POPULATION, ECONOMY, AND ENVIRONMENT IN MAURITIUS

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(Editors)

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FOREWORD

Studies of population and of sustainable development enjoy a long and distinguished tradition at IIASA as does research of complex systems. The papers included in this volume build on that tradition, in the same way that our project on Mauritius does, but the research also has several characteristics that make it especially interesting.

This is the first time that IIASA has directed a project that entails scientific collaboration with one specific academic institution in the Southern hemisphere, and focuses on a country which has only 0.00125 percent of the world's land surface and 0.020 percent of its population. In conducting this type of project, the objective is to gain a deeper understanding of the population-development-environment puzzle by concentrating on a single spot on the world map. IIASA has always been dedicated to interdisciplinary research, but this is the first time that the studies of population, environment and development have been brought together into one project which examines the interaction between these factors in a specific context.

The project has the significant support of the United Nations Population Fund (UNFPA) and lies at the intersection of the scientific interests of IIASA, the expertise of the University of Mauritius, and the priorities of UNFPA. All involved parties also hope that this project will provide useful background information for the 1992 World Conference on Environment and Development.

The present proceedings of a task force meeting only document the very first step in the project work, namely the assembly of information on Mauritius from many different perspectives. The collection of papers is multidisciplinary, but not yet interdisciplinary. The latter is the task of the presently ongoing project work and will be documented in future publications.

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INTRODUCTION

Chapter 1

A CASE STUDY ON MAURITIUS: TOWARDS THE HOLISTIC UNDERSTANDING OF A MICROCOSMOS

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The Population and Sustainable Development Project of IIASA's Population Program recently began an ambitious research project in scientific collaboration with the University of Mauritius and with financial support from the United Nations Population Fund (UNFPA). The objective of this project is, stated in rather general terms, to study the complex interactions between population change, socio-economic development, and the physical environment for the island of Mauritius with the help of a computer information system that allows the quick and user-friendly evaluation of different development scenarios and options for political intervention.

Countless papers and books on sustainable development have recently been written and are presently being produced, partly in preparation for the 1992 World Conference on Environment and Development to which the present project will also be input. Some of these also consider the role of the population variable in interaction with development and the environment. Typically such studies have a global perspective in geographic terms but tend to be rather narrow in the substantive approach to the question, ranging from specific schools of economic thinking to climatology and hydrology. Only very few studies give attention to social structure and behavior, life style, or even culture. But commonsense tells us that these factors are very important if we want to study changes in consumption patterns, types of energy use, land use, and other forms of behavior which are deeply embedded in the social fabric of a society. And these factors differ considerably from one region to another, and from one state of development to another. A global analysis of them especially in conjunction with economic and environmental factors would be inconceivably complex.

One alternative to a global view within disciplinary limits is an interdisciplinary, holistic approach to a very specific place in the world. For a specific case it should be easier to study a large array of factors that influence the socio-economic and environmental system at its given state of development and in its given cultural setting. *Pars pro toto*, this may also give us some insight into the more general structure of the population-development-environment interdependencies.

Mauritius has been chosen for an interdisciplinary IIASA case study on population and sustainable development for several reasons. Firstly, high-quality statistics on population trends, social indicators, consumer behavior, energy use, and various other economic aspects are readily available. Secondly, it is a geographically (but not culturally or economically) isolated island that is relatively easy to overview and understand despite ethno-religious diversity. Both in economic and environmental issues one can clearly distinguish between home-made and imported goods and problems. Thirdly, very high population density together with the recent extremely fast industrialization and the virtual absence of land-use plans and environmental legislation make a thorough analysis of the population-development-environment interactions very relevant, not only for scientific understanding, but hopefully also as a planning tool for the government of Mauritius. Last but not least, an already established scientific partnership between IIASA and the University of Mauritius provides the necessary institutional framework for this kind of study.

This project will combine three different goals. First of all, it will attempt to serve Mauritius. Second, it will contribute to the population and development debate in the demographic and social science community. And third, it might become a prototype of a new holistic approach to modeling and understanding sustainable development in a broader scientific community and for policy makers. The border lines between these goals are fuzzy and may be seen differently two years from now, but at the moment, these distinctions seem to be useful for structuring our thinking and the work of the project.

Use for Mauritius

The most immediate goal of this project is to work together with the University of Mauritius for a better understanding of development options for the island of Mauritius. This feeds directly into the "Mauritius 2000" effort outlined below by Professor Manrakhan. Similar to "Mauritius 2000" the project will take a truly interdisciplinary approach, attempting to consider all relevant factors ranging from population, labor force considerations, education, economic development, international trade, tourism, energy, agriculture, and water systems to cultural understanding and even political feasibility.

Aside from taking part in the exciting intellectual exercise of "Mauritius 2000" this project is expected to have two contributions which will benefit Mauritius:

A: It should serve the political authorities as a planning tool that demonstrates the impacts of alternative policies and also indicates feasible pathways towards politically desirable goals without compromising other desired objectives (e.g. the environment, social welfare, etc.). For this purpose, it is intended to involve policy makers from the beginning of the project and constantly interact with them. Once we have the first results, we will also conduct something we call at IIASA "Policy Exercises," where policy makers are acquainted with our tools and we understand their needs and see whether the tools are useful in solving their problems.

B: A second direct benefit should be the training component of this project. This consists of workshops of junior Mauritian scientists at IIASA as well as courses to be held at the University of Mauritius. These courses will cover areas which are presently not on the curriculum of the University of Mauritius, such as population dynamics or environmental modeling.

Contribution to the Population and Development Debate

The second purpose of the project goes beyond Mauritius. It is directed towards the international demographic and social science community and also towards policy makers in the area of international development. There are several aspects to this debate. One, I think rather superficial question, is whether population growth is generally harmful to development or not. Some authors even say it is good. At this very general and abstract level, the debate does not seem to make much sense. In the concrete situation of many developing countries, it seems to be quite obvious that a decrease in population growth rates would be beneficial. Mauritius gives a good example that fertility decline was beneficial for the country, and for Mauritius it is rather straightforward to show the hypothetical negative consequences that a continued fast population growth would have had -- as clearly indicated by the Titmuss report and others (Titmuss and Abel-Smith, 1968; Mead, 1961).

Another more interesting aspect of the debate is concerned with the factors that help bring fertility down. Conventional wisdom now says that it is mostly socio-economic development that will sooner or later result in changing values and a changed incentive structure leading towards smaller families. After much emphasis on family planning in the 1960s, the slogan of the 1974 World Population Conference was "development is the best pill." In Mauritius, however, fertility decline (which was probably the most rapid of any population in the world with rates declining by more than half between 1963 and 1971) took place in the absence of any significant economic development. What, then, brought Mauritian fertility down from about six children in the early 1960s to about replacement fertility today? A thorough analysis of this question will be part of the project. The first hypothesis is that it was mostly social development and, in particular, the education of young women, that in combination with effective propagation of family planning brought about a change in values.

For the global debate where there is highly justified concern about the vicious cycle that population growth itself hinders the development necessary to bring down fertility and stop population growth (e.g. Keyfitz, 1991), the Mauritian experience is very good news. It indicates that fertility decline is possible even without economic growth if emphasis is put on the right aspects of social development, namely basic education, status of women, and a way of disseminating family planning that is appropriate to the given culture.

Contribution to the Modeling for Holistic Understanding

This third contribution is expected to go not only beyond Mauritius but also beyond disciplinary boundaries. Here we enter the arena of general modeling in the physical as well as social sciences. We see our approach in comparison with all global modeling efforts that started in the early 1970s with "Limits to Growth" and other reports to the Club of Rome. Although in the late 1970s and early 1980s IIASA had been a center for global modeling efforts, we now have to consider in our work more recent developments. During the late 1980s, large scale models as well as some of the associated terminology such as carrying capacity came out of fashion because of harsh and often justified criticism. Our effort should learn from these discussions and should be at the forefront of development.

As a consequence of these criticisms, at IIASA as well as elsewhere, emphasis was put again on more specific sectoral models of population, social security, agricultural trade, acid rain, substitution of technologies, certain water systems and many others. Interdisciplinary work even within the Institute turned out to be difficult even though recent awareness about climatic change clearly indicated the need of linking, e.g., population growth to energy consumption and CO_2 emissions. But at a global level, the issues seem to be so complex that it has been hard to come up with meaningful statements on the population-environment interactions. The number of people does not directly affect the environment, rather the kind of technology they use, their life styles and many other fundamental things that are quite different for different parts of the world. This is why we look at Mauritius as a microcosmos.

In short, the project attempts to achieve the following goals over a period of two and a half years:

- Develop a computer information system based on the tools of systems dynamics that is clear and parsimonious in its structure and takes account of lessons learned from "global modeling" approaches during the 1970s and 1980s.

- Try to approach the question in a truly holistic manner and avoid the pitfalls of purely sectoral approaches.

- Be action oriented in a way that the results can be directly translated into viable political options for Mauritius.

- Have educational value for a general demonstration of the links between population, development and the environment.

Two teams of researchers will work towards the achievement of these goals, one at IIASA mostly in charge of developing the computer tool, and one at the University of Mauritius to provide the local expertise.

At this point it is too early to speak about the detailed structure of the model. This will be done extensively in future publications on the project. But it might be useful to quickly describe the basic approach and philosophy of the project as it is presently seen.

Figure 1 shows the basic analytical framework, where the population with its given size, age, sex, educational status and labor force composition uses the economic system surrounding it to meet its needs for food and water consumption, shelter, energy, manufactured goods, services, and so on. On the other hand, the population pays for this by contributing its labor to the economy. Income may be earned in agriculture, industry, or services. Together with capital and land (physical environment) human labor produces, via the economic system, products that in turn will be consumed by the population. This economic conversion process from work to consumption includes domestic and international trade. Government policies can influence this process through regulations, taxation, government services and investment.

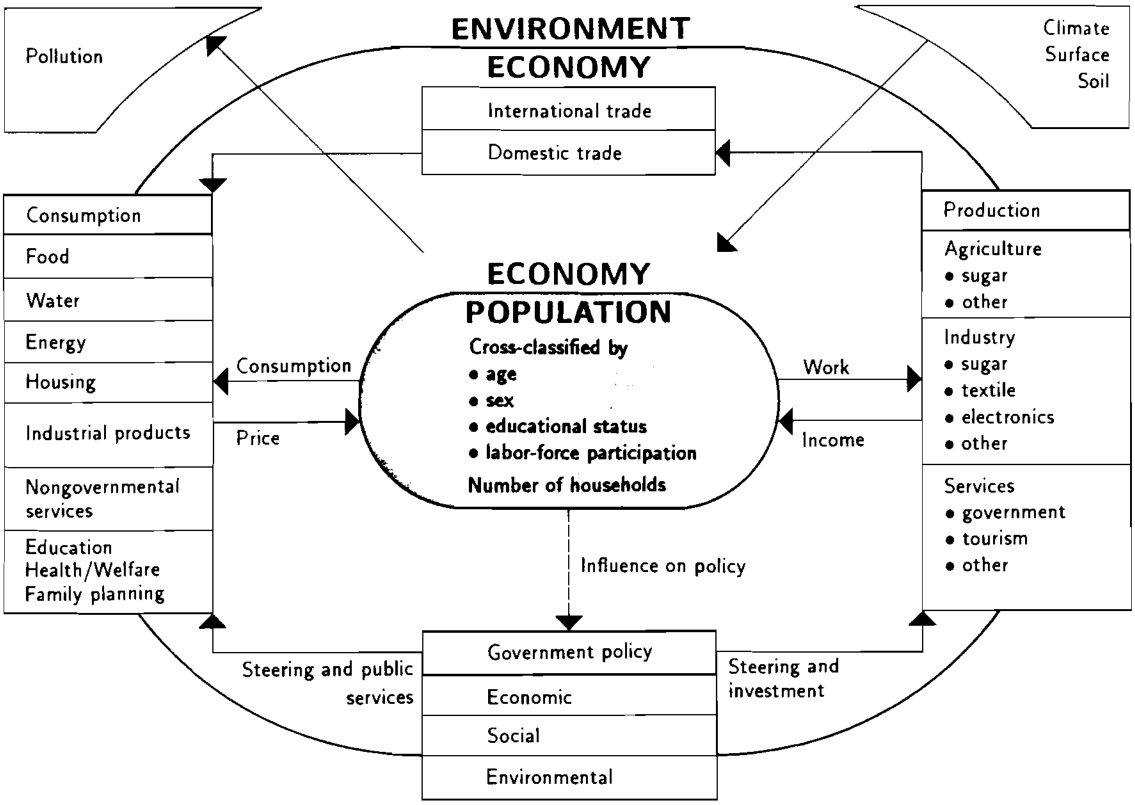

Figure 1. Basic analytical framework for the case study on population and sustainable development in Mauritius.

The economic sphere surrounding the population, however, does not float in space but is embedded in and surrounded by the environment. This view is different from main stream economics in which the environment is only of marginal concern, if it is considered at all. In our view, climate, structure of surface, and soil composition (including raw materials) are the basic physical surroundings within which land use, energy supply, water management, and waste disposal have to be managed. Pollution is a direct influence from population and industry on the environment.

This is all that should be said about the model for the time being. The purpose of the first task force meeting in the project was to assemble information on Mauritius from as many different angles as possible. Contributors to this volume of proceedings include Mauritian scientists, international experts who have worked on Mauritius at some point, IIASA scientists presently working on the project and a fourth group of scholars (mostly from other IIASA projects) who describe the Mauritian case from an international perspective. By its nature this volume is not a homogeneous book. Some gaps as well as some redundancies among the papers remain. First priority was given to the multi-disciplinary collection of the papers and their quick dissemination.

The sponsoring agency UNFPA has recently expressed the wish that the project should not be exclusively focused on the computer model itself, but that emphasis should be put on intermediate scientific analyses and results. The structure and content of this volume of papers attempts to reflect this second point of emphasis. Hence the conference proceedings on "Population, Economy, and Environment in Mauritius" serve a dual purpose: they document parts of the first project phase consisting of data assembly and first analysis; and the present volume has value in itself as a interdisciplinary view on the island of Mauritius in a way that has not been given before.

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Chapter 2

"MAURITIUS 2000" AND THE IIASA RESEARCH FRAMEWORK: A VIEW FROM THE RÉDUIT CAMPUS

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"...the age of chivalry is gone. That of sophisters, economists, and calculators, has succeeded..."
Edmund BURKE (1729-97)

The concept of "Mauritius 2000" is introduced and several of its component exercises examined under the four IIASA research program areas, namely: The Environment; Technology, Economy and Society; Population; and Systems and Decision Sciences. Integration among the exercises is stressed both in the text and in the Appendix, with emphasis on the ECCO methodology. The paper ends with a set of concluding remarks, welcoming the re-orientation of "Mauritius 2000" efforts within the IIASA framework.

1. INTRODUCTION

"Mauritius 2000" was developed at the University of Mauritius in the early 1980s following student unrest, in an attempt to reverse the deliberate curtailment of teaching activities. Through gradual but sustained growth and viable academic development, the wherewithal was created for enhancing multidisciplinary research in biotechnology, employment, energy, food and nutrition, micro-electronics, environmental sciences, industrialization, and the welfare state, among others, with repercussions on teaching activities. Practically oriented, based on various swim-or-sink academic teams, and with linkages involving the private and public sectors, local and international, "Mauritius 2000" aims broadly to:

1. Create the image of a center of learning and knowledge with a major think-tank capacity.

2. Develop non-teaching activities.

3. Undertake high-quality research work which can be seen to be of direct relevance and importance to the country.

4. Encourage higher degree projects, each combining with others to form a broadly-based body of knowledge.

The results of various "Mauritius 2000" exercises were presented to a Council Meeting of the Association of Commonwealth Universities, and a summary was published in the latter's Bulletin (Association of Commonwealth Universities, 1987).

Following discussions with the International Institute for Applied Systems Analysis (IIASA) based at Laxenburg in Austria, a project has started which, in effect, would lead to certain aspects of "Mauritius 2000" (now being extended to the year 2010 and beyond) becoming blended within an IIASA framework. Founded in 1972, IIASA is sponsored by various member organizations in 16 different countries spanning both East and West. It has established four inter-related, continuously updated, research programs to address emerging issues involving: The Environment; Technology, Economy and Society; Population; Systems and Decision Science. The purpose of the present paper is to examine briefly how "Mauritius 2000" would fit into the above-mentioned IIASA research program areas.

2. THE ENVIRONMENT

Under this heading would come those "Mauritius 2000" exercises involving energy, food and nutrition, marine resources, physical resources planning, the small farmer concept, and so on.

Here and now, the following should be highlighted:

1. Mauritius currently consumes at least 300,000 tons of coral sand annually for construction purposes, far more than the corresponding rate of natural replenishment.

2. In 1986-87, University estimates showed that there were around 40 to 50 million tons of rocks available on cane lands (in the sub-surface), representing around 25 years of the then prevailing rate of consumption of aggregates, again for construction purposes. That consumption rate has now at least doubled.

3. A recent survey of primary energy consumption in households has now confirmed what we had begun to suspect three years ago, namely that firewood is of major importance as a carrier of primary energy. The household survey has now revealed it to be the main source. In rural areas it provides nearly 72% of the total primary energy consumed in households, whereas kerosene provides 14%, liquefied petroleum gas (LPG) 8%, and electricity 6%. Even in urban areas, firewood at 27% comes ahead as the primary energy carrier in households; LPG at 26% and electricity at 20% are the next major carriers. (It should be stressed that we are talking here in terms of primary energy: thus 4.5 units of the latter are required for 1 unit of electricity used, or 1.4 units of primary energy are required for 1 unit of

LPG in, for example, cooking purposes.) So where is the firewood coming from - deforestation?

4. Mauritian agriculture is currently losing prime land at the rate of around 500 hectares per annum from an existing area under cultivation of around 90,000 hectares. How long can this continue?

5. However, the most pressing of all environmental problems currently revolve around water, whether fresh, brackish or salty:

   (a) Underground aquifers produce around 60% of the domestic water needs of Mauritius. It is imperative that an excessive use of pumped underground water be avoided to prevent damage to the soil structure. In addition, dyehouses of the textile industry are apt to jettison their disused chemicals in the soil or in rivers; it is essential to prevent contamination of underground water.

