for the food, population size and density of a specific place

do not seem to negatively influence food supply. Whether there is enough food on the world market is a different question.

As part of our future scenario calculations using the PDE-Mauritius model, we also studied whether a certain minimal degree of food self-sufficiency would be advisable under sustainable development criteria. In short, the results show that under an assumed future economic crisis, it is advantageous to have a rather high proportion of food self-sufficiency, which will also help reduce unemployment. Under prosperous economic conditions, however, increased food production would mean lower income. Hence the key to robust policies is to assure maximum flexibility that allows a quick increase in food production (similar to World War II), should the state of international trade require it.

1.4. Population Density and Disease Mortality

Originally Mauritius must have been a very healthy place for humans. The story says that the first inhabitants were a group of seriously ill sailors abandoned by their ship. Some time later when the ship returned, all sailors were in best health.

In the following centuries, however, a large number of diseases came to the island via immigrants or merchant ships. Death rates for the 19th century show frequent peaks due to cholera, smallpox and other epidemics. Prior to 1862 malaria, a major killer in subsequent years, was not endemic to Mauritius. Malaria even induced the resettlement of many Mauritians from the coast to the cooler highlands. In 1919 the Spanish flu killed more than 6% of the Mauritian population. The spread of these diseases resulted from a combination of high density and poor sanitation together with a lack of treatment possibilities.

After 1945 the death rate dropped to less than half its previous level within a few years as a consequence of malaria eradication, antibiotics and preventive medicine. Today Mauritius has almost European mortality conditions with no negative influence of population density.

1.5. Conclusion

The evidence from Mauritian history shows that in the early days, very low population density was an obstacle to sustainable agriculture and development on the island. Most of the deforestation and species loss was not related to population density but to shortsighted economic exploitation. Some of the human suffering, however, especially that due to diseases before modern medicine, seems to be related to population density beyond a certain threshold. Pollution due to the recent industrialization, again, seems to have been more a function of lacking environmental legislation than of population density. The increasing proportion of land used for urban purposes is certainly related to increasing density but does not automatically imply environmental destruction.

Saying that the density stress argument could not be verified for Mauritius as a direct cause of environmental destruction however, does not exclude the possibility of more indirect effects operating through attitudes. In order to find jobs for the rapidly increasing number of young people (a consequence of population growth), society as well as

government may give more weight to attracting international companies without many conditions, than to setting tight pollution standards. This question, which is only indirectly related to density and more to international competition in production costs, is an issue in most countries of the world.

2. WHAT TRIGGERED THE WORLD'S MOST RAPID FERTILITY DECLINE?

As described in Chapter 4, the total fertility rate in Mauritius declined from a level of 6.2 in 1963 to only 3.2 in 1972. This decline happened essentially parallel within all ethnic groups. This is assumed to be one of the most rapid fertility declines in the world. In this section, an attempt is made to identify the most important factors that contributed to this drastic change in Mauritian reproductive patterns.

2.1. Social and Economic Development before the Fertility Decline

A most remarkable feature of the Mauritian fertility decline is that it happened in the absence of any economic growth. Per capita income was very low and stagnant during the 1950s and 1960s (see also Figure 4 below). This contradicts the popular view that economic development is the major reason for a decline in desired family size and consequently fertility. Figure 2, however, shows that the relationship between economic growth and fertility decline is varied across developing countries. In some cases such as Mauritius, Bangladesh and to some extent Thailand, the fertility decline preceded economic growth. The historical fertility transitions of some European countries (e.g. Finland) also showed this pattern. In a number of countries fertility declined simultaneously with increasing income, and in a third group (mostly Arab countries) income grew without much fertility decline. This comparison shows that on an empirical basis, it is hard to argue that income growth is an essential determinant of declining fertility. Similar diversity of the fertility-income relationship is also shown at individual levels (such as in the World Fertility Survey, Cleland and Scott 1987).

In Mauritius, income had not grown in the years prior to the onset of the fertility decline, but social development and especially education were well advanced by this time. Already in 1960 nearly universal primary education had been achieved in Mauritius and aspirations for secondary education for girls almost equaled that for boys. This high educational status of the younger generation and especially of younger women comes out as probably the single most important factor in explaining the Mauritian fertility decline. This assumed effect of female education on fertility can be seen as operating through three different mechanisms: first, it increases the age at marriage, and indeed it could be shown that about half of the steep fertility decline in Mauritius is attributable to changing marriage patterns; second, education is likely to change the value system by putting more emphasis on the life opportunities of children and women than on a large quantity of children; finally, there is evidence that education increases the acceptance of family planning methods by women and increases the relative status of a woman within the family to carry through her own (usually lower) desired family size.