   (b) Sewage is dumped in a raw state into the sea, killing the living coral with long term adverse consequences on sandy beaches, through the direct pounding of ocean waves on shores progressively shorn of their protective coral fringe. It is also important to examine the recycling of sewage water in agriculture, for example, and of the use of chemicals in agriculture, deemed as excessive in some quarters.

   (c) Under the UN Law of the Sea Convention, the State of Mauritius, with a land area of just under 2000 km^2 would have jurisdiction of 1.7 million km^2. What is it that can be usefully done with that Exclusive Economic Zone in a sustainable manner in terms of fishery resources and, eventually, seabed minerals?

   (d) Mauritius, through a judicious policy of renewable energy use and appropriate renewable energy technologies, can become largely self-sufficient in energy, besides achieving a substantial measure of food self-sufficiency. This, in turn, has repercussions on agro-forestry, land use (inclusive of food, cash crop production and energy farming, irrigation and drainage, fertilizers, land use for non-agricultural purposes, transport systems, and so on). In the longer term, we may have to mine the mountains (for rocks) or "go nuclear" for example, with scientific and technological, industrial and commercial, environmental and social implications, and repercussions - these must be studied.

There are other aspects, such as the socio-economic impact of emerging technologies, e.g. biotechnology, recycling wastes, energy technologies, and micro-electronics as well as socio-cultural dimensions requiring attention. As far as practicable, all these are being incorporated in ECCO exercises, current or planned.

3. TECHNOLOGY, ECONOMY AND SOCIETY

Thoughts on this topic include:

1. The future of sugar as a sweetener is becoming increasingly dubious.

2. The sugar cane, however, remains the most efficient commercially available converter of solar radiation energy into dry matter under Mauritian bioclimatic conditions.

3. What else can be done with the sugar cane, other than its traditional use? How much of it should Mauritius produce to ensure that the alternatives are viable?

4. The Mauritian Export Processing Zone (EPZ) has been taking up what the Newly Industrializing Countries have been jettisoning: Is this desirable? Can Mauritius jump the gun?

5. What does the future hold for tourism?

The interplay of sugar cane, EPZ and tourism is central for Mauritian society, present and future, and underlies the four macro-economic "starter" scenarios (MAYDAY, DOOMWATCH, MODESTY and SYMPHONY) outlined in the Appendix.

In many ways, "Mauritius 2000" is very much about science and technology in society. Whether a separate team should be set up to deal with the latter topic as such, or whether "Mauritius 2000" as an entity can deal satisfactorily with the topic is debatable. However, the growing importance of the topic on its own, and the necessity to avoid overburdening of the overall management of "Mauritius 2000" would, in due course, constitute sufficient grounds to actually set up a separate team on science and technology in Mauritian society.

Technology, Economy and Society can be regarded as a single large project, broken down into a series of smaller, overlapping studies, linking up with other areas and teams. The following thoughts are relevant:

1. One of the crucial items requiring study is in the mechanics and efficacy of technology transfer. To begin with, an examination of technology transfer in relation to the sugar industry would be desirable, as the relevant documentation of the latter industry is substantial and covers several decades. Thereby a reference frame would become available for comparative studies for other industries and for the future (tea, fruit, ornamentals, vegetables, feeds, food and beverages, textiles, micro-electronics, among others).

2. With "technology" taken in its widest sense, a study would be worthwhile on the immediate past, present and future of the Export Services Zone of Mauritius, particularly in the context of greater regional collaboration in the south-west Indian Ocean (management and financial services, port and entrepôt facilities, etc.).

3. With "continuing education" undoubtedly becoming a prominent feature of the University in the foreseeable future, attention should also focus on the associated problems and prospects. Biotechnology, energy, marine resources, and micro-electronics, appear to offer useful areas to begin with.

4. Among other areas of interest are:

   (a) helping to identify and close "gaps" in scientific and technological systems;

   (b) the process of popularization of science and technology in a society committed towards becoming more science-based to avoid poverty, if not enhance prosperity, but lacking newspaper science correspondents;

   (c) helping in the re-orientation of science education systems in the secondary schools to enable science to contribute more effectively to technological and economic prosperity in the short term;

   (d) helping with national policies with respect to science for technology for development. In the immediate, attention should be paid to the elaboration and use of appropriate indicators to assess research and development (R&D), and "Mauritius 2000" in particular.

5. A number of interlinked studies would be crucial on industrialization, e.g. what are the mechanics, implications and repercussions of the setting up of new industries and the continuous creation of job opportunities; the type and characteristics of the industries or occupations; the training and skills required; the age-structure and male/female distribution of the changing labor force; the impact of wage structure; the amount and type of investment; the contribution to standards of living and socio-economic development generally; the impact on industrial relations and productivity; the world of work of tomorrow; the new industries or occupations of the early 21st century and their organization?

6. In addition, various topics in the social sciences would also be relevant: What makes Mauritian society tick? What are the underlying factors governing behavioral patterns in its special multi-cultural complexity? How will the spirit of entrepreneurship and initiative be maintained or enhanced? What will be the shape of the welfare state of the future?

7. Furthermore, health-related studies would be most useful. Mauritian society is still largely conditioned by diets appropriate for heavy physical work rather than a sedentary way of life, with consequential health and medical problems. There are also problems arising from increasing levels of stress associated with rapid industrialization. Where should emphasis be placed in research: community health/community medicine/health systems (where an undoubted gold mine of knowledge exists to be tapped), or high technology medicine (and for which there is undoubtedly a potential, if not an existing, demand with R&D implications, in terms of technology transfer to begin with)?

4. POPULATION

In 1981, a number of projections up to the year 2025 were made concerning population as part of "Mauritius 2000," using the conventional "low," "medium" and "high" variants, and covering population size (1.25 million by the year 2000 and between 1.50-1.65 million by 2025); age characteristics (the economically active population from 15 years to just short of 65 years of age reaching around 850,000 in the year 2000; those above 65 years growing proportionately more than the total with time); the labor force based on the sex-specific labor participation rates projected from 1982 in the National Plan, 1980-82 (around 480,000-485,000 by the year 2000, between 545,000-570,000 by 2010, and to between 585,000-635,000 by 2025); student population numbers for the primary and secondary education levels; and so on.

Those projections should be continuously revised in the light of updated information concerning, for example, fertility and mortality rates, and sex-specific participation rates in the labor force. Many aspects have already been mentioned under The Environment or Technology, Economy and Society: thus town and country planning, welfare state, industrialization, health-related studies, and the like, which also properly belong to population.

And clearly there are close dynamic interlinkages among those several (and other) components. Thus, in one of the earliest "Mauritius 2000" exercises, the following features (among others) were emphasized:

1. Increased housing facilities and associated infrastructure required for a better standard of living for more people may by the year 2000 be absorbing as much, or more, prime agricultural land as would be needed for the production of potatoes and tomatoes. Should Mauritius not take more drastic action to prevent the steady encroachment of agricultural land? Should there not be resolute action to build on mountain flanks, for example?

2. If the then current level of non-sugar food production were to remain less constant, then Mauritius would be importing twice as much food by the year 2000 (expressed in terms of kilocalories of food energy and in terms of

kilograms of protein) at prices which in all probability would be much higher in real terms.

We conclude our survey of "Population" with a matter of vital importance for the University of Mauritius, namely manpower planning. National forecasts do not exist in Mauritius for the specific needs of higher education, e.g. how many biologists (or even scientists generally), civil engineers (or even technologists generally), would be required in Mauritius by the year 2000 (or even over the next three years). The University has had to fend on its own, only to be criticized *ex poste* for not satisfying manpower requirements in periods of slumps and booms, which no one had forecast *ex ante*. Thus employers in the private sector who thought the University of Mauritius had done its sums wrong in the early 1980s (by overproducing), were also caught by the depressed economic conditions. Within a period of three months between the preparation of university advertisements for courses for 1986-87, and the closing date for submission of completed application forms by aspirant students, the Mauritian private sector had shifted from the pessimistic outlook prevailing since the late 1970s to a highly optimistic one - what manpower planning techniques can cope with such a state of affairs?

The approach to manpower planning at the Réduit campus developed over years of experience, has been pragmatic, relying on making intuitive medium-term sense from various, often conflicting, signals emanating from both public and private sectors on the economics-employment interface. But there have been more formal exercises as well. Thus on the occasion of its 21st Anniversary celebrations in 1986, the University rendered public its perceptions of the engineering needs of Mauritius up to the year 2000, and pointed out that it should be equipped to at least triple its production of B.Tech. graduates in a sustained manner. By and large, reactions ranged from "highly skeptical" to "very hostile;" some members of the engineering profession even argued that the then number of engineers in Mauritius was "excessive" (at 300). In the process, the University's plans for expansion were deemed as highly premature, if not pure "ivory tower dreams." Today, the private sector is crying aloud for engineers.

Academic staff at the Réduit campus now numbers 112. The student population is now 1500, and is scheduled to double over the next three years or so through a Physical Development Program. And yet the fundamental issue remains: What blend of vocational and non-vocational training should the University aim at? And towards what sort of overall student population? For example, that population could well cross the 6,000 mark in the last years of the 20th century, based heavily on non-vocational "open university" type degree courses, along with a whole range of new vocational courses, e.g. biochemical engineering, marine sciences, biotechnology, new management courses, health and medical sciences, and so on. But if there are bottlenecks in employment, society and the government may not accept, or be prepared to pay for such a size. On the other hand, developments in educational technology might very well move the issue outside the control of Mauritius altogether, in which case it might be best to proceed nonetheless towards the sort of size implied within the educational system generally, particularly concerning the secondary schools' throughput. Clearly then, employment considerations would no longer be paramount for size considerations; those will be vital, however, for "streaming" purposes, i.e. how many for which vocational courses.

5. FUTURE CHALLENGES FOR THE MAURITIAN ECONOMY AND SOCIETY

Perhaps the most convenient way for me to introduce this particular area for "Mauritius 2000" is to refer to the Agricultural Diversification Seminar held jointly by the University and the Ministry of Agriculture at the Réduit campus in August-September 1980, and to my Welcoming Address in particular (Journal of the University of Mauritius, 1981).

Not only is sugar cane the most efficient converter of solar radiation energy into dry matter that we have for commercial exploitation under our bioclimatic conditions, but it is the crop that has, over the years, proved to be the most suitable one to cope with bio-weather, and pest and disease conditions prevailing in Mauritius. The sugar industry from the 1830s has built up massive and efficient support structures ranging from research and extension to credit and marketing facilities; indeed one of the very reasons for the relative lack of success of non-sugar agriculture here has been the contention that, unless similar facilities are provided to the latter, there is no point in paying more than lip-service to agricultural diversification. Further, the sugar cane is not just a crop in Mauritius: it is deeply embedded in our way of life; it is part of our society. With justification, it might even be argued that "Mauritius is the gift of the sugar cane." "Or has it become a curse?" I asked. If food supplies are becoming more expensive and more difficult to secure from overseas, then is it not better on social cost/benefit grounds to produce our own at the expense of sugar cane? The problems are the "ifs," the reliability of social cost/benefit analyses, the major social problems of who produces the food, and at the expense of whose canes?

The short term fluctuations in energy supplies and prices further complicate the issues involved. For the sugar cane, long regarded as a provider of sugar to be used as a sweetener, and whose demand was seemingly levelling off, if not declining, must now be looked upon as a provider of energy and a raw material for chemical products (other than saccharose). Just how does one make cost/benefit analyses in such circumstances (then in 1980 and, indeed, right now)?

I pointed out that two extreme alternatives remain:

1. Keep the present area of sugar cane intact; produce food as much as possible, or desirable, over whatever area is left over with appropriate support measures. The corollaries here appear to be:

(a) the support measures must be seen to be durable and set at appropriate levels - a nice exercise in economic management which generally succeeds only in highly subsidized agriculture;

(b) bankable assurances must be obtained that we would be assured of our food supplies at prices we can afford from overseas - a nice exercise in international diplomacy.

2. Produce all our food requirements with a consequent reduction in sugar production. The latest round of calculations at the University puts the reduction in sugar production at 20%-30% of current normal production for self-sufficiency in our food requirements. The corollaries here appear to be:

(a) the problems mentioned before must be solved to the satisfaction of all and sundry involved in the process - a nice exercise in socio-politico-economic management;

(b) massive support measures must be instituted - a nice exercise in institutional and financial management.

In between are numerous variants consisting of various blends of the two extreme alternatives. The point to bear in mind in finding our way out is that none of the alternatives that might be adopted can be implemented overnight. Thus the second alternative would normally, if widely accepted, take between eight to ten years to implement. And herein might well lie the solution: continue with the first alternative and move steadily towards the second alternative in accordance with a phased program of implementation after thorough and comprehensive studies; shift emphasis in accordance with the results stemming from the studies; take decisions, admittedly on political grounds, but after allowing free interplay of ideas from various sectors of the nation.

"The studies then are of crucial importance, but it is also important to look at some other factors," I emphasized, in "restating the obvious," thus:

1. The task of actually producing food, when all is said and done, is that of food producers, individually or in whatever group or organization they have chosen to operate within. To do so efficiently, the food producers will need support measures of one kind or another - this is where the government, its parastatal bodies, the University and other institutions come in.

2. There is a considerable array of measures which food producers, despite contrary claims, can adopt by themselves to help themselves without necessarily waiting for State intervention. In the final analysis these measures depend on the sort of organizational structure and management practices the food producers choose to adopt.

3. It is crucial to realize that there is a strict limit on the financial resources Mauritius can devote to support its agriculture, as well as making provision for a whole range of welfare measures to the population at large. Within an overall financial envelope of welfare measures, it is crucial to choose those which will enhance and not hamper agricultural diversification; many an "obvious" measure has turned out to be detrimental in Third World conditions.

4. In particular, however admirable a policy of providing "cheap food" is - and this is official policy - it is necessary to examine whether such a policy will not, in the end, be detrimental to the socio-economic development of Mauritius. Many a country has come to live, and progress on a policy of "expensive food."

5. Among the support measures which the government can and should provide for, directly and indirectly, are: research and extension; credit facilities beyond what ordinary commercial banking can provide; facilities for the disposal and storage of food items which are beyond the capabilities of producer groups to provide; and measures to regulate the marketing of food items.

To conclude, I stressed that the University remains ready and willing to contribute by way of ideas, proposals and plans concerning production, distribution and consumption of food items, in terms of research, monitoring of action programs, and, of course, in looking at the future.

It has already been anticipated, when action was initiated on the "Mauritius 2000" concept, that there would be interactions among the various exercises, necessitating revising initial aims and objectives of each separate one, and the overall project. Input-output relationships among research areas of "Mauritius 2000" have to be continuously borne in mind. Moreover, the question of how best to integrate the various "Mauritius 2000" exercises into an overall dynamic framework has had to receive attention. That, in particular, implied the necessity to use or develop a methodology of long term macro-economic scenario-building appropriate for a small highly-open economy, still periodically disturbed on a relatively large scale by vagaries of the weather with, on a mathematical basis, the handling of discontinuous rather than continuous functions.

Nonetheless, to start with, a multiple regression analysis was thought of and data began to be collected. However, it soon became available to the University team because of their confidential nature.

The following thoughts were thoroughly aired in March 1985 at a workshop to reach agreement with the Ministry of Economic Planning and Development (MEPD):

1. A crucial objective of the "Mauritius 2000" studies is an evaluation of the possible outcomes for Mauritian society over the long run, e.g. over the period ending in the year 2000, allowing an identification of required

measures for favoring desired outcomes, while bringing forth those dangers and opportunities usually not presented in a five-year plan. Moreover, long range studies would allow policy-makers a chance to view trends without the distortion of the immediate short-run pressures they face in day-to-day decision-making, and provide a perspective for the formulation of short term action programs. Although particular strategies need not necessarily emerge from "Mauritius 2000," the identification of the limits, constraints and interactions across sectors of the economy, will enable policy-makers to have a sense of possibilities and of the measures required to achieve desired objectives.

2. In particular, the MEPD would be able to use the results of the study to orient its (then) newly adopted two-year rolling plan so as to ensure that the objectives desired for the year 2000 (for example) can be achieved. Further, the project's results should provide an opportunity to use the government budget to provide the necessary measures and incentives that will allow fulfillment of desirable outcomes.

3. "Mauritius 2000" thus is not in conflict with either the planning, or budgeting activities of the government, but on the contrary can be used to reinforce and strengthen and orient these activities. There is need for striking the right balance between the conflicting aims of academic freedom and government confidentiality.

As a first step, the "Revised Minimum Standard Model" (RMSM) developed by the World Bank and already adapted and utilized by the MEPD, could with advantage be adopted. For that purpose, four macro-economic long-range scenarios were intuitively elaborated, with two versions to cover the most pessimistic (MAYDAY) and optimistic (SYMPHONY) outcomes felt to be possible. The other scenarios are "most likely" outcomes with the main difference being GDP growth rates (DOOMWATCH and MODESTY). Details of working assumptions for each of these "starter" scenarios are given in the Appendix.

It is crucial to appreciate that such scenarios are, in the final analysis, projections and are subject to amendments in the light of continual changes with respect to both cover and quality of information over time. Very often, the elaboration of scenarios is done to identify how various forces will impinge on society in the future so as to work out well beforehand, the sort of measures a society must take to shift, as it were, from one scenario to another, deemed to be more desirable by those conducting the affairs of that society on the latter's behalf. The elaboration of scenarios is meant to be of help to political decision-makers and must not in any way be seen as a substitute for the latter - political decision-makers, whatever label they may wear, constitute an inescapable fact of life in human society.

It must be added that there is nothing particularly sacrosanct about the year 2000 as such. The "Mauritius 2000" concept is a flexible one which enables the University to use a fairly long time-horizon to build alternative internally consistent scenarios, working backwards to the present in attempting to find solutions, practical in nature, to existing and foreseeable problems within an integrated and dynamic context. Indeed, a large part of "Mauritius 2000" involves explorations well into the 21st century.