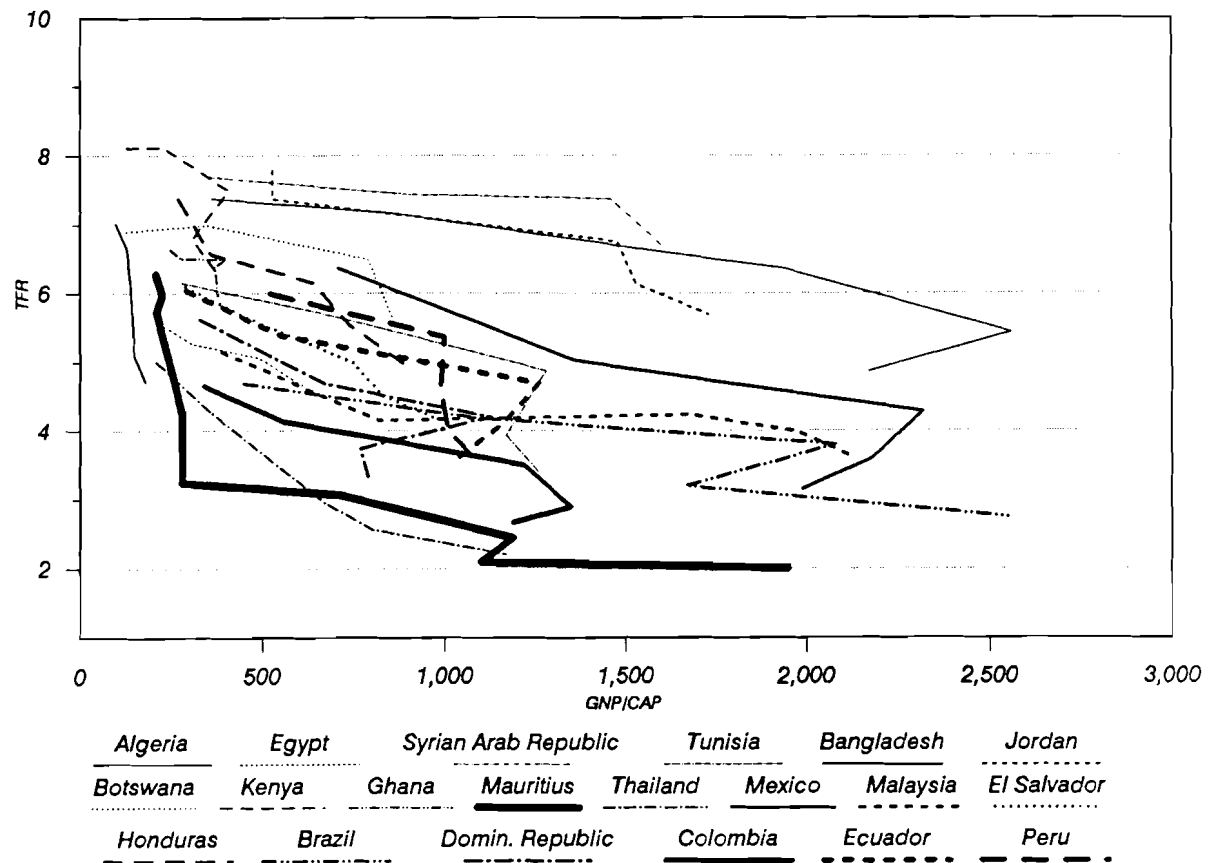


Figure 2. Relationship between per capita income and fertility in a sample of developing countries 1970-1990 and in Mauritius 1950-1990.

In sharp contrast to the non-relationship between fertility and income in Figure 2, Figure 3 shows that the strong association between basic female education and the onset of fertility transition that is observed for Mauritius is very common in the rest of the world as well. As the sample of twenty other developing nations shows, there seems to be some kind of threshold at the point when about half of society's women can read and write. Since educational efforts are usually rather recent, this means that in practice most younger women are literate, while illiteracy is still high among the elderly. Only in some Arab countries is this threshold not clearly visible.

The literature on the relationship between fertility and education as well as between fertility and income is extremely large. No attempt was made to review it here. It should only be pointed out that Mauritius is just one additional strong piece of evidence supporting the already overwhelming evidence (especially on the micro-level) that basic education, especially of women, is an extremely important factor in explaining the onset of fertility decline, whereas increasing income had no visible direct role in Mauritius.

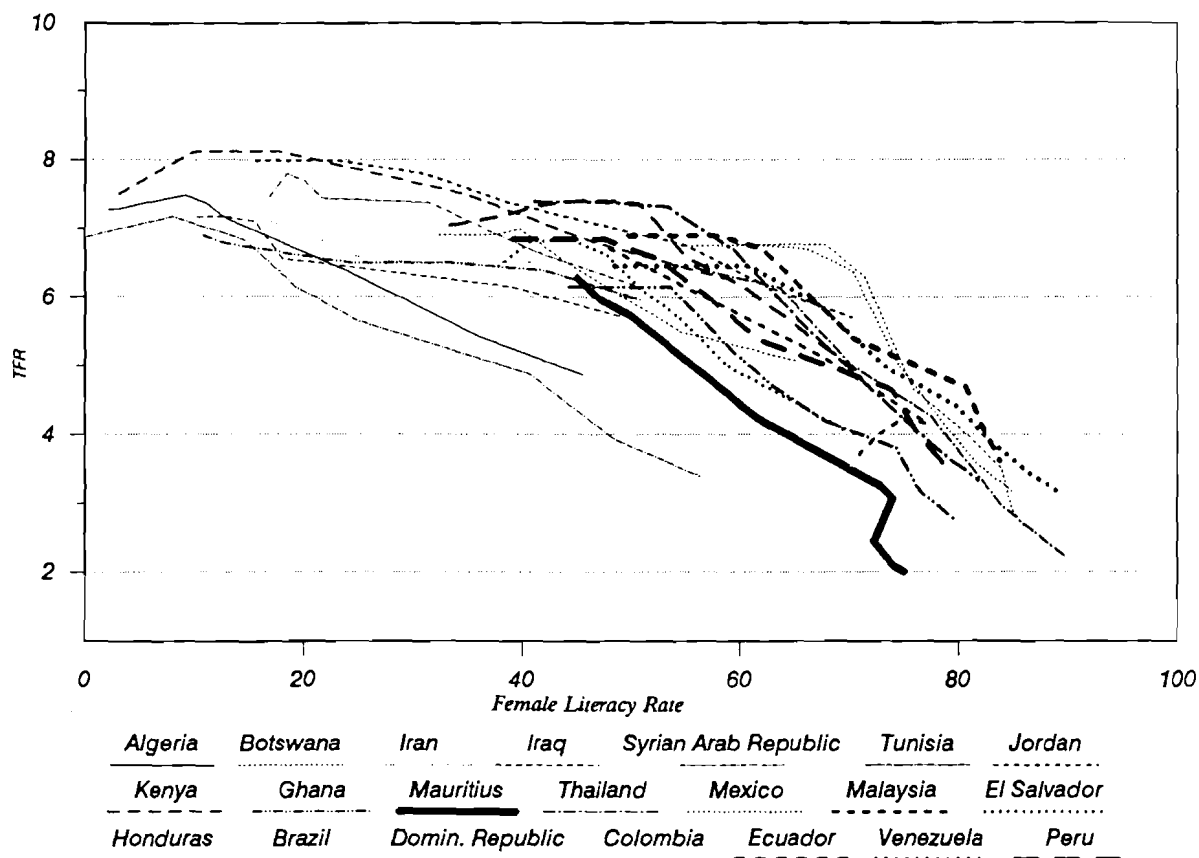


Figure 3. Relationship between female literacy rates and a sample of developing countries (1950-1990) that had a Total Fertility Rate above 6.0 in 1950.

2.2. The Role of Ethnic and Religious Factors

In the early 1960s the scientific reports by Titmuss and Meade on the future of Mauritius had both identified rapid population growth as the major obstacle to development. These scientific studies had an important influence on policy makers and also on the general public in Mauritius to understand that--to use Malthusian language--the island would have to suffer from a positive check (i.e. increased mortality) or at least severe poverty, if no preventive check (i.e. declining fertility) was found.

The influential religious communities, although traditionally pronatalist (Roman Catholic, Hindu, Muslim) found it difficult to oppose this argument, especially on a small island where spatial limitations were clearly visible. As to the Catholic church, which was most influential on Mauritius, it is largely the merit of one individual, the French Jesuit Lestapis, to convince Catholic authorities and politicians that the church doctrine was not against family planning in general but only against certain methods. As a consequence, Catholics did not block the introduction of government supported family planning programs, but established their own family planning organization which only propagated natural methods and also received government support.

In his report Titmuss (published as Titmuss and Abel-Smith 1968) had expected that the great ethnic diversity of Mauritius would present a major problem to the acceptance and success of his recommendations. But this was not the case in Mauritius. Fertility declines within the Hindu, Muslim, and Chinese communities were even more rapid than in the total population that included the "General Population" (a residual category including Europeans, Africans, etc.) in which fertility had already been below average in 1962. In Mauritius other factors were obviously strong enough to easily overcome the potential impediment of ethnic diversity. There has always been peaceful coexistence between the religions in Mauritius, and religious leaders have shown flexibility in the family planning issue.

2.3. The Role of Family Planning

The declines in age-specific fertility and marriage rates as well as the use of various family planning methods since 1962 have been well monitored in Mauritius (Xenos 1991). It has been calculated that about half of the births averted between 1962 and 1972 are attributable to marriage postponement, the other half to a drop in marital fertility. This coincidence of rapid transition in marriage patterns as well as in marital fertility may explain the extraordinary speed of the Mauritian fertility decline. In 1952 57% of the young Indian women aged 15-19 were married in Mauritius. By 1962 this percentage had already declined to 37%, and further declined by more than half to 15% in 1972. In the age group 20-24 the percentage fell from 85% in 1962 to 58% in 1972. This trend towards increasing age at marriage was universal among all ethnic groups.

The decline in marital fertility was strongest at the higher age groups, a typical pattern for fertility transition. In the age group 30-34 the birth rate declined from 0.256 in 1963 to only 0.128 in 1972. For all age groups above 35 the rates more than halved over these few years. The "Index of Family Limitation" increased threefold over this period. This is directly related to the strong family planning efforts in both propagating smaller families and providing efficient contraceptive methods, together with village level health care and counseling.

Although the decision to launch strong family planning efforts was based on a broad national consensus and saw active government support, the external financial contributions of IPPF and UNFPA were also instrumental for the successful implementation on a larger scale. The number of new acceptors to the two Mauritian family planning organizations grew very rapidly during the late 1960s and peaked around 1970-72. Surveys showed that contraceptive use had reached 46% in 1975 (30% "supplied" and 16% "natural" methods) and 74% in 1985 (44% "supplied" and 30% "natural"). In the early 1970s the density of family planning clinics was one of the highest in the world.

2.4. Conclusion

Based on extensive surveys of historical and modern fertility transitions Ansley Coale (1974) specified three preconditions for the introduction of deliberate family limitation, i.e. fertility control dependent upon the number of children already born. All three of these conditions find strong support from the study of the Mauritian fertility transition.

1. "Fertility must be within the calculus of conscious choice." This refers to a mental and cultural transition that seems to be intimately tied to education, especially female education. Also the fact that Mauritius has a minority group of French origin with already lower fertility in 1962 may have facilitated a kind of cultural diffusion process on this issue similar to that in Europe at the beginning of this century.
2. "Reduced fertility must be advantageous." It was both on the macro and micro levels that Mauritians understood that lower fertility was advantageous to them. On the macro level the scientific reports by Titmuss and Meade seem to have been of crucial importance. On the level of families it seems to have been the rather high cost of education together with the high desirability of education as a prerequisite for a career that made some difference. Also the early introduction of social policies to support the disabled and elderly made parents less dependent on their children.
3. "Effective techniques of fertility reduction must be available." The wide distribution of modern contraceptive methods and especially the pill through family planning organizations certainly facilitated the rapidness of the fertility decline. Both international aid and good local organization were also instrumental and show that motivation to limit family size need not entirely rely on the supply of modern methods. Without such methods, however, fertility would most likely be higher in Mauritius today.