At this stage, it is convenient to mention how work in one area, Energy, was to lead to the new integrative machinery which is now in use. Interest in energy matter grew, as was the case in many countries and universities, from the mid-1970s, including projections on energy supply and demand. Again, two broad approaches came to be used. There was, first, the conventional multiple-regression analysis approach. Those involved therewith were to report growing problems, including a steadily lowering of the correlation coefficients the longer the time horizon used - beyond approximately seven years or thereabouts. However, independently both at the Réduit campus and at the University of Tennessee, elasticity studies linking gross domestic product (GDP) and energy consumption came to be successfully investigated. Subsequently while seeking to refine that work, the first echoes from an FAO publication of what subsequently came to be known as the Enhancement of Carrying Capacity Options (ECCO) reached the Réduit campus. Developed under the aegis of UNESCO and FAO, and first tested in Kenya, ECCO came to be used for scenario building in Mauritius with the results of the separate exercises, notably energy, food and nutrition, and physical resources planning, feeding into the overall exercise. The outcome has been described in various reports (e.g. University of Mauritius, 1987; King, 1987), wherein the basic methodology of ECCO is described.

Beyond Economic Choice (King, 1987) described nine basic requirements of a methodology for assessing carrying capacity. These are summed up thus - the methodology must:

(a) operate at a national level;
(b) be dynamic;
(c) relate the rate of development with the rate at which physical resources can be made available;
(d) take account of the long term;
(e) be able to measure trade-offs between alternative uses of natural resources;
(f) take account of the demands imposed by population on a nation's resource base;
(g) give due weight to factors of a socio-cultural nature;
(h) consider energy, and
(i) embrace environmental factors.

The following notes are relevant:

1. While conceptually numbers that fit into a resource accounting study are energy units, it is perfectly practicable to use a surrogate of constant money units, so long as it is understood that they stand for energy and cannot go

round and round. This aspect has been fully utilized in the Mauritian adaptation of the initial Kenyan ECCO methodology.

2. ECCO, therefore, does not presume any specific theory of economics. It is, essentially, a feed-back structure. The economist wishing to test whether the policy resulting from a specific view of the economy (Keynesian, monetarist, marxist,etc.) is physically feasible, can use ECCO without abandoning the principles upon which the perceived policy rest.

3. ECCO is, hence, a tool for testing the feasibility of policies, which may have been arrived at by the application of economic theory, political processes, or intuitive feelings. Though the underlying concept within ECCO is applicable to any country, it is not a "black box" into which one may plug some notional generalities, but depends on the conditions of the country. The structure of ECCO must be adapted accordingly.

A first set of ECCO exercises was carried out in 1986-87 using 1980 as a reference year and 1983-85 data, and including results from certain "Mauritius 2000" exercises, as noted previously. Before looking briefly at the results, the following definitions should be borne in mind:

1. Carrying capacity is that size of population at any moment in time, which can be indefinitely sustained by a given territory at a given material standard of living.

2. Material standard of living (MSOL) is a parameter which reflects that which the individual citizen may (on average) have available to spend after meeting basic requirements, and as such is a measure of an individual's freedom to spend beyond essentials. It includes that part of output which is consumed (as opposed to being invested) plus imported manufactured goods (but not raw materials) plus output of services.

3. Sustainability ratio is the ratio of the total energy generated within a country divided by the total energy required to run that country's economy, all energies being converted into one common form and quality, e.g. "220 volt electricity."

From a reference profile (essentially "business as usual") projected up to the year 2025, several variants have been worked to produce, first, single-policy run scenarios (e.g. variations concerning population growth rate); and second, multiple-policy run scenarios (involving, e.g. population, food, sugar production, energy, export processing and services, tourism, water resources and biomass creation). By 2025, on the reference run, and compared with 1985, population grows to 1.57 million, the standard of living falls by 50%, unemployment rises to 46%, and the national debt increases three-fold. On the other hand, and again compared with 1985, a multiple-policy run shows the population reaching only 1.2 million, a material standard of living increasing by 75%, food self-sufficiency increasing five-fold, unemployment dropping to 1.7%, the national debt increasing, all by 2025.

It is also useful to mention a couple of separate single-policy alterations to the reference profile:

1. Intensification of sugar production to release land for food.
   Here self-sufficiency in carbohydrate rises to nearly 50%, unemployment decreases to 38% by 2025, but the material standard of living falls (although less than in the reference run).

2. Growth of the Export Processing Zone continues at 7.5% p.a..
   By 2012, unemployment falls below 2%; thereafter either labor has to be imported, or withdrawn from other activities (clearly there would be repercussions on wages and other conditions of work). Material standard of living increases (with further demands of imported goods, housing and services). However, energy and water requirements also increase considerably (investment implications). Altogether, there is a declining level of sustainability - the economy becomes even more fragile. In parenthesis, it should be noted that the labor situation depicted above is now on the verge of being attained 22 years ahead of time - illustrating again the necessity for multiple-policy scenarios.

Subsequent work using 1985 as base year and 1985-87 data, including more results from other "Mauritius 2000" exercises, has more or less confirmed the above-mentioned projections and, hence, serves as partial validation of the method.

To end this part of the paper, it should be emphasized that while ECCO is most promising in terms of integrative methodologies for "Mauritius 2000," a number of points remain to be addressed as a matter of some urgency.

1. ECCO seeks to bring forth long term physical relationships that are consistent with the physical laws of science, but economics remains the most appropriate discipline to study the needs and desires of people, despite shortcomings it may have relating to the long term. It is, therefore, important to link the latter with the physical laws of nature for long term future work; the quest for a consequential "grand theory" should be placed on the agenda.

2. The concepts and techniques of national accounting are carried out within the context of a United Nations Convention to ensure broad comparability across time and space. Similarly, an International System of Resource Accounts, along the lines of the UN System for National Accounts, should be elaborated.

3. Meanwhile, it appears desirable to carry out long-range future studies using both the ECCO methodology, and conventional money models (even if the latter tend to underscore the ever-increasing impact of science and technology in, and upon, society).

6. CONCLUDING REMARKS

1. There is no separate budget for "Mauritius 2000" at the Réduit campus. Staff time is paid for from the operating expenses of the University, as well as the use of existing buildings and equipment. However, grants received from various international agencies help in terms of new, small capital items. Of particular importance is the help given in terms of staff training and exchange, advice on specific exercises and small equipment by the Higher Education Division of the British Council, which in many ways, underpins the whole project. UNESCO, IDRC, the Commonwealth Secretariat, and the U.K.'s Overseas Development Administration have also been highly supportive on specific aspects, such as ECCO and Energy Studies.

2. "Mauritius 2000" is, in many ways, a "marginal" activity in terms of resource inputs. This sets limits to the pace and extent of the work. On a full costing basis, with adequate physical and human resources, "Mauritius 2000" was estimated in June 1985 to require US$ 5 million over the period 1985-90. This is a far cry from the actual current position of non-staff expenditure and staff-time equivalent, altogether amounting to US$ 0.33 million per annum (inclusive of overseas aid), or roughly one-third of requirements.

3. Moreover, with the expansion of university activities, a recasting of British Council assistance is likely to occur towards Pure Sciences, Humanities, B.Ed., and distance education teaching activities.

4. Although originally the intention was to restrict the number of working groups to four, or thereabouts, the intricacies of multidisciplinary team work have been such at the Réduit campus, that a larger number of groups has, in practice, come about even when operating on the "swim or sink" principle. However, the idea still remains for a smaller number of aggregated topics to be resorted to, particularly for overall scenario constructs.

5. The IIASA research framework with emphasis from the very outset on integration (under the four major headings of The Environment; Technology, Development and Society; Population; Systems and Decision Sciences) is a very appropriate one for the present stage of "Mauritius 2000." Not only will attention be focussed on the aggregation procedure mentioned at (4) - with consequential reordering of priorities and efforts - but also on the "final" output in terms of a book. In addition, the necessary "product-oriented" funding under the aegis of IIASA should prove most welcome.

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APPENDIX

MAURITIUS 2000 ALTERNATIVE SCENARIOS : ASSUMPTIONS

MAYDAY	DOOMWATCH	MODESTY	SYMPHONY
1. Enough Cane Production for self-sufficiency	1. Enough Cane for EEC + self-sufficiency + stock contingencies	1. Ave Cane production 11 to 12 million tonne p.a.	1. Ave Cane Production 11 to 12 million tonne (higher fibre content e.g. x 2 existing, with sucrose % cane as existing for agro chem. plus energy (not sweetener)
2. Food Self-Sufficiency	2. 75% food self-sufficiency	2. 50% food self-sufficiency (intensive)	2 50% food self-sufficiency. (very intensive)
3. Energy Farming (cane?) 4. Intensive Small Farmer Sector (2 above) intensive agro-forestry systems, etc	3.)Primarily intensive small farmer)sector for 2 above; plus intensive 4. agro-forestry. biomass; bagasse	3.)Intensive Small Farmer)Sector (around 50%). Int. Agro- 4.)forestry. Biomass; bagasse Energy 300 GWh	3.)Very Intensive Small Farmer Sector)(around 50%). Int. Agro-forestry 4. Biomass; bagasse. Energy 600 GWh.
5. EPZ collapses into self-sufficiency activities EEZ: no development	5. EPZ/Exp. Serv. Zone: overall level of manuf activities = '1984' level. EEZ ?	5. EPZ/ESZ steady expansion four times GDP rate; overall Manuf. twice GDP rate. South West Indian Ocean Commission. EEZ starts being exploited.	5. EPZ/ESZ expands faster cf Modesty. Indian Ocean Comm. E & S African Pref. Trade (+EEC, USA, etc.). EEZ: exploitation actively pursued.
6. Tourism main export earner (unless collapses, 9, 10, 11)	6. Tourism more important than (5), less important than (1) for GDP.	6. Tourism expands at 3 x GDP rate	6. Tourism expands faster cf Modesty.
7. State support measures for destitute only. 8. Full Economic cost approach to other users of welfare measures	7.)Volume of state welfare measures)at '1984' level but at ½ economic 8.)cost to users.	7.)Same as Doomwatch but (i) reorganised)on contributory basis; 8.)(ii) 1/3 econ. cost for users. Unempl. Fund. Water: 24 hrs/day supply to all users.	7 Welfare State reorganised & 8. Contributory (Health, Education, Social Security/Unempl. benefits) around 15% of econ. cost. Water 24 hrs/day supply to all users. All families properly housed with full amenities. Transportation, phy. dev. planning optimal.
9. % Unemployed rises beyond 20%	9. % Unemployed: 17%	9. % Unemployed decreases	9. % Unemployed declines faster cf Modesty
10. Status of women worsens	10. Status of women around 1984 level of early 1980s	10. Status of women improves	10. Status of women at par with that of industrialised countries in early 1980s
11. Fast growing social unrest, social barriers heightened; increased emphasis on law & order	11. At more moderate rates cf. Mayday	11. Around '1984', with barriers gradually down	11. Around '1984', with rel. few barriers
12. GDP = Rs10,550m at 1982 factor costs.	12. GDP = Rs13,200 m at 1982 factor costs growth rate per head = nil	12. GDP = Rs18,050 m at 1982 factor costs. Growth rate per head = 2% p.a.	12. GDP = Rs42,200 m at 1982 factor costs. Growth rate per head = 7.5% p.a.

NOTES : 1. Cane, not necessarily sugar. EEC : Europe on Economic Community.
2. Food Self-Sufficiency in terms of Kilocalories and Kilogrammes of protein.
Conversion into specific items (e.g. potatoes), implications: food habits, 'new' food products.
5. EPZ = Export Processing Zone; EEZ = Exclusive Economic Zone (1.7 million km^2).
ESZ = Export Services Zone; GDP = Gross Domestic Product at factor cost.
7. '1984' = average of 1982 to 1986 in constant 1982 factor costs; Table IV.2: 1984-86 Development Plan; MEPD; p.32.
12. In 1982, one US dollar was worth around 11 Mauritian rupees (Rs).

General : There are other assumptions implied in the scenarios e.g. investments, savings, government budgetary deficits or surpluses, balance of payments etc.

21st August, 1990

JM/sl

Chapter 3

POPULATION, DEVELOPMENT, AND THE ENVIRONMENT

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1. CAUSAL INTERPRETATIONS OF THREE FUNDAMENTAL VARIABLES

Environment, development and population are three variables that interact with one another. We may think of the three as forming a triangle, and on each side of the triangle are causal relations in both directions. Based on simple permutations we can assert that that gives 6 relations involving two items, and another 6 involving three. I was surprised to find that the literature includes examples of all of these 12 kinds of interaction. What follows is far from exhaustive, but it is hoped that the examples will be illuminating, and will lead to a more unified and comprehensive model in which reciprocal interactions will have their due place.

Causal interrelations among three fundamental variables

Dev-->		Env	Positive or negative depending on technology
Env-->		Dev	Provides raw materials or fails to provide
Dev-->	Pop-->	Env	
Env-->	Pop-->	Dev	
Pop-->		Env	Stress on Env greater with more Pop
Env-->		Pop	Pollution can raise death rates
Pop-->	Dev-->	Env	
Env-->	Dev-->	Pop	
Dev-->		Pop	Dev solves the classical Pop problem
Pop-->		Dev	Rapid Pop growth hinders development
Dev-->	Env-->	Pop	
Pop-->	Env-->	Dev	

The point of reviewing these here is that the relations are not equally operative for all countries, and it helps the formation of policy to know which are the most important for Mauritius. No country has unlimited capacities for action, and a scheme of priorities is needed. One would like to establish the priorities with the help of empirical data, but I do not have either the data or the techniques for doing that. Perhaps you have suggestions. What I will do is to cite some of the literature in the hope of clarifying the relations, and, to repeat, hope that we can ultimately end up with an integrated model.

Development --> environment. Development can affect the environment favorably or disastrously, depending on how it is carried out, what technologies are engaged, how large is the developing population.[1] It can be argued that it is in the early stages that this effect is most conspicuous; witness the smoke-blackened Potteries in 19th century, or the similar effects of the burning of coal in Chungking and other parts of China. On the other hand late development with its extensive use of automobiles has a different impact on the environment that may be equally undesirable.

> What is wanted is a line of development that is environment-neutral; that does not mean leaving the environment in exactly the same condition as before it began, for to do so is impossible; environment-neutral means leaving it in equivalent condition as far as the livelihoods and amenities of the succeeding generation are concerned.
>
> The treacherous feature is the delay in the response of the environment to abuse; it is not so much the prosperity of the present generation that is at stake as the welfare, even the survival, of the ensuing generations. There is a paradox here: development requires sacrifice of those presently undertaking it, in the form of work, and saving, abstinence from the fruits of the work, so that it is something bestowed by the present generation on their descendants, a gift, an inheritance, an endowment. That is exemplified by examination of any case in which development has actually taken place, from 19th century England through late 20th century Korea; hard work and delayed satisfaction are seen in all. If the development is accompanied by destruction of the environment, then it is wiping out its benefits for the very people it is intended to serve: the descendants of the generation now sacrificing.

Development --> environment --> population. With orderly development in an environment-benign path the capacity of a territory to maintain population can be increased. (The path being followed throughout the world now is not environmentally benign, but let us suppose a configuration of technology such as recommended by Barry Commoner.)

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[1]That excessive population is the culprit has been argued by the Ehrlich's; that technology gets the blame is the thesis of Commoner: Ehrlich and Ehrlich, 1990; Commoner, 1971. Yet in fact neither of these excludes the other, as both the protagonists agree. For policy the question is which one should we act on to secure the most protection for the given effort.

A rich Bangladesh would be able to build dikes in the Dutch style, and behind them have increased territory for agriculture and other uses. But its development process depends on the control of population, among other things. Thus we conclude that population control now could well permit larger population in later generations. If a country wants to maximize its ultimate population, and we do not assert that it should, its best strategy would be to limit population now and then expand after it had the facilities that come with increased wealth.

Environment --> development. Deterioration of the environment, exhaustion of materials, directly and indirectly checks development.[2]

Sensitivity to the environment will lead to better choices of project, more judicious selection of the path of development. With books that are properly kept the sale of raw materials would not show up as development (see Repetto et al., 1989). Sale of mineral or forest products is legitimate enough, but in reckoning the contribution to development the value of the raw resource ought to be deducted. It is right for Indonesia to forbid the export of logs, since on a proper accounting that is not durably profitable for the country; converted to plywood or to furniture some part of the selling price constitutes genuine income.

More difficult for bookkeeping are side-effects of development that damage health and amenities: unbreathable city air, disease-carrying water. They suggest that beyond the proper set of books that would take account of the value of resources is a wider definition of development in terms of quality of life.

Population --> environment. The demands of the population on the environment are proportional to its numbers; the corresponding stress on the environment at low levels of population is proportional to numbers, at high levels of population much more than proportional.

I have shown elsewhere (Keyfitz, 1990) in relation to fisheries and forests how at the moment when a resource starts to diminish worldwide the market can raise prices so as to increase the catch effort, and the resulting non-linearity accelerates the decline of the resource. Prior to this, before there is serious pressure on the resource, the population impact will be linear, i.e. simply proportional to the number of people.

[2]A convenient review of the main economic-development models is provided by McNicoll, 1975.

It has been argued that population density can be constructive in leading to changed institutions (National Academy of Sciences, 1986), in particular the privatization of resources that withdraws them from the commons.[3] With privatization land will be better cared for, without doubt, but whether population density will lead to that is far from clear. Dense populations that need firewood for cooking level the forests in parts of Africa and in Central India. The authorities are more than aware of the problem and would like to assign the forests to someone who would look after what he had within his own boundaries, but this is politically impossible to legislate and practically impossible to police if it could be legislated. Even if they were willing to use force the authorities have no way of keeping local people out.

A major defect of much theory in the field is its inability to take account of scale, as Herman Daly (1986) has pointed out. It is easy to believe that twice as many people in the forest will need twice as much firewood to cook their meals, and that they will therefore put twice as much stress on the forest. But if they keep increasing they will come to a point where they interfere with the natural process on which they are dependent. Theory that is to cover this must include some of the biology of forest reproduction, and that is not ordinarily a part of social science. Whether social theory can handle it or not we have to accept that at some point an increment of population cannot have a corresponding increment of firewood however badly it wants it, simply because the trees are not there. That is the element of non-linearity of stress to which any resource is subject beyond a certain point in the face of rising need for it.