3. DID DECLINING FERTILITY STIMULATE ECONOMIC DEVELOPMENT?

In the previous section we concluded that economic growth was not among the possible factors bringing down the fertility rate in Mauritius. Now we will consider the opposite direction of causation: Did fertility decline and the slowing population growth rate exert a positive influence on the start of the economic boom of the 1980s? Does the traditional Coale/Hoover (1958) argument on capital shortage due to many children hold for Mauritius, or were other mechanisms dominant during the past three decades?

On an international level the aggregate empirical evidence on this issue seems to be very mixed depending to a large degree on the choice of variables. In their 1986 report the U.S. National Academy of Sciences presented a summary of recent research on the economic consequences of population growth in developing countries. Most of that report focuses on the question whether slowing population growth is advantageous under certain economic and resource availability criteria. The conclusions distinguish between short term and long term consequences. For the short term the report generally sees beneficial consequences of slower population growth. But for the long run, it stresses the possibility of positive effects of population growth due to incentives for improved organization and technology.

Such general statements on the long term behavior of highly complex and hardly understood societal and economic systems, however, are largely based on mental concepts with little possibility for empirical support. Consequently the report also concludes: "In short, the effects of rapid population growth are likely to be conditioned by the quality of markets, the nature of government policies, and features of the natural environment. Since the effects are so dependent on these conditions, a reliable assessment of many of

the net effects of population growth can best be carried out on the national level..." (NAS 1986, p. 89). In the following we will have a look at the Mauritian evidence.

3.1. Fertility, Population Growth and Income

Figure 4 plots the evolution of three basic variables in Mauritius: per capita income, population size and fertility. Already the timing of changes in those variables can give important indications of their relationship. The first observation on the demographic side is that despite dramatic fertility decline, total population size is rather inert and increases steadily. This is due to the momentum of population growth and the fact that mortality also improved.

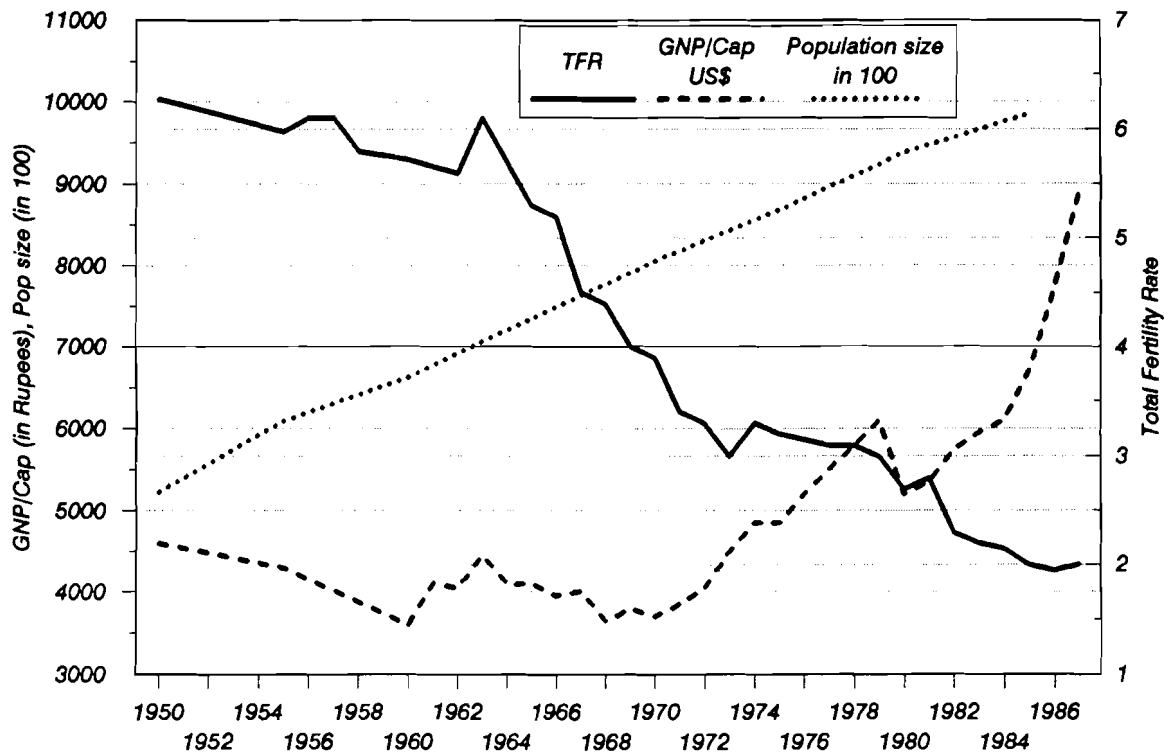


Figure 4. Fertility, per capita income and population size in Mauritius, 1950-1986.

Because of the almost linear trend in population size between 1950 and 1990, it is difficult to make any argument directly related to GNP which, on a per capita basis, was almost constant between 1950 and 1970 and then shows two big jumps in the 1970s and the late 1980s. If increasing population size should have induced economic growth, one must make the unlikely assumption that some magic population density thresholds were reached in 1970 and 1985. Based on the Mauritian evidence, it is equally difficult to make the point that total population size was an obstacle to economic growth.