Disregard of this point goes all the way back to Malthus, or at least to his vulgar interpreters. If we think of the gamut from no people increasing to a population standing elbow to elbow then there is a certain range within that where more people mean a proportional strain on the resource, but below that density it is possible that more people are not a strain at all. Trees and fish die anyway, so up to a point they can be harmlessly exploited, beyond that point the damage or stress is linear, at least to a second point. And beyond that point the stress becomes nonlinear, and can rise very quickly.

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[3]The idea goes back to a work of Durkheim, first published about the beginning of the century, The division of labor in society. For Durkheim the division of labor, equivalent to what we now call development, arose because in the press of competition as societies became larger and denser, individuals sought shelter in specialization. People following each trade and profession can face competition indeed, but at most from others with the same skills. The locksmith is not in competition with the bricklayer. One can agree with Durkheim without admitting the application of the mechanism to much higher levels of density than he contemplated.

Environment --> population. Pollution of the environment can raise death rates.

Pulmonary and cardiovascular disease is increased by polluted air, and contagious disease by polluted water. Insofar as these raise death rates there is in some cultures a more than offsetting increase of birth rates.

We have to distinguish between adverse effects of nature and those of human activity. Environments that are naturally harsh do not show especially high death rates. New England with its cold winters actually has a lower death rate than Florida. That could be due to the selective effect of migration between the two, but what about the Scandinavian countries where migration is slight, and that have some of the lowest death rates in the world despite their rigorous climate. Some of the low mortality is due to cultural adaptation over the centuries. Such adaptation occurs generally in the face of natural environmental severity, but not so readily in the face of anthropogenic interference. We can hardly imagine cultural (or genetic, for that matter) adaptation to excessive ozone in the lower atmosphere.

Population --> development. Rapidly expanding population slows development--through pushing on the limits of land and capital.[4]

If land (standing for resources in general) is limited, then its division among more people will make each of them poorer, and quite in addition to this is a regressive distributive effect, as Ricardo showed. These considerations have become less important with the development and application of knowledge to economic innovation, permitting various kinds of substitution for resources.

On the other hand capital is scarce, and never has the demand for it been more widespread and active than now. In the face of capital scarcity more population checks development though a) dependency ratios and b) unemployment.

Quite independently of the direct effect of population on development is its effect via the environment. Thus we have a three-element causal sequence:

Population --> environment --> development

taking in all sides of the triangle, with environment now an intervening variable between population and development.

[4]There is some uncertainty how strong the effect is here; see National Research Council, 1986.

Development --> population. On the other direction of causation, slow development keeps the birth rate high.

> The demographic transition does not take place among people who are very poor (Notestein, 1944). Education helps independently of income, but it in turn depends on income; poor people need the labor of their children and cannot afford to leave them in school after they have learned to read and write. Thus we again have a three element causal sequence by which development aids population control through education:
>
> Development --> education --> population control
>
> so education is an intervening variable between development and the control of population. In this instance there is probably also a direct effect of development on population, along with the indirect effect through education.

One of our next tasks is to find what other variables ought to be introduced into such schemes, either as operating directly or as accentuating or attenuating, initiating or mediating, the effect of the three basic variables here discussed. Tracing those effects empirically, finding the strength of the different paths here sketched, is essential for drawing up policies that will stimulate development.

Development policies are mainly the charge of national governments. Few think that the nation-state is the ideal form of organization, but most accept that it is the framework within which the dominant political activity in the world today proceeds. If runaway populations are to be brought under control as quickly as possible, national governments will have to play their part. And equally if the environment is to be protected it will have to be by rules set by governments. Let us look briefly at the role of nationalism in population and environment policy.

2. POPULATION, ENVIRONMENT AND DEVELOPMENT IN EVOLVING NATION-STATES

A sense of nationalism that moved through the colonies of Britain, France and Holland after World War II mobilized their populations into an irresistible force that expelled the foreign rulers. In some instances--Indonesia for instance-violence was necessary; in others peaceful negotiation accomplished the separation from the colonial power.

For Mauritius the British read the book of history, accurately deciphered the trend, and gave political rights and set up a representative assembly in 1947. They gracefully withdrew in 1968 at the request of a majority in that same assembly.

Since independence nationalism in Mauritius as elsewhere has gone through a series of changes. It is instructive to trace these in the world as a whole, and to show how the logic of development can hopefully cause nationalism to continue its evolution in a positive direction.

Two features of the early postwar nationalism were its concentration on population and the economy. The more people the better; the countries were poor; the colonial powers had left something behind, but not much wealth for the average citizen; whatever wealth the new countries had consisted their own people. Sukarno in Indonesia was one of the most insistent in expounding the need for more people; the attitude everywhere resembled that of the mercantilists writing at the dawn of nationalism in Europe. Jean Bodin in the 16th century provided a theoretical basis for the modern state; for him there was no wealth but people.

And the new nationalism of the second half of the 20th century did not trust foreigners with the economy. All of the important elements, the "commanding heights" of the economy would have to be placed under national control. Nehru, influenced by Mahalanobis, a good statistician but not a good social scientist, sought the physical control of the investment process that would modernize India; that meant among other things a state-run steel industry to produce the capital goods that would produce the multitude of badly needed goods for consumption. Everything basic and hence important: electric power, transport, telephone and other communication, had to be run by the state. The development sequence, starting with these, had to be guided by a national plan written out in advance. Marxist theory, and the Soviet practice of the time, seemed to give sanction.

It took about two decades of experience with increasing population and government constraints on investment to weaken the faith of governments and publics in this approach. More people are an increased load on the whole system; more guidance of the economy builds up and then preserves sectors--like steel--that are no longer the leading edge. Excessive central planning produces the wrong things, and produces them inefficiently. A housewife going to market can write out a shopping list that is her plan for the morning; securing the welfare of the nation is not so simple. No one can have as clear an understanding of the nation's economic objective as the housewife has of hers. Plans aroused the expectations of the population without providing realistic means to the fulfillment of those expectations. The divergence between the promise of the plans and their meager results became more and more conspicuous, starting with the USSR.

National planning is by no means terminated, but nearly every country is now moving to give it no more than its due place. Nigeria recently passed a law that allows all investments of more than $2 million to be entirely controlled by their foreign owners, who do not have to take in Nigerian partners as before, and who have entire liberty to repatriate profits. Only small shops and service establishments are reserved for Nigerians. Permission to invest is provided by a single agency, rather than by dozens; that saves time for the investor, reduces cost to the country, narrows the scope for corruption.

Notwithstanding more emphasis on population control and a market economy there is still one feature of the national spirit that has been absolutely constant: its identification with the national territory. No government could think of giving away or selling a square meter of the national territory. Even renting land for foreign bases is suspect, and trading pieces of land with other countries is repugnant, even where there would be a common advantage to the two parties. The national soil is sacred, to be handed down intact to all the following generations; it is not subject to negotiation, to truck or trade, for any purpose whatever, economic or political.

An outsider therefore finds it strange that there is no such national identification with what lies on, over, or under the soil. It is regarded as perfectly proper to sell the oil, the copper, and other subsoil wealth; to run down the soil itself by producing more peanuts than the world needs--as in Senegal--and so lower the water table and help the spread of the desert; to sell the forests in the form of plywood or furniture as in Indonesia, or to cut them down to produce beef for a few years, as in Brazil's Amazon.

Thus the spirit of nationalism has moved from having more people, to having a healthy and prosperous population no longer in rapid increase; from the state conducting all investment, to the state standing back and encouraging private capital, domestic and foreign. Can we now hope that on the geographical and ecological front there will be a move from exclusive concentration on the national territory, disregarding its natural wealth, to identification with the national territory AND its ecological content? The purpose would be a durable nation, in which development will make a better life for each succeeding generation.

It is still said that preserving the forests of the Amazon has to yield to more urgent matters, like investment in factories, paying interest on the debt and so maintaining the nation's credit standing. These are of immediate importance for development. But it is in the nature of development that it requires harder work and more saving than would be needed if there was no development. Development means that the present generation labors and abstains to accumulate capital for future generations.

Here lies the paradox in the present carelessness on ecological matters. Development is going forward with many sacrifices mostly for the benefit of children and grandchildren. Yet to accomplish the economic side by sacrificing the ecological will not leave the means for a prosperous existence to later generations. Selling off those forests to serve developmental purposes makes little sense if the supposedly wealthy descendants will inherit only a barren wilderness. The labor and the abstention of the present generation will be worthwhile if along with a prospering economy the children and grandchildren of those now alive can have a territory as naturally rich as the one that exists today. And the stress on the environment, other things equal, will be proportional to the number of people.

This is the case for the nation identifying not only with the national territory but with the content of that territory, for choosing a route of development that will preserve the ecosphere in which the economy has to sit.

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PART II.

POPULATION AND LABOR FORCE

Chapter 4

THE DEMOGRAPHIC DISCONTINUITIES OF MAURITIUS

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1. INTRODUCTION

Mauritius - situated in the Indian Ocean about 800 km east of Madagascar - has been known to mankind much longer than it has been settled. Arab merchants had it marked on their maps 1000 years ago and called it Dina Mozare, but did not live on it. The population history of the island of Mauritius started in 1638 when the Dutch East India Company sent a group of settlers to the previously uninhabited island. While the major interest of the Dutch was in cutting and selling the valuable ebony trees, the island also served as a haven for merchant ships to Asia. It is estimated that by the end of the 17th century, about 200 Dutch and 500-1000 slaves lived on Mauritius. But in 1710 the Dutch abandoned Mauritius in favor of their new stronghold at the Cape of Africa.

In 1721 a small French party landed in Mauritius, which was then called Ile de France. Soon the French East India Company brought more settlers to Mauritius. It is reported that during the influential governorship of Mahe de Labourdonnais (1735-1746), the population of the island increased from under 1000 to over 3000. Already during this time sugar cultivation was introduced, and increasing numbers of slaves were brought from Madagascar and West Africa to work on the sugar estates. By 1817 the population of the island had increased to almost 100,000, consisting of more than 80% slaves, 11% free colored population, and 8% Europeans or descendants of Europeans.

In 1810 Mauritius was conquered by the British. This made little difference to the life of the island and its people because the French were guaranteed their properties, use of language, laws, and religion. The biggest change came with the abolition of slavery between 1835 and 1839. Large numbers of indentured laborers were brought in from India to replace the freed slaves. From 1851-1861 more than 100,000 Indians arrived in Mauritius. Since that time a majority of the Mauritian population is of Indian origin. The most recent political change came with the independence of Mauritius in 1968. In terms of population trends, this had little immediate impact.

Already in the late 1940s and early 1950s, mortality had declined considerably due to malaria eradication and other health improvements. Simultaneously, fertility rates increased even further, thus resulting in a steep increase of population growth rates reaching levels of more than 3% per year. This demographic discontinuity which dominates the picture of any kind of visual or quantitative description of Mauritian population trends resulted in a large number of young Mauritians born in the 1950s. This phenomenon, together with a second remarkable discontinuity of past trends, i.e. the steep decline of fertility during the late 1960s and 1970s, resulted in an unusually large cohort of young people - the youth cohort - that will characterize the Mauritian age structure over decades to come.

This paper will be mostly devoted to the appropriate quantitative description and analysis of these two discontinuities in the Mauritian population history that may also be viewed as the mortality and fertility components of the demographic transition in Mauritius. In addition to the usual analysis of demographic transition that studies the determinants of mortality and fertility trends which together with migration result in specific growth rates and age structures, this paper will approach the phenomenon from the other end and take changes in the age structure and age-specific growth rates as the point of departure. In this it follows the example of several papers by Keyfitz (1987, 1989) on the demographic discontinuity under a global perspective and for individual countries such as Indonesia.

2. THE HISTORY OF POPULATION GROWTH IN MAURITIUS

Information From Censuses

Official census enumerations of the population living on the island of Mauritius are available from 1767 onwards. Generally the censuses were taken in ten-year intervals, with irregularities during the middle of the last century and since World War II. The censuses also give an ethnic breakdown of the population which is very informative for understanding the population history of Mauritius. The abolition of slavery in 1834 brought about a reclassification of the categories. After that year the category "General Population" includes the descendants of Europeans and the freed slave population, whereas for the Indians, the Indo-Mauritians (Indians born in Mauritius) and the Chinese, separate categories were kept in the census. Figure 1 and Table 1 give the series of censuses since 1767 (mostly derived from Central Statistical Office of Mauritius, 1956), broken down by ethnic groups.

During the 18th century the largest part of the population was slaves from Africa. A small portion of the population was white, European and their descendants. A third group, the free coloreds were about as large as the European population. Population growth from 1767 (the first year we have data) to 1834 - the year of slavery abolition - was steady and high. The average annual increase was 8%. The available data indicate that very little of this growth was natural; almost all of it was due to the import of new slaves and immigration of Europeans and others. The sex ratio in the majority, the slave population, was about 1.6 men to each woman, and the crude birth rate in that population was accordingly low - estimated at around 25 per 1000. The sex ratio among the white and free colored population was more favorable. In the colored population, it was even 0.8 men to each woman because women who married out of their race were subsequently categorized as colored. In this free population the birth rate is estimated to have been around 40 per 1000. Together, this would amount to a total crude birth rate a little under 30. At the same time, the death rate cannot have been much below 30 - the first year we have data is 1875, when the death rate starts around this level - resulting in natural growth close to nil.

In 1834 slavery was abolished, and in the same year, the active recruitment of indentured laborers from India began to replace the freed slaves in the sugar cane plantations. The white plantation owners, who were expanding their sugar production, instigated the wave of indentured labor, often misleading the Indians about the conditions they would live and work under. Initially, the laborers were mostly males and promised a free return passage, but after 1853, the planters decided it was more profitable to bring over men and women and scrap the return passage from the contract, meaning that all laborers who arrived after this date were in fact emigrating from India for good. The Indian laborers were not treated much better than the slaves, the sanitary conditions were terrible (Parahoo, 1986), and death rates were extremely high.

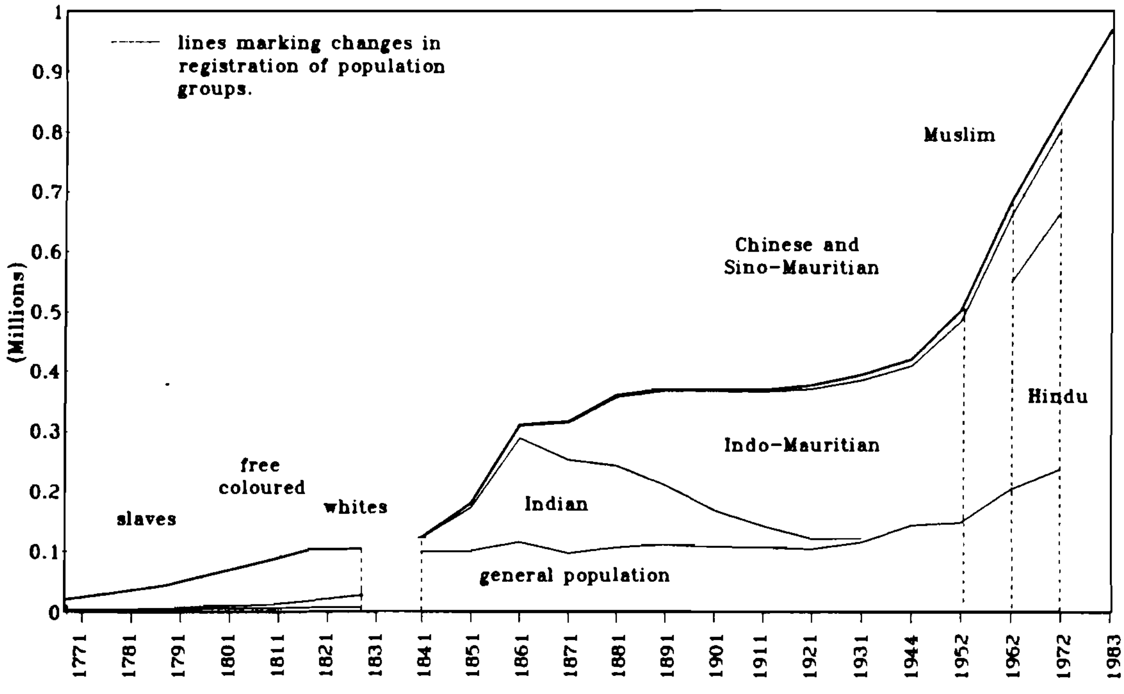

Figure 1. Population on Mauritius by groups 1767-1983. Note: Criteria were not always the same from census to census; this figure is an approximation of the population composition.

Table 1. Population of Mauritius for census years 1767-1983.

Year	Population of Europeans and descendants of Europeans	Free colored population	Slave population		Total population
1767	3,163	587	15,027		18,777
1777	3,434	1,173	25,154		29,761
1787	4,372	2,235	33,832		40,439
1797	6,237	3,703	49,080		59,020
1807	6,489	5,912	65,367		77,768
1817	7,375	10,979	79,493		97,847
1830	8,592	18,877[1]	69,476		96,945
Year	**General population**	**Indian population**	**Indo-Mauritian population**	**Chinese population**	**Total population**
1840	99,450[2]	23,490	-	1,395[3]	124,335
1846	101,017	56,245	-	1,200[4]	158,462
1851	101,527	72,180	5,816	1,300[4]	180,823
1861	115,864	172,425	20,209	1,552	310,050
1871	97,497	155,367	60,891	2,287	316,042
1881	107,323	135,595	113,398	3,558	359,874
1891	111,517	99,329	156,591	3,151	370,588
1901	108,422	60,208	198,878	3,515	371,023
1911	107,432	35,396	222,301	3,662	368,791
1921	104,216	17,056	248,468	6,745	376,485
1931	115,666	7,044	261,605	8,923	393,238
1944	143,056	-	265,247	10,882	419,185
1952	148,238	-	335,327	17,850	501,415
1962	------------------	658,561	------------------	23,058	681,619
1973	------------------	802,115	------------------	24,084	826,199
1983	------------------	---------------	-------------------	---------------	966,863

1 Includes a small number (less than 1000) of Indians and Chinese.
2 Includes for 1840 all native born.
3 Includes also some Malayans and Europeans in 1840.
4 Approximate figures.