It is much more instructive, however, to study the relationship of income to fertility instead of total population growth, which is quite a different question because of different assumed mechanisms of causation. (Looking at population growth rates would be a

mixture of these two aspects.) It is remarkable to see that the first big increase in income followed immediately after the first big fertility decline. The second jump in income followed another moderate fertility decline that brought fertility down to replacement level.

Several chapters of this book have extensively discussed the non-demographic factors associated with the phases of economic development. For the late 1980s the introduction of the Export Producing Zone policies seems to be the overwhelming determinant. For the 1970s the external reasons for the rapid income growth are less clear. It coincides with Mauritian independence, with first industrialization efforts, favorable international conditions and stable sugar prices. But the preceding fertility decline may have well been instrumental for this economic takeoff.

We can think of two arguments aside from the Coale/Hoover savings argument that would support a causal effect from declining fertility to increasing income. The first relates to the labor force by freeing young women to work in the new factories instead of being locked at home with children. And indeed, female labor force participation rates in Mauritius increased from 20% in 1972 to 28% in 1983. For young women (aged 20-24) this increase was even much stronger, reaching 40% in 1983. Mostly in textile factories but also in the service sector, the rapidly increasing young female labor force contributed substantially to economic growth. With traditional high fertility and young age at marriage, this could not have happened. Certainly, to be effective, such a development requires the availability of new jobs for women, which was the case in Mauritius.

The second argument is much broader. It relates to the view that the fertility transition is essentially based on a mental transition, on a change from aiming at quantity of children to quality (skills, higher status). This refers to the first of Coale's basic conditions for a sustained marital fertility decline as discussed above. Some even call it a transition from fatalism to individual rationality. Now the argument is, once individual rational choice has been introduced into one's private life, it is this mental transition that consequently results in longer term investments into the future, including training (of oneself and of children) and economic activities. Such longer term investments on individual as well as on familial and societal levels are also the basis for any economic development. In this sense the fertility decline may be seen as being closely related to a takeoff in economic development.

There are several other countries where the sequence of fertility decline and economic growth is similar to Mauritius (most notably China) but as shown above, the two developments may also be simultaneous or in specific cases (such as some Arab oil exporting states) in reversed order.

3.2. What Would Have Happened Without Fertility Decline?

The PDE-Mauritius model developed for this study allows not only projections into the distant future but can also be used to construct alternative histories (see Chapter 17). In this case 1962 (a census year) is chosen as the initial state. Thereafter the observed development for 25 years (up to 1987) is reconstructed as one scenario. But several hypothetical alternative scenarios also have been calculated, four of which will be briefly

discussed here for a quantitative assessment of the role of population variables in income growth.

Table 1 shows that the observed development between 1962 and 1987 brought a 280% increase in per capita GNP. If no development at all had taken place--i.e. all demographic, social and economic parameters would have remained at their 1962 level--GNP per capita would have declined to almost half of the already very low level by 1987. If, however, fertility had declined and education improved with otherwise constant parameters, per capita income would have only declined by 30%. Hence a fertility decline would have made the bad situation somewhat better.

Table 1. Observed and hypothetical effects of declining fertility under different social (mostly education) and economic scenarios on per capita income in constant Mauritian Rupees.

	1962	1987	% Change
Observed development	4,410	16,790	+280%
All 1962 parameters constant		2,430	-45%
No economic development but fertility decline and social development		3,070	-30%
Economic development but ...			
... no fertility decline		13,670	+210%
... no fertility decline and no social development		11,730	+166%

In the case of assuming progress in the economic parameters along the line actually observed between 1962 and 1987 but without a fertility decline, per capita income would have increased "only" by 210% instead of 280%, i.e. one-fourth less. If one also assumed no social development which mostly refers to observed education, GNP per capita would have increased by "only" 166%, i.e. just somewhat more than half of the observed increase.

Because there are many other relevant economic variables such as unemployment, government deficit and trade balance, that develop differently under the various scenarios, the figures on GNP in 1987 demonstrate only part of the economic consequences of alternative demographic and educational developments. But the directions and the orders of magnitude are clear: Between 1962 and 1987 the exogenous economic parameters had a larger relative influence on income than direct effects of fertility decline that are clearly visible nevertheless. When extending these hypothetical histories to 2002 the negative relative effect of higher fertility and lower education comes out even stronger. The given calculations, however, include only direct "hard-wired" effects and do not include more indirect effects of the kind described in the previous subsection which, under the PDE approach, belong to the "soft" model that is implemented by means of a user-defined scenario setting.

3.3. Conclusions

In short, there are several reasons to assume that the fertility decline in Mauritius had a role in triggering the subsequent economic boom. Despite the fact that economic and political variables are the most visible determinants of economic growth, the model also shows that without a fertility decline, Mauritius would be clearly worse off today. On a deeper level mental changes associated with the fertility transition may be essential for economic development.

4. WHAT ARE THE CONDITIONS FOR SUSTAINABLE ECONOMIC GROWTH IN MAURITIUS?

This question is extensively and comprehensively studied in Chapter 16, which compares a large number of scenarios for the period 1990-2050 using the full PDE-Mauritius model. For each segment of the model (population, economy, environment) two opposing sets of parameters have been defined (traditional - modern, crisis - boom, laissez-faire - garden) which are then combined in aggregate scenarios and adjusted in order to meet the basic required balances (water, labor, budget) and some user-defined feedback mechanisms. Specific policy options (such as priority to sugar or food self-sufficiency) have also been tested in this context. A concise summary of the results of these alternative model runs is given on pp. xx-yy and will not be repeated here. Instead the following points will highlight some of the key results under a somewhat broader perspective.

4.1. Water as the Basic Physical Constraint Even on a Tropical Island

The international discussion on resource availability has recently given more attention to the management of renewable resources since the concern about non-renewable resources has somewhat diminished. Water is a very special kind of renewable resource because its local availability is essentially determined by the climate and topography, and can only be transported over longer distances under specific conditions. On Mauritius total freshwater availability must essentially be considered as a "fixed resource" with significant seasonal and annual variations.

Whether Mauritius has scarce or plentiful fresh water resources depends on the point of view, whether we consider water per person or water per land area. Figure 5 shows a cross classification of a number of countries according to these two variables. Mauritius is found in the lower right corner of this graph, indicating that because of its tropical climate and mountains, Mauritius has more water per km² than most other countries in the world, whereas it has very low per capita water resources. The discrepancy results from the very high population density on Mauritius.

The set of future scenarios consistently shows that water availability at a given high standard of quality is the essential environmental constraint to unlimited economic growth on Mauritius. Whether this constraint will actually inhibit economic growth depends on the investment made into water storage and treatment. Under environmental laissez-faire policies together with an export-driven economic boom, the limits will be met relatively soon. But the model also shows that timely investment into water management

infrastructure will make possible even very rapid further economic growth. This is especially the case when growth is not based on irrigation intensive sugar cane but rather on industry and services. Among the many relevant aspects of water management waste water treatment comes out as the most significant.

Another aspect which is considered in the water module of the PDE model is the water quality of the lagoon which surrounds large parts of Mauritius and is an important natural asset, not least for tourism. It also affects the survival of the coral reef which is already partly damaged. It is shown that enforced legislation on water treatment and waste disposal can make a big difference here.

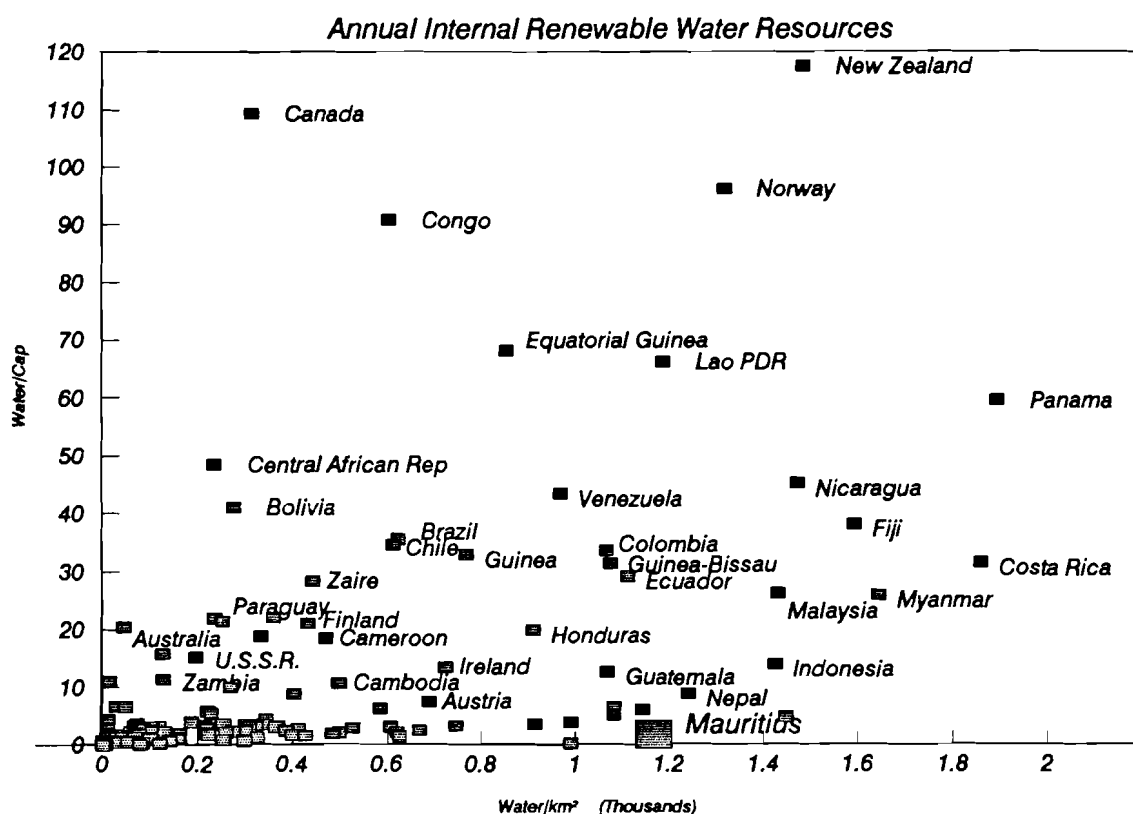


Figure 5. Annual internal freshwater resources per person and per km² in all countries of the world (except for five extreme outliers).

4.2. Future Agriculture and Industrial Production

Sugar cane has traditionally been the backbone of the Mauritian economy. Sugar fields and sugar factories still dominate the Mauritian landscape. Only in recent years industrial exports (especially textiles) have surpassed sugar exports. Over the past decades sugar prices and quantities guaranteed to Mauritius by the European Community were a very important element of stability during the onset of the recent economic boom in Mauritius. But prospects for the future are unclear if not shaky. Sugar exports to the US have significantly declined due to changes in diet, and it is not clear how the European market, where domestic sugar beet is a serious competitor, will develop. The recent labor

scarcity in Mauritius and the general increase in salaries also affect the labor intensive sugar plantations negatively.