Source: Central Statistical Office (CSO).

The immigration was enormous, and the population of Mauritius tripled during this time from around 100,000 in 1834 to 310,000 by the census of 1861. The strongest intercensal immigration decade was 1851-1861, with a total of over

100,000 immigrants. As women began to arrive from India soon after the men and Indo-Mauritian children were born, the sex ratio normalized.

Figure 1 and Table 1 show that the Indian population, that is, those born in India, Burma, and surrounding countries, began to decrease after a peak was registered in the 1861 census, particularly noticeable after the 1881 census. Since we know that almost none of the Indians returned home - who could afford the passage? - the very steep decline of the Indian population seems to be due to very high mortality rates and fewer newcomers compensating the mortality attrition.

The growth rate of the Indo-Mauritian population was initially enormous, 12% annual average from 1851 to 1861, due to the increasing numbers of immigrant Indian parents compared to the small number of Mauritian-born. By 1891-1901, this growth rate had decreased to 2.3% annual average, and in the 1920s and 1930s there was practically no growth. After World War II, the population growth among the Indo-Mauritians shot up to 2.3% per year again between the censuses of 1944 and 1952, this time being almost entirely due to natural increase.

During the century of Indian immigration and the birth of the Indo-Mauritian population, other ethnic groups in the population - previously the white, free colored, and slave population, classified as "general population" after the census of 1846 - barely grew at all. There were 101,000 general population enumerated in the 1846 census; 100 years later, there were 143,000. As the general population includes those of mixed origin, for example white and Indian origin, the almost zero growth rate of the general population may indicate that intermarriage was not common.

In the censuses of 1962 and 1972, the heads of households could themselves classify according to the categories: Hindu, Muslim, Sino-Mauritian, and General Population. In the census of 1983 no such classification was given. Over this period the total population grew very rapidly from 681,619 in 1962 to 826,199 in 1972 and 966,863 in 1983. In 1987, the population was estimated at about 1.003 million. Special attention will be given to this period of most rapid growth below.

Information From Vital Statistics

In the following paragraphs we will only describe the basic trends in the crude birth and death rates and in migration rates as far as they can be reconstructed. A separate in-depth study of the demographic transition based on age-specific rates is under preparation.

As indicated above, the early growth of the Mauritian population was characterized by immigration. Crude birth and death rates were roughly at the same level until World War II (see Figure 2) but showed enormous annual variations that are typical for pre-modern conditions. This resulted in very little or no natural growth. On the very left side of the figure, from 1875 to about 1893, the crude birth rate is slightly higher than the death rate which was probably due to a more favorable disease environment. Death rates are unstable, moving up and down around an average of 30-35. The peaks are caused by various epidemics - cholera, smallpox, the Bubonic plague in 1899 - and particularly strong hurricanes. Prior to around 1862 malaria, a major killer in subsequent years, was not endemic to Mauritius. In 1919 there was a mortality peak of more than 60 per 1000, not caused by Mauritian soldiers who died fighting for the British in World War I, but by an outbreak of the Spanish flu which killed thousands of Mauritians (Titmuss and Abel-Smith, 1968, p.49).

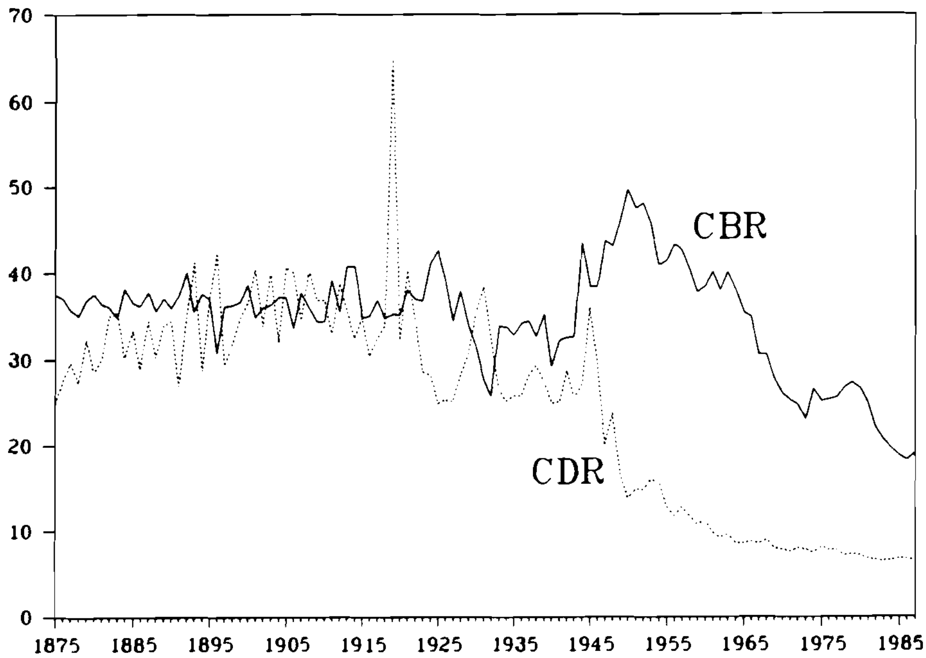

Figure 2. Crude birth and death rates in Mauritius, 1875-1985. Source: Mitchell, 1982.

In the beginning of the 1920s, mortality rates declined more consistently for the first time. During this period the water supply was chlorinated and there were campaigns against malaria and hookworm apparently resulting in the permanent decrease of the crude death rate (see Figure 2). There continued to be mortality peaks from epidemics, but they became less frequent. During that time, the birth rate was usually above the death rate, resulting in some natural growth after many decades of stagnation. However, this growth is still small, compared to the burst after 1948.

The big blow to mortality came in 1948-1949 mostly as a result of the eradication of malaria. Death rates dropped to a little over half of their previous (average) level in a few years. Simultaneously, birth rates increased to their highest level ever. In 1950 the crude birth rate (49.7) was 3.6 times greater than the crude death rate (13.9). The enormous gap between birth and death rates resulted in the burst of Mauritian population growth.

The growth rate was around 3% from the beginning of the 1950s to the mid-1960s. Although birth rates had been declining from their peak in 1950-1954, death rates also continued to fall quickly after the eradication of malaria in 1948-1949. From the second half of the 1960s to the present, the death rate decrease slowed down to a trickle, while the birth rates plummeted, bringing the current growth rate down to just over 1% annually. This presently observed growth is only due to the young age structure of the population, while the net reproduction rate has been below 1.0 since 1984, indicating that one generation will not even replace itself completely and the population size will decline in the long run.

Total Fertility Rate

The movement of the crude birth rate in Mauritius is an extreme example of a fertility increase in response to, among other things, better health of the mothers, and a very strong fertility decrease. Part of the crude birth rate movement was influenced by the proportion of women in childbearing ages in those years. A more accurate measure of the actual fertility behavior underlying the birth rate is the Total Fertility Rate (TFR), which may be interpreted as the mean number of children per woman as derived from observation over the period of one year. Table 2 shows the total fertility rate in the census years from 1911 to 1983, and for 1986.

Table 2. Total fertility rate in the census years from 1911 to 1983, and for 1986.

Year	TFR
1911	5.05
1921	5.08
1931	4.29
1944	5.15
1952	6.74
1962	5.86
1972	3.42
1983	2.23
1986	1.94

In the first half of the century, TFR flluctuated around five children per woman. The low rate in 1931 was an extreme low peak lasting two to three years, concurring with the depression, and probably a reaction to it. In 1952 TFR was at the highest level recorded here, and subsequently declined. Data for single years show that the decline was steepest between 1963 and 1971. Over just these eight years, fertility fell among some of of the ethnic groups by more than half. This is probably one of the steepest fertility declines in world history. The following paper by Xenos will take a closer look at this.

Concerning migration - the third component of population change - exact information is much more difficult to obtain than for births and deaths. Early Mauritian population growth was due to a large extent to the immigration/import of slaves. The growth resulting from this was fairly steady and high. But it was nothing compared to the burst of population growth between 1851 and 1861 when Indian labor inundation began. The 1968 Report of the Committee on Population (Titmuss and Abel-Smith, 1968, p. 45) reports that between 1851 and 1881 almost 200,000 Indian migrants arrived on Mauritius. The report also states that Indian migration had almost stopped by 1880. Between 1881 and 1901 about 15,000 non-Indians immigrated, and between 1901 and 1911 another 9,000. These are averages of less than 1,000 per year or less than 4 arrivals per 1000 of the Mauritian population annually.

An indirect way to estimate immigration levels into Mauritius is to relate the population growth as measured in subsequent censuses to the registered numbers of births and deaths between the censuses, and assume that the residuals give us the number of migrants. If all census figures and birth and death statistics were perfect, this method should give the right results. We know, however, of various deficiencies - especially undercount - that are common, especially in earlier periods. For this reason the calculations given below have to be seen with extreme caution, especially since we have no information about the quality of registration and the changes in this quality over time. An application to more recent years for which we have real migration statistics indicates relatively good correspondence between the residuals calculated from births and deaths and the given migration figures. This, however, does not say much about the reliability of statistics in earlier years.

Another disconcerting factor is that the migration figures calculated as residuals in Table 3 do not correspond to those published by Titmuss and Abel-Smith (1968). In the period from 1881 to 1901, the residuals amount to -11,500 compared to +15,000 in Titmuss; in the period from 1901 to 1911 to only 2,800 compared to 9,000 in Titmuss. The numbers disagree on the sign, but they do agree that migration was a negligible factor in population change in this period.

Table 3. Total population, births, deaths, and estimated migration from residual in ten-year intervals from 1871 to 1931.

	Estimation of migration from actual residuals			
Year	Population	Births	Deaths	Migration
1871	316,042			
1881	359,874	123,836	97,864	17,860
1891	370,588	133,667	119,533	-3,420
1901	371,023	137,448	128,900	-8,113
1911	368,791	134,639	139,667	2,796
1921	376,485	137,478	137,757	7,973
1931	393,238	145,207	116,858	-11,596

Source for population: Census; for births and deaths: Titmuss and Abel-Smith, 1968, p.46.

3. ANALYSIS OF CHANGING AGE STRUCTURES

The development of the population by age group for men and women from 1851 to 1983 is shown in Figure 3. The x-axis, starting in the front middle and going back to the right, is the age axis, beginning with age group 0-4 in the front middle and going to age group 85+ in the back. The y-axis, starting from the front middle and going back to the left, is the period axis, starting from 1851 in the front and going to 1983 in the back left corner by five-year intervals. The vertical z-axis represents the number of people in each period age group. Cohorts move across diagonals of the graph to the back of the figure. These 3-D plots may be viewed as a series of subsequent age pyramids rotated by 90^0.

In 1851 there was a large group of young adults. In the next two decades, there is a big bump in the male population resulting from the young Indian men brought over as laborers. The mountain quickly decreases in later decades, indicating that the import of labor slowed down. The big cohort of initial laborers disappears quickly as the cohort moves into older age groups. Since available information indicates that only few laborers returned to their Asian homelands, almost all of this quick shrinkage of the cohort should be due to extremely high mortality rates. In the female figure there is also an increase in young adults from 1851 to 1861, but there is much less of a bump effect, that is, this cohort disappears less quickly. Perhaps female mortality was less high than male mortality.

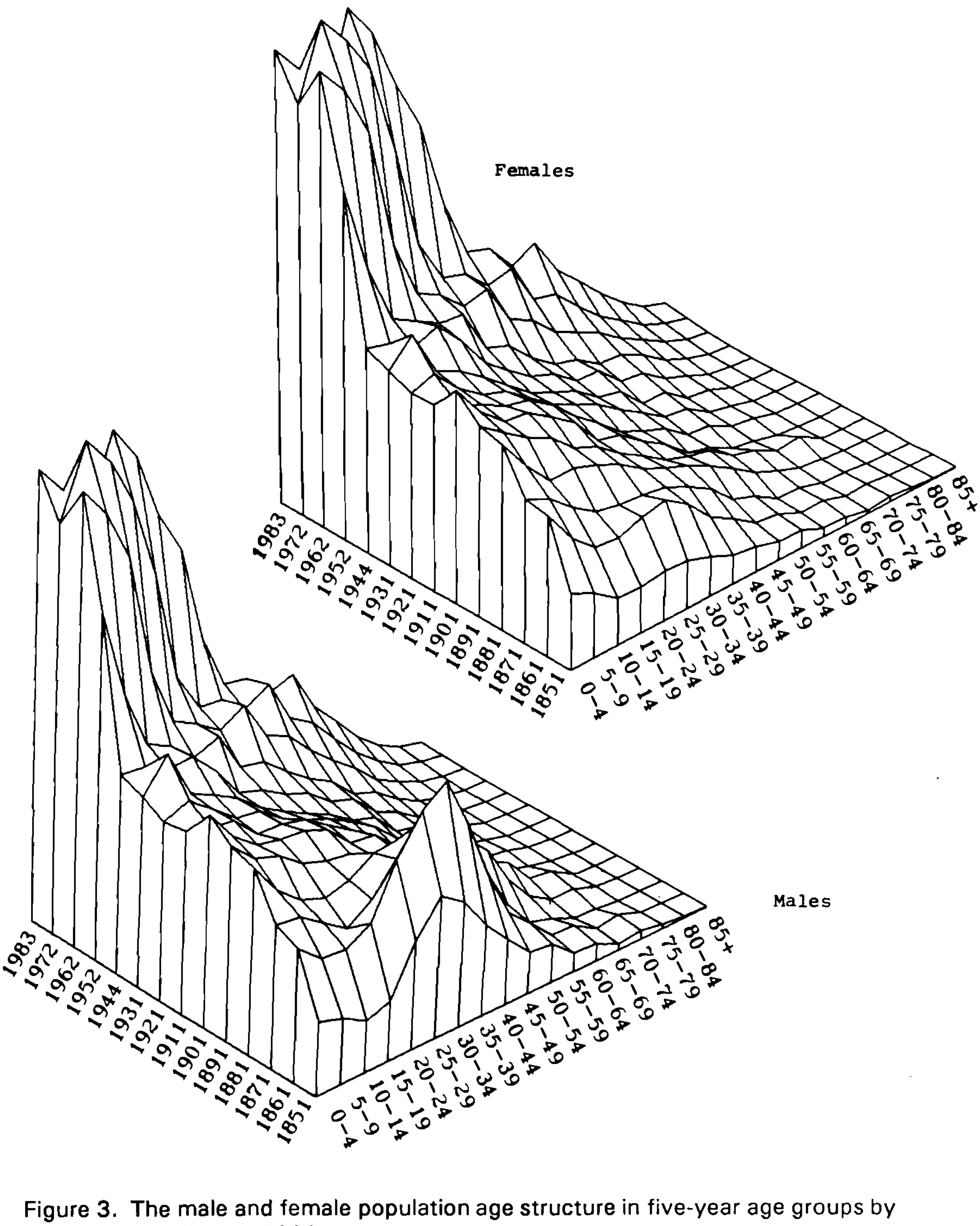

Figure 3. The male and female population age structure in five-year age groups by census from 1851 to 1983.

During the second half of the 19th century, the age structure of Mauritius "normalized," that is, took on a regular pyramid form with large young age groups and smaller old ones. The number of young children aged 0-4 increased continually from 1851 to a peak in 1901 as the number of women of childbearing age increased. In 1911, 1921 and 1931 the number of 0-4 year olds was smaller than in 1901. There was an increase in the number of births in the early 1920s which does not show up in the 0-4 year old group in the figure because this bigger group was born just after the 1921 census. This big group shows up as a large group of 5-9 year olds in 1931. This first cohort of small growth ripples through the age structure quietly. The fact that this cohort remains in the age structure as a large group even as it ages indicates that mortality is relatively low.

After a minimum in the census of 1931, the group of 0-4 year olds begins to increase slowly. Between 1944 and 1952 it jumps from 50,979 to 86,954. By 1962, the size of the 0-4 age group has increased even more to 112,126. These increases in cohort size show up on the three dimensional figure as a steep wall moving diagonally left.

In 1972, the 0-4 age group is, for the first time, smaller than the five years before. The smaller group is the result of the fertility decline indicated by the rapidly declining crude birth rates shown in Figure 2. In 1983, the 0-4 age group is a bit larger again. This is the "echo effect" of the large cohorts from the 1950s and 1960s. The effect of the high birth rates in the 1950s and 1960s and the lowered birth rates thereafter is that a high ridge moves diagonally across the population figure - the large cohorts as they age.

4. THE TIMING OF THE POPULATION EXPLOSION

The analysis of age-specific growth rates from 1950-2025 has shown that the highest periods of growth in all ages are generally found during the 1950s and 1960s. Very high rates of intercohort increase run diagonally across a period age population matrix reflecting the cohorts born during these decades. Birth cohort increases (estimated by the size of the 0-4 year old group) are evident from the interval 1950-1955 to 1960-1965. But, when were these areas of high growth initiated? With which cohorts does the intercohort increase begin, that is, where is/are the population growth discontinuity/ies located?

Keyfitz (1987) proposed that by observing first and second intercohort differences one could pinpoint the beginning of a discontinuity. We refer the reader to this publication for more information on method. Table 4 shows the average annual births of five-year birth cohorts as estimated by multiplying crude birth rate and estimated population from the cohort 1920-1925 to 1970-1975 in the first row. To remain consistent with the UN age-specific period data, half of the births in the first and last years were taken and summed to the births of the four years in between (the UN measures 0-4 year olds in the year X - presumably in the middle of that year, although they do not specify - who would have been born from the middle of the year X-5 to the middle of year X). In the second row are the first differences and in the third row the second differences.