Several scenarios have been calculated that assume drastic changes in international sugar demand and domestic factors such as a sugar policy for reasons of tradition rather than profitability. The general result is that it does not make much sense to further intensify sugar growing (which already has a very high fertilizer and irrigation input) for economic and environmental reasons. Sugar refining, however, can be made more efficient especially by using the large energy potential of bagasse. To prohibit the conversion of sugar land for industrial or urban use is neither economical nor practical, but the present land conversion tax that depends on the fertility of the soil is an interesting solution.

Future industrial growth is assumed to be mostly driven by export demand. When staying in the same export market dominated by textiles, per capita income could still grow significantly to about five times the present GNP/capita by the year 2050. Through a structural change in the economy toward higher value added products and especially services, however, economic growth could potentially be even more rapid (following the example of the Asian tigers) and result in income levels by 2050 that are higher than today's European levels. Because of a move toward less polluting and less water-intensive industries, this would also be possible from an ecological perspective. Aside from favorable international conditions one domestic prerequisite for such a rapid and sustainable development is a highly skilled labor force.

4.3. Role of Tourism

Despite the rapid growth of international tourism on Mauritius over the past years, in 1990 foreign exchange earnings from tourism comprised only 15% of the total exports and an estimated 3.3% of the GDP. But there are also important indirect benefits from tourism. Mauritius has made a clear choice for high quality expensive hotels and has put an upper limit on the number of hotel rooms. Because of the limited availability of attractive beaches there is an inherent conflict between private and public access that requires careful management.

In an international perspective Mauritius is still in an early stage of a hypothetical tourist resort cycle (see Debbage 1991) in which very rapid expansion may be followed by stagnation and even decline because of loss of attractiveness. To avoid an ultimately destructive development such as on the Bahamas, Mauritius must make efforts to regulate and limit the expansion of tourism. The present policy of high cost and quantitative limitations (no charter flights are allowed to land in Mauritius) seem to move in the right direction. But to remain internationally competitive in the future, attention must also be given to water quality in the lagoon, the status of the protective reefs, the preservation of original landscapes and cultural attractions.

In a way high level selective tourism in international competition turns out to be conducive to environmental protection. It provides a very quick economic feedback mechanism that cannot be ignored even in short term politics. Already small signs of environmental destruction and pollution may cause tourists to go to cleaner island destinations instead.

4.4. Population and Labor Force

The role of population variables in actual and hypothetical past developments has been discussed extensively above. Mauritius now has passed the fertility transition and it cannot be imagined that fertility would return to high premodern levels in the future. The population presently still grows by 1% per year which is entirely due to the momentum of population growth, i.e., the young age structure of the population and some mortality improvements. For the future alternative fertility assumptions are considered separately for all three educational groups of women that result in fertility levels somewhat above replacement level ("traditional") or below replacement level ("modern"). Fertility is also influenced by changing educational compositions for the population. In the "traditional" case the total population size of Mauritius would increase from presently 1.1 million to 1.9 million by 2050; in the "modern" case it would only increase to 1.25 in 2020 and then decline to 1.12 by 2050.

These alternative population sizes and structures also have a sizable impact on the future trends in the economic variables of the model. When comparing the two scenarios, which both have the "boom" assumptions in the economic sector and the "garden" assumptions in the environmental sector, the "modern" assumptions in the population-education sector result in twice as much per capita income in 2050 than the one using the "traditional" assumptions. Hence stagnation in the social development that brings lower fertility and higher productivity through better education would have serious negative effects even under otherwise very favorable economic conditions.

Size and quality of the labor force are of special concern. For the past two decades the World Bank has identified the Mauritian labor force, including an increasing number of educated women, as "the engine of economic growth". If Mauritius is to be successful in expanding into new markets requiring higher technology, the quality of the labor force once again will be the key for success. For this reason the economic development plans of the government put high emphasis on further technical training of the labor force. As long as the local expertise is flexible enough to adjust to new technologies, investment into human capital will be one of the most effective and most robust strategies for sustainable economic development in Mauritius.

4.5. Dependence on the Global Economy and the Global Environment

While Mauritius is rather isolated geographically, it is heavily interwoven into the global economy. The overwhelming dependence on export earnings and imports of food and most other consumer goods has a long tradition. A change of this situation does not seem to be possible without a significant loss in welfare. Especially with a further diversification of export and import markets that makes Mauritius less vulnerable to possible crises in different world regions, the benefits of such an international orientation outweigh the risks by far. But, as indicated for the question of food self-sufficiency above, a maximum of flexibility in the change of markets and necessary imports is an important component of resilient development strategies.

In the case of the environment, Mauritius is hardly affected by any transport of pollutants from other countries, but it would certainly be affected by changes in the global climate.

The Mauritian contribution to global warming is negligible not only because of its small population but because of one of the lowest CO₂ emissions per GNP in the world. Present general circulation models are not yet detailed enough to study the impact of a double CO₂ climate on rainfall and temperature, given the Mauritian topography. For the region the various models tend to show a temperature increase of 2-3 degrees Celsius and also some increase in precipitation in the already wet months. Effects of a possible increase in the sea level depends among others on the question whether the coral reefs are healthy enough to grow with the same speed. Probably the most relevant question for Mauritius is the future of cyclones, since Mauritius is situated in the usual path of cyclones through the Indian ocean. If the intensity of cyclones increased, this would be destructive; if their paths changed it might be advantageous; and if the frequency increased with lower intensity, this may also be good because of more rain.