The annual number of children born is about stable until 1940-1945, and then increases for a number of years. The second row shows the first differences of the number of births. For example, the difference between the cohort 1935-1940 and 1940-1945 is 981; between 1945-1950 and 1950-1955 it is 4844, meaning an increase about four times as great. The third row of second differences shows that the amount of increase of the increase described above was greatest after 1940-1945, which pinpoints the beginning of the population growth discontinuity in the interval after the cohort of 1940-1945. There is a second, smaller peak below 1955-1960. The timing of the discontinuity in Mauritius corresponds to the timing Keyfitz found for the world as a whole.

Of course, the socioeconomic effects of such a discontinuity depend not only on the number born, but also on the number surviving into critical ages, say school age, or early labor age. Particularly large birth cohorts could theoretically be wiped out into insignificance by particularly high infant- and early childhood mortality. Table 5 examines the discontinuity by cohort measured by the intercohort differences at ages 20-44. The first five rows show the size of each cohort by five-year age groups, followed by the average of these five groups. The next row of first differences shows that - contrary to births - there are small intercohort increases from the cohort 1920-1925 through to the 1950s. The greatest increase is between 1950-1955 and 1955-1960. After that, cohort size decreases. The peak of the second differences is 10.4 underneath the cohort born 1955-1960, fifteen years later than the peak difference of the number of births! Through improved mortality, from which later cohorts profited increasingly, and also because many belonging to the first big cohorts from the 1950s apparently emigrated, the 1960-1965 cohort improved its relative size by quite a bit. This fact is of importance for such practical matters as labor market: although the largest birth cohort increases were in the beginning of the 1950s, the members of which arrive on the labor market in the beginning of the 1970s; the largest adult cohort increases affect the cohort 1960-1965 which arrived on the labor market in the beginning of the 1980s. The next section explores the relative contributions of fertility and mortality to the intercohort increase.

Table 4. Total average annual birth rates by five-year periods, first and second differences.

	1920–1925	1925–1930	1930–1935	1935–1940	1940–1945	1945–1950	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975
Average number of births	14,322	14,134	12,127	13,521	14,502	19,346	23,133	24,279	26,571	23,560	20,804
First differences		-188	-2,007	1,394	981	4,844	3,787	1,146	2,292	-3,011	-2,756
Second differences		-1,819	3,401	-413	3,863	-1,057	-2,641	1,146	-5,303	255	

Averages		
Abs	1st	2nd
18,754.5	2,240.6	2,210.9

Table 5. Total population in age groups 20-24 to 40-44 from cohort born 1925-30 to 1970-75, averages of these numbers, and first and second differences.

	Birth Year of Cohort										
	1920–1925	1925–1930	1930–1935	1935–1940	1940–1945	1945–1950	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975
20–24		43.0	48.0	56.0	66.0	75.0	80.0	99.0	128.0	112.0	96.0
25–29	36.0	41.0	47.0	55.0	64.0	70.0	79.0	98.0	127.0	111.0	96.0
30–34	34.0	40.0	46.0	52.0	59.0	69.0	78.0	97.0	126.0	111.0	96.0
35–39	33.0	39.0	44.0	49.0	58.0	68.0	78.0	96.0	126.0	110.0	95.0
40–44	32.0	38.0	42.0	48.0	57.0	67.0	77.0	96.0	125.0	110.0	95.0
Average	33.8	40.2	45.4	52.0	60.8	69.8	78.4	97.2	126.4	110.8	95.6
First differences		6.4	5.2	4.6	8.8	9.0	8.6	18.8	29.2	-15.6	-15.2
Second differences		-1.2		4.2	0.2	-0.4	10.2	10.4	-44.8	-30.8	

5. DECOMPOSING THE GROWTH OF THE YOUTH COHORT INTO FERTILITY AND MORTALITY COMPONENTS

We have seen above from the age structures of the population and will see from the patterns of age-specific growth rates discussed below, that the sizes of subsequent birth cohorts increased very rapidly since the mid-1940s. Together with the steep fertility decline during the 1970s, this results in a large youth cohort that dominates the picture of the Mauritian age structure.

In the most recent published census of 1983 the largest 5-year age group in the whole population was that of young men and women aged 15-19, comprising 113,804 Mauritians. Still 105,372 Mauritians belong to the age group 20-24 as compared to only 94,872 in the age group 10-14. It is not so much the absolute size of cohorts but rather their speed of increase that interests us in this section.

In particular we want to know what fraction of this observed increase is due to increases in the total number of births and which part can be attributed to the enormous improvements in mortality that were experienced in Mauritius especially during the late 1940s and early 1950s. Since during that time fertility also increased, it is not surprising that the cohorts born between the mid-1940s and mid-1950s show the highest relative increases as compared to previous cohorts. In the 1983 census the cohort of persons aged 30-34 is 42% greater than that of Mauritians aged 35-39. Only a small portion of this difference can be attributed to the fact that some people die between ages 30-34 and 35-39. The major portion of this increase is due to increasing numbers of births between 1944-1948 and 1949-1953 and to rapidly declining infant and child mortality during this period.

To distinguish between these different effects quantitatively, one needs a more rigorous approach. The logic behind the decomposition method described below is that we can infer the effect of fertility from the annual sequence of births given by vital statistics for birth cohorts that correspond to the age groups in the census. This ratio of subsequent birth cohort sizes can then be related to the ratios of subsequent age groups in one census.

Because of the irregular intervals between censuses in Mauritius in combination with the age structure given in 5-year age groups, it is not possible to directly calculate intercensal growth rates. Instead of attempting to estimate one-year age groups, in this context we prefer to stick to real data and apply the decomposition to the ratios between age group sizes in one census, namely that of 1983. This involves several steps which can also be seen from Table 6, which is a working table giving all the intermediate steps that are needed to get to the results presented in Table 7.

Table 6. Working table of decomposition into fertility and mortality effects for relative increase in cohort size for 1983 census.

Year of birth	Age group	(1) POP 1983	(2) Mortality adjustment factor (average of males, females, both age groups, from life table qx 1982-1984)	(3) Adjusted POP 1983 (1)x[1-(2)]	(4) (3)/(1) Increase over previous cohort	(5) Size of cohort at birth	(6) Ratio of cohort size at birth
68-73	(a1) 10-14	94,872	0.003492		0.8307	104,943	
63-68	(a2) 15-19	113,804	0.005299	94,541	1.0743	127,681	0.8220
58-63	(a3) 20-24	105,372	0.006442	113,200	1.1705	127,351	1.0026
53-58	(a4) 25-29	89,446	0.008040	104,693	1.1381	117,775	1.0813
48-53	(a5) 30-34	77,961	0.010681	88,727	1.4069	113,931	1.0337
43-48	(a6) 35-39	54,820	0.018093	77,128	1.3293	86,840	1.3120
38-43	(a7) 40-44	40,492	0.028147	53,828	1.0126	66,266	1.3105
33-38	(a8) 45-50	38,861		39,352		67,458	0.9826

(1) Size of total age groups (male and female) in 1983 census.
(2) Probabilities of death from one 5-year age group to next (e.g. 10-14 to 15-19) taken from Mauritian life table 1982-84 (average of both sexes).
(3) Population of previous age group adjusted for mortality (e.g. (a1, 1) x (a1, 2) = (a2, 3).
(4) Relative increase of mortality adjusted younger cohort over next older cohort, (4) = (3)/(1).
(5) Size of cohort at birth calculated from annual series of births. Since census is at mid-year 1983, e.g. for age group 10-14, births from mid-1968 to mid-1973 were calculated. It was assumed that births are equally distributed over the year.
(6) Ratio of cohort sizes at birth, e.g. (a2, 6) = (a1, 5)/(a2, 5).

Table 7. Summary table of decomposition.

Age group	Total increase over previous cohort in %	Increase due to fertility	Increase due to mortality improvement
15-19	-16.9	-17.8	0.9
20-24	7.4	0.3	7.1
25-29	17.1	8.1	9.1
30-34	13.8	3.4	10.4
35-39	40.7	31.2	9.5
40-44	32.9	31.0	1.9
45-50	1.2	-1.7	2.9

1. First the enumerated population in a given age group must be multiplied with a mortality adjustment factor to make it comparable with the next older age group. This is only adjusting for the natural depletion from one 5-year age group to the next under current (i.e. over the last five years) mortality conditions. The appropriate probabilities of death were derived from a Mauritian life table of 1982-84. This is calculated in columns (1) to (3) in Table 6.
2. The ratio of the mortality-adjusted age group size to the enumerated (i.e. unadjusted) size of the next older age group is calculated. This gives an indication of whether the number of survivors to a certain age is larger (ratio above unity) or smaller (ratio below unity) for more recent cohorts. This ratio is given in column (4) of Table 6.
3. Next the absolute numbers of births are taken from vital registration for the 5-year periods that correspond to the age groups given in the census. This figure is given in column (5).
4. Finally the accumulated births over the 5-year period are divided by the total number of births in the subsequent 5-year period and the ratios - given in column (6) - are compared to the ratio of cohort sizes - as given in column (4).

Since column (6) gives the increase in cohort size resulting from fertility only while column (4) gives the increase in age group sizes due to fertility and mortality changes, the effect of mortality can be derived by subtracting the ratio in (6) from that in (4) if we assume the absence of significant migration streams. If there was migration, this difference between (4) and (6) gives the combined effect of migration and mortality.

The results of this decomposition procedure are given in Table 7. From there we see that the increase of a cohort over the mortality adjusted size of the previous cohort - derived from column (4) in Table 6 - was highest for the age group 35-39 in 1983. The size of this cohort in 1983 was 40.7% higher than that of the previous cohort aged 40-45 in 1983. From the corresponding series of births - column (6) in Table 6 - we see that 31.2% of this increase can be explained by increasing numbers of births, the remaining 9.5% being attributable to improvements in mortality. If there was relevant migration over this period, it was probably more outmigration than immigration, which would tend to increase the share of growth due to mortality improvements.

The second largest intercohort increase is measured for the age group 40-44 in 1983. In sharp contrast to the next younger cohort described above, here the 32.9% increase is almost entirely due to fertility. The share of mortality is only 1.9 percentage points.

For the next younger age group 30-34 the picture is again very different. Here more than two-thirds of the 13.8% increase are attributable to mortality decline and only 3.4% to fertility. This drastic change of the relative influences of fertility and mortality reflects the differential timing of fertility increase and mortality decrease during the years after 1945. During the period 1945-49 birth rates started to increase sharply while mortality rates still remained at a high level. During the 1950s mortality dropped dramatically while the number of births increased only to a lesser extent. This explains why the increase between age groups in today's population of Mauritius is first mostly attributable to fertility and later to mortality.

For the age group 15-19, which is actually 16.9% smaller than the next older age group, the rapidly shrinking fertility rates would have implied an even somewhat stronger decline of 17.8%. It was - though not very significant - improvement in mortality conditions over the past two decades that dampened that decline by one percentage point.

In conclusion, one can say that there is no simple unique answer to whether the youth cohort is more an effect of increasing numbers of births or decreasing numbers of child deaths. Both factors played different roles at different times. For the first cohorts of the youth cohort, those aged 35-44 in 1983, showing the highest growth ratios of all, increasing numbers of births were certainly the major factor. For the subsequent cohorts having less significant growth ratios but showing higher increases in absolute numbers, mortality decline especially in childhood played the more important role. As for the recent decline of young age groups, it is only fertility through rapidly declining birth rates that causes the decline with further mortality improvements weakly counteracting this trend.

6. ANALYSIS OF AGE-SPECIFIC GROWTH RATES 1950-2025 USING U.N. POPULATION ESTIMATES

In this section we use the 1988 United Nations Population Assessment data (UN, 1989). Table 8 shows the male and female population of Mauritius from 1950-2025 in five-year intervals by five-year age groups, estimated prior to 1985 and projected from 1990-2025. The UN data, though it does not span as long a historical period as the Mauritius census data, does include most of the time period in which the population of Mauritius began its explosive growth, and the decline of growth rates. The UN data is presented in regular five-year intervals which makes detailed analysis possible, in contrast to the data from the irregular census intervals. In future work, we will be able to present the population in five-year intervals from 1950-1990 using original Mauritian census data. At the time of writing, not all data needed was available to us at IIASA. One disadvantage of the UN data is that they are an extra step removed from the real census data. The UN uses national population counts and estimates to produce its own estimates. Oddly enough, although the Mauritian population data is perceived as being good quality data, the UN population estimates diverge from the national data. Particularly, the UN data show a much larger wave of emigration during the 1970s than the national data. We believe that, given the quality, the Mauritian data is probably closer to the actual population than the UN estimates. But this must be investigated further.

Table 8 shows the UN population estimate in absolute numbers from 1950-2025 by five-year age groups. Overall, the population age structure changes from a pyramid form to one with similar sized young to middle aged groups and attrition in the older age groups. The fertility increase of the 1940s is seen in the much larger size of the 0-4 year old group in 1980 than the 5-9 year old group.

The fertility decline is obvious from the table by going along the 0-4 column. The actual extent of the decline is larger than shown in the column, because the column does not show that the smaller groups of young children in the 1970s came from the largest group of women in childbearing age in the history of Mauritius.

The extent of the mortality decline is difficult to see from the table. We can compare the survival of the male group aged 0-4 in 1955 to aged 5-9 in 1960 to the survival of the 0-4 group in 1985. There were 54,084 males 0-4 years old in 1955, and 54,089 in 1985. Of the 1955 group, 52,517 5-9 year olds were left in 1960, compared to 53,685 5-9 year olds in 1990 - an attrition rate of less than 1/3 compared to the 1955-1960 level.

Table 8. The population of Mauritius, male and female, estimated by the UN until 1985, and projected until 2025.

MAURITIUS

POPULATION,FEMALES,1950-2025

YEAR																	
AGE	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
1950	43.7	35.748	30.022	25.324	21.238	17.862	14.901	12.356	10.325	8.466	6.949	5.628	4.38	3.279	2.251	1.321	0.93
1955	51.535	41.289	35.197	28.79	24.51	20.578	17.182	14.432	11.962	9.819	7.957	6.364	4.994	3.659	2.48	1.453	0.93
1960	60.13	49.959	40.79	33.766	27.984	23.921	19.953	16.795	14.105	11.477	9.335	7.389	5.758	4.285	2.867	1.676	1.049
1965	67.947	58.592	49.506	39.649	33.068	27.448	23.35	19.567	16.452	13.623	10.975	8.742	6.741	4.991	3.401	1.97	1.228
1970	57.914	66.39	57.488	45.034	37.597	31.895	26.139	22.798	19.193	15.564	12.853	10.046	7.867	5.763	3.906	2.295	1.405
1975	48.906	56.667	64.422	48.454	41.145	35.579	29.579	25.391	22.396	17.76	14.463	11.481	8.902	6.626	4.439	2.581	1.581
1980	56.21	48.285	56.409	63.805	47.999	40.729	35.135	29.219	25.025	21.897	17.193	13.776	10.672	7.907	5.427	3.18	1.989
1985	52.251	55.688	48.095	55.895	63.349	47.609	40.315	34.78	28.858	24.532	21.266	16.446	12.875	9.548	6.539	3.937	2.517
1990	46.749	51.945	55.52	47.642	55.559	62.982	47.249	40.009	34.442	28.387	23.932	20.467	15.497	11.653	8.025	4.85	3.236
1995	48.527	46.524	51.814	55.156	47.393	55.284	62.599	46.935	39.657	33.939	27.747	23.095	19.355	14.095	9.862	6.007	4.103
2000	49.272	48.355	46.473	51.747	55.029	47.24	55.054	62.269	46.585	39.181	33.274	26.89	21.955	17.737	12.058	7.468	5.222
2005	48.761	49.139	48.311	46.421	51.648	54.883	47.078	54.81	61.871	46.093	38.494	32.343	25.675	20.252	15.32	9.228	6.662
2010	47.414	48.664	49.108	48.271	46.353	51.541	54.734	46.908	54.514	61.3	45.374	37.521	31.005	23.824	17.647	11.875	8.465
2015	46.49	47.347	48.64	49.076	48.216	46.278	51.43	54.573	46.695	54.078	60.455	44.343	36.107	28.936	20.939	13.85	10.993
2020	46.017	46.445	47.329	48.616	49.034	48.156	46.2	51.309	54.367	46.375	53.428	59.235	42.839	33.901	25.666	16.658	13.642
2025	45.669	45.984	46.43	47.311	48.582	48.984	48.09	46.11	51.144	54.042	45.881	52.458	57.408	40.42	30.3	20.657	16.868

MAURITIUS

POPULATION,MALES,1950-2025

YEAR																	
AGE	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
1950	44.299	36.095	30.22	25.438	21.288	17.744	14.71	12.161	10.05	8.205	6.603	5.171	4.054	2.938	1.919	1.118	0.707
1955	54.084	42.234	35.352	28.959	23.916	20.598	17.108	14.005	11.516	9.33	7.447	5.708	4.083	2.935	1.872	1.032	0.628
1960	62.649	52.517	41.633	34.217	27.565	23.334	20.059	16.502	13.462	10.889	8.654	6.618	4.681	3.09	1.97	1.071	0.614
1965	71.085	61.255	51.99	40.689	33.055	27.06	22.864	19.514	15.983	12.847	10.191	7.786	5.54	3.619	2.127	1.157	0.644
1970	60.638	69.197	60.022	49.014	36.917	31.82	26.005	21.678	18.651	15.025	11.97	9.063	6.277	4.196	2.4	1.231	0.67
1975	50.8	57.882	66.255	52.118	38.854	33.943	29.348	23.266	20.059	16.947	13.828	10.35	6.689	4.505	2.54	1.33	0.65
1980	58.048	49.981	57.381	65.079	50.645	38.278	33.406	28.718	22.693	19.323	16.049	12.636	8.857	5.307	3.198	1.547	0.791
1985	54.089	57.439	49.725	56.803	64.268	50.232	37.906	32.952	28.194	22.025	18.416	14.805	11.01	7.155	3.858	1.991	0.963
1990	48.328	53.685	57.229	49.227	56.103	63.878	49.867	37.492	32.46	27.489	21.109	17.116	13.042	9.02	5.295	2.451	1.251
1995	50.362	48.087	53.585	56.96	48.854	55.868	63.574	49.501	37.051	31.783	26.48	19.762	15.253	10.831	6.794	3.434	1.607
2000	51.139	50.213	48.074	53.542	56.858	48.737	55.69	63.248	49.033	36.393	30.732	24.93	17.773	12.809	8.276	4.473	2.236
2005	50.628	51.043	50.199	48.059	53.482	56.764	48.623	55.467	62.754	48.28	35.32	29.09	22.601	15.092	9.927	5.522	3.045
2010	49.265	50.579	51.028	50.183	48.027	53.428	56.673	48.475	55.112	61.919	47.004	33.585	26.548	19.37	11.834	6.697	3.961
2015	48.319	49.242	50.565	51.012	50.151	47.979	53.356	56.551	48.227	54.483	60.466	44.897	30.861	22.973	15.377	8.116	5.015
2020	47.89	48.296	49.228	50.548	50.979	50.101	47.915	53.262	56.361	47.793	53.393	58.046	41.559	26.976	18.47	10.723	6.29
2025	47.583	47.867	48.283	49.212	50.516	50.928	50.033	47.831	53.108	55.955	46.963	51.457	54.042	36.62	21.91	13.054	8.267

Table 9 shows the age-specific growth rates for males and females. The rates are period average annual growth rates, e.g. the growth rate of the age group 5-9 from 1950 to 1955: in 1950, the male age group 5-9 was 36,095; in 1955 it was 42,234; the average annual growth rate from 1950 to 1955 of the 5-9 year old group was ln(42,234/36,095)/5 = .0314 shown in the first row, second column of the table. In general terms, the figures are arranged in the table such that

$$r_t^a = \frac{1}{5}\ln\left(\frac{P_{t+5}^a}{P_t^a}\right)$$

where t is the first of the two years, and a is the age group.