4.6. Conclusion: Towards a Prosperous Garden Island

The scenario that combines all the "good" assumptions in the three segments of the PDE-Mauritius ("modern" for the population sector, "boom" for the economy, and "garden" for the environment) can be called the "Prosperous Garden Island Scenario". This scenario points the direction towards sustainable development. It is called "garden island" because Mauritius has little original nature left and already has a largely man-made environment. For this reason the metaphor of a man-made well-kept garden is seen as appropriate for Mauritius. It also reflects the high population density and need not be in conflict with economic growth and prosperity. In fact some wealth is necessary to sustain the garden. It also requires wise environmental legislation, good infrastructure as well as the skills and willingness of the population to take good care of the garden. In most of these aspects Mauritius presently seems to be on the right track.

5. WHAT ARE THE POLICY PRIORITIES?

Despite efforts to keep this concluding section as short and clear as possible, the answers given to the questions often include qualifications and differentiations. This is due to the intrinsic complexity of the system studied. But still it is justified and highly relevant to ask for the major policy implications of this study. What are the two most important policy priorities to which this study of the history and future of Mauritius boils down under a truly holistic perspective?

5.1. Accountability

In Mauritian history things went well when the persons in charge had a longer time horizon; irreparable damage was caused when immediate advantages were the only objective. The scientific studies on Mauritius in the 1960s, showing that a change was necessary, had a long time horizon and were fortunately heard by responsible politicians, and understood on individual and societal levels. This flexibility and farsightedness was the basis for the Mauritian success story. Similar foresight is necessary now to set the right steps towards sustainable development.

When comparing Mauritius to other countries in the African region since the 1960s, one of the major non-material differences is that during the whole period, Mauritius had a

truly democratic system that despite the extreme ethnic heterogeneity managed to settle conflicts peacefully and develop a sophisticated balance of power. Although this dimension is beyond our quantitative model, it comes out as number one under a holistic perspective. Many things could have gone wrong in Mauritian politics that could have inhibited development or even ruined the island. Conditions under which decision makers are accountable to the majority of the population, including families with children who represent the future generation and do not primarily serve the interest of themselves or a subgroup, seem to be a basic prerequisite to sustainable development.

On an individual level the understanding that you are accountable for your own choices, including the number of children, education, private business and the environment at your disposal, is a basic prerequisite for the demographic transition as well as for modern economic development in balance with the natural environment.

5.2. Investment in Human Skills and the Status of Women

More concretely, the first policy priority for sustainable development should be focusing on the development of people or what economists call the human capital. This really seems to be the "ultimate resource" under a longer time horizon, but in terms of skills (and attitudes) rather than quantity. It is not the starving and unskilled desperate that bring about progress, but those who have the possibility to think creatively and care about others at all different levels. The Mauritian experience suggests that education is the key, especially basic education of broad segments of the population rather than of elites in an otherwise illiterate society.

More specifically, it is the basic education of women and their status in society that seems to have a very important role in the transition to lower fertility and is also conducive to economic development and possibly even to a better harmony with nature. The gender dimension at familial and societal levels certainly needs more attention in the context of sustainable development.

Provision of family planning services, one specific and hotly debated policy issue, is one of the factors that is conducive to the fertility transition and is desirable not only for macro level considerations but also for facilitating individual choice and personal life course planning. Family planning, however, should not be singled out of the context of female status and health care, and pushed for as an independent "engineering" solution. It does not work this way and can be counterproductive. Instead it should be viewed as one aspect of empowering women and families to more actively plan their lives and those of their society. It is part of the investment in the human resource.

Last but not least with respect to the priorities in international development policies, this suggests a radical change of emphasis giving less attention to large scale technological projects that often prove to be inappropriately designed for the specific local conditions and may even turn out to be harmful to the environment and the social fabric. In contrast, investment into the human resource, into education, health and family planning can hardly be wrong. It is a very robust policy that may only show modest immediate results, but greatly pays off in the longer run.

REFERENCES

- Boserup, Ester. 1981. *Population and Technological Change: A Study of Long Terms*. Chicago, Illinois: University of Chicago Press.
- Cleland, J. and C. Scott, Eds. 1987. *The World Fertility Survey: An Assessment*. New York: Oxford University Press.
- Coale, Ansley. 1974. The demographic transition. Pages 347-356 in *UN, The Population Debate, Dimensions and Perspectives: Papers of the World Population Conference*. Bucharest.
- Coale, Ansley J. and Edgar M. Hoover. 1958. *Population Growth and Economic Development in Low-Income Countries*. Princeton, New Jersey: Princeton University Press.
- Debbage, Keith G. 1991. Tourist destination cycles and sustainable development: A comparative analysis of the Bahamas and Mauritius. Pages 255-270 in W. Lutz and F.L. Toth, eds. *Population, Economy, and Environment in Mauritius*. CP-91-01. Laxenburg, Austria: International Institute for Applied Systems Analysis.
- Mead, J.E. 1961. *The Economic and Social Structure of Mauritius*. London: Frank Cass and Company.
- Simon, Julian L. 1982. A scheme to promote world economic development with migration. In *Research in Population Economics*, edited by J.L. Simon and P.H. Lindert, Volume 4. Greenwich, Connecticut: JAI Press.
- Titmuss, R. and B. Abel-Smith. 1968. *Social Policies and Population Growth in Mauritius*. London: Frank Cass and Company.
- U.S. National Academy of Sciences. 1986. *Population Growth and Economic Development: Policy Questions*. Washington, D.C.: National Academy Press.
- Xenos, Christos. 1991. Family planning and fertility change in Mauritius. Pages 67-85 in W. Lutz and F.L. Toth, eds. *Population, Economy, and Environment in Mauritius*. CP-91-01. Laxenburg, Austria: International Institute for Applied Systems Analysis.