The first row of Table 9 shows that the growth rates from 1950 to 1955 were fairly high, above 0.025 (2.5% growth annually) in each age group below age 55. From 1955 to 1960, and 1960 to 1965, the high growth rates even extend to the oldest female age groups, and to 60-64 among the males. In other words, in this period, all age groups of the population were increasing at similar, high rates. In general, the growth rates are highest in the third interval 1960-1965.

From 1965 to 1970 the growth rate of the 0-4 year group is negative because of the decreased birth rate. In all the older age groups, growth is still positive, still high, but generally lower than in the previous two decades. From 1970 to 1975, the growth rates in the age groups above 0-4 and 5-9 are even lower. Such across the board decreases in age-specific growth rates would indicate increases in mortality or other attrition. Mortality increases are nowhere documented, so we presume emigration. We will return to this strong decrease in the rate of age-specific growth below. Total population growth rates were low from 1965-1975, 1.8% in 1965-1970 and 0.5% in 1970-1975.

From 1975 to 1980 the growth of the 0-4 year group is again positive. In this period, total fertility - children per women - actually decreased, but because the number of women in childbearing ages increased (the enormous cohorts from 1950 to 1965 now entering and dominating the childbearing ages), the total number of births and the crude birth rate are higher than in the two intervals before. The growth rates of the groups 5-9 and 10-14 are negative, reflecting the decreasing cohort sizes of the late 1960s and early 1970s. At higher ages, the growth rates are enormous, peaking at 5.5% for the male 15-19 and female 20-24 age groups. These high growth rates are in strong contrast with the previous time interval from 1970 to 1975. The total population growth is 1.9% annually. The increases in the age groups with positive growth rates are much higher than 1.9%. They are compensated by the two age groups with negative growth rates -5-9 and 10-14.

Table 9. Annual age-specific growth rates of the population of Mauritius measured between 5-year age groups in 5-year time intervals. Calculated from Table 8 data.

MAURITIUS

GROWTH, FEMALES, 1950-2025

YEAR / AGE	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
1950	0.0329	0.0288	0.0318	0.0256	0.0286	0.0283	0.0284	0.0310	0.0294	0.0296	0.0270	0.0245	0.0262	0.0219	0.0193	0.0190	0
1955	0.0308	0.0381	0.0294	0.0318	0.0265	0.0301	0.0299	0.0303	0.0329	0.0312	0.0319	0.0298	0.0284	0.0315	0.0290	0.0285	0.0240
1960	0.0244	0.0318	0.0387	0.0321	0.0333	0.0275	0.0314	0.0305	0.0307	0.0342	0.0323	0.0336	0.0315	0.0305	0.0341	0.0323	0.0315
1965	-0.031	0.0249	0.0298	0.0254	0.0256	0.0300	0.0225	0.0305	0.0308	0.0266	0.0315	0.0278	0.0308	0.0287	0.0276	0.0305	0.0269
1970	-0.033	-0.031	0.0227	0.0146	0.0180	0.0218	0.0247	0.0215	0.0308	0.0263	0.0236	0.0267	0.0247	0.0279	0.0255	0.0234	0.0236
1975	0.0278	-0.032	-0.026	0.0550	0.0308	0.0270	0.0344	0.0280	0.0221	0.0418	0.0345	0.0364	0.0362	0.0353	0.0401	0.0417	0.0459
1980	-0.014	0.0285	-0.031	-0.026	0.0554	0.0312	0.0275	0.0348	0.0285	0.0227	0.0425	0.0354	0.0375	0.0377	0.0372	0.0427	0.0470
1985	-0.022	-0.013	0.0287	-0.031	-0.026	0.0559	0.0317	0.0280	0.0353	0.0291	0.0236	0.0437	0.0370	0.0398	0.0409	0.0417	0.0502
1990	0.0074	-0.022	-0.013	0.0292	-0.031	-0.026	0.0562	0.0319	0.0281	0.0357	0.0295	0.0241	0.0444	0.0380	0.0412	0.0427	0.0474
1995	0.0030	0.0077	-0.021	-0.012	0.0298	-0.031	-0.025	0.0565	0.0322	0.0287	0.0363	0.0304	0.0252	0.0459	0.0402	0.0435	0.0482
2000	-0.002	0.0032	0.0077	-0.021	-0.012	0.0299	-0.031	-0.025	0.0567	0.0324	0.0291	0.0369	0.0313	0.0265	0.0478	0.0423	0.0487
2005	-0.005	-0.001	0.0032	0.0078	-0.021	-0.012	0.0301	-0.031	-0.025	0.0570	0.0328	0.0297	0.0377	0.0324	0.0282	0.0504	0.0479
2010	-0.003	-0.005	-0.001	0.0033	0.0078	-0.021	-0.012	0.0302	-0.030	-0.025	0.0573	0.0334	0.0304	0.0388	0.0342	0.0307	0.0522
2015	-0.002	-0.003	-0.005	-0.001	0.0033	0.0079	-0.021	-0.012	0.0304	-0.025	-0.024	0.0579	0.0341	0.0316	0.0407	0.0369	0.0431
2020	-0.001	-0.001	-0.003	-0.005	-0.001	0.0034	0.0080	-0.021	-0.012	0.0306	-0.025	-0.024	0.0585	0.0351	0.0331	0.0430	0.0424

MAURITIUS

GROWTH, MALES, 1950-2025

YEAR / AGE	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
1950	0.0399	0.0314	0.0313	0.0259	0.0232	0.0298	0.0302	0.0282	0.0272	0.0256	0.0240	0.0197	0.0014	-0.000	-0.004	-0.016	-0.023
1955	0.0294	0.0435	0.0327	0.0333	0.0283	0.0249	0.0318	0.0328	0.0312	0.0309	0.0300	0.0295	0.0273	0.0102	0.0102	0.0074	-0.004
1960	0.0252	0.0307	0.0444	0.0346	0.0363	0.0296	0.0261	0.0335	0.0343	0.0330	0.0326	0.0325	0.0336	0.0316	0.0153	0.0154	0.0095
1965	-0.031	0.0243	0.0287	0.0372	0.0220	0.0324	0.0257	0.0210	0.0308	0.0313	0.0321	0.0303	0.0249	0.0295	0.0241	0.0123	0.0079
1970	-0.035	-0.035	0.0197	0.0122	0.0102	0.0129	0.0241	0.0141	0.0145	0.0240	0.0288	0.0265	0.0127	0.0142	0.0113	0.0154	-0.006
1975	0.0266	-0.029	-0.028	0.0444	0.0530	0.0240	0.0259	0.0421	0.0246	0.0262	0.0297	0.0399	0.0561	0.0327	0.0460	0.0302	0.0392
1980	-0.014	0.0278	-0.028	-0.027	0.0476	0.0543	0.0252	0.0275	0.0434	0.0261	0.0275	0.0316	0.0435	0.0597	0.0375	0.0504	0.0393
1985	-0.022	-0.013	0.0281	-0.028	-0.027	0.0480	0.0548	0.0258	0.0281	0.0443	0.0272	0.0290	0.0338	0.0463	0.0633	0.0415	0.0523
1990	0.0082	-0.022	-0.013	0.0291	-0.027	-0.026	0.0485	0.0555	0.0264	0.0290	0.0453	0.0287	0.0313	0.0365	0.0498	0.0674	0.0500
1995	0.0030	0.0086	-0.021	-0.012	0.0303	-0.027	-0.026	0.0490	0.0560	0.0270	0.0297	0.0464	0.0305	0.0335	0.0394	0.0528	0.0660
2000	-0.002	0.0032	0.0086	-0.021	-0.012	0.0304	-0.027	-0.026	0.0493	0.0565	0.0278	0.0308	0.0480	0.0328	0.0363	0.0421	0.0617
2005	-0.005	-0.001	0.0032	0.0086	-0.021	-0.012	0.0306	-0.026	-0.025	0.0497	0.0571	0.0287	0.0321	0.0499	0.0351	0.0385	0.0525
2010	-0.003	-0.005	-0.001	0.0032	0.0086	-0.021	-0.012	0.0308	-0.026	-0.025	0.0503	0.0580	0.0301	0.0341	0.0523	0.0384	0.0471
2015	-0.001	-0.003	-0.005	-0.001	0.0032	0.0086	-0.021	-0.011	0.0311	-0.026	-0.024	0.0513	0.0595	0.0321	0.0366	0.0557	0.0453
2020	-0.001	-0.001	-0.003	-0.005	-0.001	0.0032	0.0086	-0.021	-0.011	0.0315	-0.025	-0.024	0.0525	0.0611	0.0341	0.0393	0.0546

Projection 1990-2025

In later intervals from 1985 to 2025, the growth of the older age groups - to the right of a diagonal trough of negative values - is always higher than the total average annual population growth. In the UN projection period, from 1990-2025, these high rates recede one age group to the right in each interval. On the left side, preceding one age group in each interval, are low values (of later cohorts). The high, right-side growth rates illustrate clearly that population growth continues even after fertility has dropped, and in which age groups this happens.

The diagonality of the patterns points to cohort patterns moving through time. The regularity of the height of the high and low rates along cohort diagonals is not surprising: data after 1985 are projected, which almost always produces regular population changes.

Cohort Patterns

The diagonal patterns mentioned above are caused by differences in the size of consecutive cohorts. Changes in the size of the differences (or growth rate) indicate that the mortality experiences of the two cohorts are different. If the mortality experience of two cohorts is the same, then the ratio of the growth rates between these two cohorts will remain the same as they age. The regularity of the troughs and ridges after 1975-1980 are caused by cohorts of different sizes with similar mortality experiences moving side by side across the matrix. Decreasing mortality causes the growth rates between the two cohorts to increase from age interval to age interval. This is what we see in the section of the matrix along the highest ridge and to the right of it, and in the first three rows.

In the intervals 1965-1970 and 1970-1975, the growth rates are smaller than in the preceding interval when moving down along the cohort diagonals. This means mortality or some other attrition increased during this interval. This period is marked by independence - causing some Mauritians to leave for England and other countries - and the beginning of crowding at the younger edge of the labor market as the first big cohorts enter it. It is surprising that it looks as if men and women from all adult age categories appear to have left: usually, migrants are concentrated in the young adult categories. A table with the changing ratios of the growth rates, this time calculated along cohort diagonals rather than vertically as in Table 9, will clarify some of the combined effects of mortality (presumably decreasing throughout the observation and projected period) and migration. The numbers in Table 10 are the ratios of the rates of intercohort growth as these two cohorts move from one age group to the next.

Table 10. Ratios of intercohort growth rates shown in Table 9, as measured along cohort diagonals.

Females

YEAR AGE	0/5	5/10	10/15	15/20	20/25	25/30	30/35	35/40	40/45	45/50	50/55	55/60	60/65	65/70	70/75	75/80
1950-55/1955-60	1.156	1.023	1.002	1.033	1.051	1.056	1.065	1.061	1.060	1.077	1.102	1.158	1.204	1.322	1.474	1.264
1955-60/1960-65	1.033	1.016	1.089	1.047	1.038	1.044	1.022	1.015	1.040	1.037	1.053	1.055	1.071	1.082	1.115	1.103
1960-65/1965-70	1.022	0.938	0.658	0.799	0.899	0.820	0.972	1.009	0.865	0.921	0.859	0.919	0.912	0.908	0.894	0.833
1965-70/1970-75	0.991	0.911	0.490	0.708	0.852	0.823	0.955	1.010	0.857	0.886	0.845	0.889	0.903	0.889	0.848	0.773
1970-75/1975-80	0.947	0.839	2.417	2.105	1.499	1.575	1.136	1.030	1.357	1.310	1.544	1.358	1.430	1.440	1.632	1.955
1975-80/1980-85	1.025	0.996	0.996	1.008	1.013	1.017	1.012	1.015	1.024	1.015	1.025	1.030	1.040	1.055	1.063	1.128
1980-85/1985-90	0.953	1.006	1.002	0.991	1.008	1.017	1.018	1.015	1.024	1.039	1.029	1.046	1.062	1.086	1.119	1.177
1985-90/1990-95	0.991	0.993	1.020	0.995	0.994	1.005	1.006	1.007	1.010	1.013	1.023	1.016	1.026	1.035	1.045	1.138
1990-95/1995-00	1.034	0.987	0.924	1.020	0.989	0.985	1.005	1.008	1.019	1.017	1.029	1.043	1.034	1.057	1.056	1.127
1995-00/2000-05	1.056	1.005	0.998	0.994	1.004	0.995	0.993	1.004	1.009	1.015	1.016	1.029	1.052	1.042	1.053	1.119
2000-05/2005-10	0.932	1.017	1.008	0.996	0.991	1.005	0.995	0.992	1.005	1.012	1.019	1.022	1.038	1.066	1.053	1.132
2005-10/2010-15	0.979	0.986	1.011	1.008	0.996	0.991	1.004	0.994	0.990	1.006	1.016	1.026	1.031	1.053	1.088	1.036
2010-15/2015-20	0.977	0.996	0.983	1.017	1.009	0.996	0.991	1.005	0.993	0.986	1.009	1.023	1.040	1.047	1.079	1.403
2015-20/1020-25	0.975	0.997	0.996	0.983	1.013	1.008	0.996	0.991	1.006	0.991	0.983	1.011	1.029	1.048	1.057	1.150

Males

YEAR AGE	0/5	5/10	10/15	15/20	20/25	25/30	30/35	35/40	40/45	45/50	50/55	55/60	60/65	65/70	70/75	75/80
1950-55/1955-60	1.092	1.041	1.064	1.095	1.071	1.067	1.086	1.106	1.135	1.169	1.230	1.383	7.220	*******	-1.496	0.282
1955-60/1960-65	1.047	1.019	1.059	1.089	1.043	1.049	1.054	1.046	1.059	1.058	1.082	1.139	1.156	1.490	1.514	1.286
1960-65/1965-70	0.965	0.933	0.838	0.638	0.892	0.869	0.803	0.921	0.912	0.973	0.929	0.768	0.878	0.764	0.809	0.512
1965-70/1970-75	1.123	0.810	0.427	0.275	0.585	0.746	0.549	0.692	0.780	0.921	0.825	0.419	0.569	0.383	0.641	-0.489
1970-75/1975-80	0.829	0.805	2.248	4.316	2.350	2.005	1.741	1.745	1.803	1.237	1.383	2.114	2.577	3.242	2.666	2.538
1975-80/1980-85	1.043	0.976	0.946	1.073	1.025	1.051	1.062	1.031	1.061	1.049	1.064	1.090	1.064	1.145	1.095	1.302
1980-85/1985-90	0.957	1.011	1.000	0.999	1.009	1.009	1.021	1.025	1.021	1.043	1.054	1.069	1.065	1.060	1.108	1.037
1985-90/1990-95	0.978	0.973	1.038	0.967	0.986	1.010	1.013	1.025	1.030	1.023	1.053	1.080	1.080	1.076	1.065	1.205
1990-95/1995-00	1.049	0.986	0.941	1.040	0.987	0.988	1.009	1.008	1.024	1.026	1.025	1.064	1.071	1.078	1.060	0.980
1995-00/2000-05	1.071	1.000	0.995	0.989	1.005	0.994	0.991	1.007	1.009	1.027	1.036	1.034	1.073	1.084	1.068	1.168
2000-05/2005-10	0.909	0.999	1.000	0.996	0.989	1.005	0.993	0.989	1.008	1.011	1.033	1.043	1.038	1.071	1.061	1.248
2005-10/2010-15	0.982	0.998	1.000	1.001	1.000	0.996	1.006	0.990	0.985	1.012	1.016	1.048	1.060	1.049	1.094	1.223
2010-15/2015-20	1.000	1.000	1.002	0.999	1.000	1.000	0.994	1.011	0.982	0.972	1.020	1.025	1.067	1.074	1.064	1.179
2015-20/1020-25	1.000	0.999	1.000	0.998	1.000	0.999	1.000	0.992	1.012	0.979	0.969	1.023	1.027	1.063	1.073	0.981

$$ratio_t^a = \frac{r_t^a}{r_{t+5}^a}$$

where r is the same as r above.

This ratio of growth rates spans a ten-year period. Values above unity mean that the growth rates between two cohorts, e.g. aged 5-9 in 1950 and 1955, had increased by the time these two cohorts were 5 years older, e.g. aged 10-14 in 1955 and 1960. An increase in growth rates means that the younger cohort had a lower rate of attrition during the age interval than the older cohort. Ratios with values below unity indicate that the younger cohort experienced *higher* attrition than the older cohort during the age interval. Values further from unity indicate greater changes in the intercohort growth rates, that is, greater changes in the rates of attrition. In the first two rows, showing the change of growth rates between the interval 1950-55 to 1955-60 and 1955-60 to 1960-65, all values are above unity, reflecting, as expected, mortality improvements across the board, more strongly among the elderly. The third and fourth rows of the table, reflecting the time from interval 1960-65 to 1965-70 and 1965-70 to 1970-75, are full of values below unity, reflecting increasing attrition. The values furthest from unity are in the fifth column for men, where the cohorts move from 15-19 to 20-24 years, and five years earlier among women, which is exactly the age of migration. Values closest to one are around middle age for both men and women. Among males, the values are below unity again at higher ages. In summary, although it seems that during the 1970s Mauritians from all age groups were disappearing, the tendency was more pronounced among young adult Mauritians.

In the next row, concerning the change in growth rates from the interval 1970-1975 to 1975-1980, the values are very high. These high rates mean that the younger cohorts experienced much lower attrition rates as they moved from one age group to the next five years later than the older cohorts. One suspects that the older age group was still emigrating, whereas the younger group five years later was not.

In later years, with values close to one except in high age groups, attrition rates apparently do not change much, although they change more for men than women and more at higher ages. The very slight deviations from unity found in the projection period in the triangle from 5-9 in 1990 to 2015 and from 30-34 in 2015 are due to statistical method; mortality is assumed to stay the same there.

7. CONCLUSION

The very rapid population growth of Mauritius during the 1960s alarmed social scientists of that time. Several reports were produced by British scientists (Mead, 1961; Titmuss and Abel-Smith, 1968) that clearly pointed at the disastrous consequences of very fast population growth on a small island without many natural resources. There was fear of mass unemployment and poverty among others.

We have seen that since then, Mauritius has experienced a most remarkable decline in fertility down to an almost European level. To explain the factors that brought fertility down will be the subject of another paper. Without doubt these early warning reports played a role in preparing the grounds for efficient family planning efforts. But despite the fertility declines, the warnings of mass unemployment came true for large sections of the young generation because of the momentum of population growth, i.e. the fact that through the very young age structure of the population, growth in absolute numbers will continue for some time, although the number of children per woman has declined.

To illustrate this important consequence of the youth cohort on the labor market, Table 11 gives the numbers of men by age groups as enumerated in the censuses of 1973 and 1983, and relates them to the number of employed men by age in the same year. This is only done for men because for women, the question whether they want to be part of the labor force or not is more ambiguous.

Table 11. Percentages of all men employed by age groups in 1973 and 1983.

	1973			1983		
	Total	Employed	Employed %	Total	Employed	Employed %
15-19	50,226	14,292	28.5%	57,431	8,402	14.6%
20-24	40,150	27,929	69.6%	53,077	22,551	42.5%
25-29	26,204	23,279	88.8%	44,708	32,941	73.7%
30-34	21,168	19,536	92.3%	39,230	32,975	84.1%
35-39	20,751	19,323	93.1%	26,955	23,749	88.1%
40-44	18,310	16,968	91.1%	19,952	17,429	87.4%

The first thing we see from Table 11 is that the employment situation significantly worsened between 1973 and 1983. A reduction in the percentage employed can be observed in all age groups. Generally the younger age groups are worse off because all available jobs are occupied by the older people and only few new jobs open up through retirement or creation of new jobs. This was still a period of economic stagnation. For the youngest age group 15-19, the decline in the numbers employed might be to a small extent due to increased rates of enrollment in secondary education, but educational statistics show that this is not a large factor. Certainly education cannot explain the fact that in 1983, almost 60% of all young men aged 20-24 were without jobs. This was indeed a dramatic situation because the growth of jobs was much smaller than the growth of the youth cohort. This presented a serious strain to the Mauritian society even in the early 1980s.

Since 1983, however, the situation has changed dramatically. Due to the rapid growth of the textile industry in the export producing zones (EPZ), today there is virtually no unemployment in Mauritius, or even a lack of labor. Through the introduction of very labor-intensive industries, Mauritius avoided the mistakes of other industrializing countries that could not reduce their unemployment through capital-intensive technologies.

In summary one can say that Mauritius succeeded in turning the potentially serious instability factor of the youth cohort into an asset for the country's economy and development. As it looks now, increased competition - another consequence of the youth cohort - is also turning into a positive phenomenon by increasing demand for continuing education and further development of skills. After successfully absorbing the youth cohort, it will be a new challenge to the Mauritian economy to adjust itself to the future scarcity of labor through a gradual replacement of labor-intensive industries by capital-intensive ones that can take advantage of a smaller but more highly-skilled labor force.

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Chapter 5

FAMILY PLANNING AND FERTILITY CHANGE IN MAURITIUS[1]

Christos Xenos

1. POPULATION GROWTH

In the 1950s and 1960s, it would have been difficult to identify a country whose rapid population growth gave much more cause for concern than Mauritius. There were well-founded reasons for this. On an island of only a little over 1,800 square kilometers, population density in the early 1960s was already about 400 per square kilometer, fertility was very high, mortality low, and the rate of growth about 3% a year. Under that rate of growth, population was projected to increase from under 700,000 to nearly 2.7 million by the end of the century. With an economy almost exclusively dependent on sugar and with early expansion unlikely, unemployment was already substantial. Moreover, the situation was deteriorating since, as a result of the large proportion of children in the population and of the large limited economic potential, the annual increase in the number of jobs available was only about a quarter of the increase in the labor force.

Within a few years however, in the late 1960s and early 1970s, Mauritius experienced a most remarkable decline in fertility, one of the largest recorded anywhere. This, together with an increase in emigration, and despite some decrease in mortality, resulted in a drop in the annual rate of population growth from 2.9% in 1963 to 1.1% in 1973. Within the same period, the crude birth rate dropped from 40.2 to 22.7.

Another major element of the changing population scene in Mauritius during that period was the development of extensive family planning services. This occurred in parallel with the drop in fertility and by the end of 1972, almost one-half of all ever-married women in the reproductive ages were or had been clients of at least one of the two family planning organizations operating on the island.

Although an increasing number of countries were attempting to curb excessive population growth, seen as a handicap to their prospects of socio-economic development, few had experienced such a substantial and rapid decrease in fertility. Further, in contrast to most underdeveloped countries, Mauritius has a record of reliable birth and death registration and censuses through which population trends may be traced adequately.

[1]This paper summarizes some of the main findings of the study: Xenos (1977).

Table 1 shows the population enumerated at each census. It is clear that after the end of the massive immigration in the 19th century, the population was growing only very slowly until the end of the Second World War. Indeed, in the 63 years between the censuses of 1881 and 1944, the population increased by only 59,000, or at an average annual rate of 0.24%. By 1952 however, the picture had changed dramatically. The census carried out in that year showed that the population had increased by 82,000 since 1944, or at an average annual rate of 2.26 %. But even these high post-war figures were to be overtaken in the years ahead. The 1962 census showed an increase of 181,000 in the preceding decade, implying an average annual rate of growth of 3.12 %. If the 1962 rates of growth continued, the population was projected to go up from 682,000 to just under 3 million by the year 2002. Although such a catastrophic increase might have been unlikely, the projection did stress the absolute necessity for a change in the rates of growth. Such a change did in fact occur and the enumerated population of 826,000 in 1972 (an increase of 145,000) implies an average annual rate of growth of only 1.94%. The population enumerated in 1972 was about 100,000 less than that projected on the basis of the 1962 growth rates. This is accounted for one-third by increased net emigration, and for two-thirds by sharply lower fertility. If fertility remained constant at 1972 levels, the projected population in the year 2002, even without any net emigration, was now revised to a little over 1.5 million, or only about one-half of that projected under the 1962 rates of growth. The table of course shows that between 1972-1982, the average annual rate of growth dropped even further, to 1.40%, but the causes and implications of this fall outside the scope of the present paper.

Table 1. Population at each census, 1846-1982.

Year	Population	Increase	Average annual rate of increase (per cent)
1846	158,462	-	-
1851	180,823	22,361	2.55
1861	310,050	129,227	5.87
1871	316,042	5,992	0.19
1881	359,874	43,832	1.31
1891	370,588	10,714	0.29
1901	371,023	435	0.01
1911	368,791	2,232	- 0.06
1921	376,486	7,694	0.21
1931	393,238	16,753	0.44
1944	419,185	25,947	0.49
1952	501,145	82,230	2.26
1962	681,619	180,474	3.12
1972	826,199	144,580	1.94
1982	949,686	123,487	1.40

The reason for the post-war change in the rate of population growth was a sudden drop in mortality and a simultaneous increase in fertility. Crude birth and death rates may be traced back to the late 19th century and, as shown in Table 2, the difference between the two was small until the 1940s. In 1946, the birth rate was 38.7 and the death rate 29.5; but by 1950, the birth rate had increased to 49.7 while the death rate had dropped to 13.9. This implied a change in the rate of natural increase from 9.2 to 35.8. Although the increase in the birth rate was temporary and lasted for only a few years, the decrease in the death rate continued. By 1962 the birth rate had more or less regained its earlier levels and was down to 38.0, but the death rate had dropped even further to 9.3 and the rate of natural increase was still as high as 28.7.

The drop in mortality in the post-war years resulted very largely from the eradication of malaria. The death rate was more than halved in about five years, from not far short of 30 towards the end of the war (36 in 1945 because of epidemics of dysentery and poliomyelitis as a result of severe cyclones in that year) to 14 in 1950. In the same period, infant mortality dropped from about 140 (188 in 1945) to 76. After the end of the war, the only major reverse in the downward trend of mortality occurred in 1948 when, because of a whooping cough epidemic, infant mortality jumped to 186 (compared to 114 in 1947 and 91 in 1949). As a result of the drop in mortality, life expectation at birth increased for males from 32.8 years in 1942-46 to 49.8 in 1951-53 and to 58.7 in 1961-63, and for females from 33.8 years to 52.3 and to 61.9, respectively.

Regarding the post-war rise in the birth rate, there are not sufficient data for a precise assessment of the two possible main causes: higher rates of marriage and higher fertility within marriage. The high birth rate of 1944 is probably associated with the conditions of recruitment for the Pioneer Corps which encouraged marriage because of the wife allowance offered. The further rise in the birth rate after the end of the war was probably the result of making-up for marriages and births prevented by the war, but also of the encouragement for family formation provided by the favorable economic conditions prevailing at the time.

Certainly, economic factors appear to have had an effect on marriage patterns in the past. In the period of economic depression around 1930, there was a marked tendency among the Indian community, who have traditionally married much earlier than other groups, to marry later than in the relatively prosperous years following the end of the First World War. This is reflected in the percentages of currently married Indian women aged 15-19 and 20-24, respectively, in the census years 1921, 1931 and 1944:

	1921	1931	1944
15-19	58.2	40.6	49.9
20-24	80.4	71.7	79.3

Table 2. Crude Birth Rate, Crude Death Rate, Rate of Natural Increase and Infant Mortality Rate, 1871-1973.

Year	CBR	CDR	RNI	IMR
1871-75	36.3	28.4	7.9	163.5
1876-80	36.6	29.2	7.4	157.7
1881-85	36.7	33.1	3.6	168.9
1886-90	37.0	32.8	4.2	161.3
1891-95	37.8	34.0	3.8	176.0
1896-1900	36.4	35.6	0.8	190.4
1901-05	36.5	37.6	- 1.1	169.6
1906-10	35.9	37.5	- 1.6	169.2
1911-15	38.0	34.7	3.3	155.6
1916-20	34.7	38.1	- 3.4	167.0
1921-25	39.0	31.0	8.0	141.8
1926-30	35.5	28.9	6.6	140.9
1931-35	31.8	30.3	1.5	151.0
1936-40	33.9	27.7	6.2	155.6
1941	33.0	25.6	7.4	134.8
1942	33.2	29.2	4.0	163.4
1943	33.2	25.9	7.3	141.6
1944	43.5	27.1	16.4	141.0
1945	38.5	36.1	2.4	188.0
1946	38.7	29.5	9.2	145.2
1947	43.7	20.1	23.6	113.9
1948	43.4	23.8	19.6	186.2
1949	45.6	16.6	29.0	91.0
1950	49.7	13.9	35.8	76.3
1951	47.5	14.9	32.6	83.5
1952	48.1	14.8	33.3	80.8
1953	46.3	16.1	30.2	93.5
1954	41.3	16.0	27.3	81.1
1955	41.8	12.9	28.9	67.2
1956	43.8	11.8	32.0	66.0
1957	43.1	13.0	30.1	75.1
1958	40.8	11.8	29.0	67.4
1959	38.1	10.8	27.3	62.5
1960	39.3	11.2	28.1	69.5
1961	39.4	9.8	29.6	62.0
1962	38.0	9.3	28.7	60.1
1963	40.2	9.6	30.6	59.3
1964	37.9	8.6	29.3	56.7
1965	35.4	8.6	26.8	64.1
1966	34.9	8.8	26.1	64.2
1967	30.6	8.5	22.1	70.5
1968	30.6	9.0	21.6	69.1
1969	27.7	8.0	19.7	70.4
1970	25.9	7.8	18.1	57.0
1971	25.1	7.6	17.5	51.7
1972	24.4	7.8	16.6	64.1
1973	22.7	7.8	14.9	63.3

Roughly paralleling the post-war increase in the birth rate and its subsequent decline, Table 3 shows that between 1944-1952, there was a trend to earlier and nearly universal marriage, while between 1952-1962 and, much more, between 1962-1972, there is evidence of marriage postponement among young Indian and Chinese women. Perhaps it is significant that the increased popularity of marriage and the high birth rates of the late 1940s and early 1950s occurred at a time when sugar production and earnings were booming. At about 1,000 kgs, per capita sugar production in the mid-1950s was at a level never reached before or since (except in 1963 which, interestingly, was one of only two or three occasions in the 1950s and 1960s when the birth rate showed an increase of any size).

Table 3. Percentage ever-married females by ethno-religion and age, 1944-1972.

	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Total							
1944	37.3	68.4	79.4	83.9	85.6	86.6	87.5
1952	41.5	76.1	88.4	92.1	93.2	94.2	94.3
1962	29.4	72.6	88.5	93.2	95.1	95.2	94.8
1972	13.2	53.9	82.7	92.1	95.0	95.7	96.3
Indian							
1944	51.9	83.2	89.6	91.4	92.0	92.6	93.7
1952	56.9	88.7	94.6	96.8	97.9	98.2	98.5
1962	37.5	84.5	94.8	97.0	98.0	98.5	98.6
1972	15.2	58.3	85.4	94.5	97.3	97.8	98.3
Hindu							
1944	55.1	84.8	89.8	91.4	92.4	92.9	93.6
1952 (1)							
1962	40.0	86.4	96.0	97.8	98.4	98.8	98.8
1972	16.3	60.2	87.2	95.6	97.8	98.5	98.8
Muslim							
1944	41.8	77.8	88.7	91.4	90.5	91.2	93.8
1952 (1)							
1962	30.2	78.9	91.3	94.8	96.6	97.6	98.1
1972	12.1	52.3	80.0	91.5	95.5	95.9	97.0
General							
1944	10.4	40.2	62.0	71.4	75.9	76.8	78.1
1952	12.6	51.1	75.3	82.3	84.8	86.6	87.3
1962	11.8	51.4	77.1	86.4	89.7	88.8	88.1
1972	9.2	44.6	75.9	87.2	90.5	91.7	92.2
Chinese							
1944	16.3	73.4	83.1	85.6	87.0	87.9	93.4
1952	11.9	71.8	89.9	94.1	93.6	97.2	96.1
1962	5.9	46.1	83.1	94.8	95.2	97.6	94.8
1972	3.2	31.0	76.5	90.2	95.5	96.8	96.8

(1) not available.

2. FERTILITY CHANGE

Summary measures of fertility in Mauritius for each year between 1962-1972 and for each population group are set out in Tables 4-6. The measures used are the following: the actual number of live births and the number projected if the 1962 age-specific birth rates had continued throughout the period (Table 4); the Crude Birth Rate (Table 5); and the Gross Reproduction Rate (Table 6).

The following main conclusions are suggested from the tables:

1. Between 1962-1972 there was a remarkable drop in fertility in Mauritius. This is reflected in all the indices used for measurement, as shown by the following figures for the total population extracted from the tables:

	Births	CBR	GRR
1962	37,182[2]	38.0	2.889
1972	20,413	24.4	1.602

   In 1972, there were about 17,000 (45%) less births than there would have been if the 1962 rates had continued. There were corresponding reductions in the crude birth rate and the gross reproduction rate.

2. Fertility dropped substantially among all ethno-religious groups:

	Births	CBR	GRR
Hindu			
1962	22,007[3]	40.8	3.194
1972	11,685	26.3	1.734
Muslim			
1962	6,619	38.9	2.977
1972	3,194	22.9	1.465
General			
1962	7,517	32.9	2.334
1972	5,139	22.6	1.519
Chinese			
1962	1,032	30.2	2.686
1972	395	15.7	0.912

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[2]Projected live births in 1972, using the age-specific rates of 1972.

[3]see Footnote 2.

Table 4. Live births by ethno-religion, 1962-1972: (1) constant 1962 age-specific birth rates; (2) actual birth rates.

Year	Total			Hindu			Muslim			General			Chinese		
	(1)	(2)	(2)/(1) X 100.0	(1)	(2)	(2)/(1) X 100.0	(1)	(2)	(2)/(1) X 100.0	(1)	(2)	(2)/(1) X 100.0	(1)	(2)	(2)/(1) X 100.0
1962	25934	25934	100.0	14144	14144	100.0	4331	4331	100.0	6762	6762	100.0	697	697	100.0
1963	26663	28225	105.9	14595	15779	108.1	4474	4871	108.9	6868	6847	99.7	726	728	100.3
1964	27542	27343	99.3	15172	14915	98.3	4663	4579	98.2	6953	7145	102.8	754	704	93.4
1965	28580	26278	91.9	15879	13985	88.1	4875	4558	93.5	7031	7107	101.1	795	628	79.0
1966	29595	26622	90.0	16611	14890	89.6	5084	4339	85.3	7068	6812	96.4	832	581	69.8
1967	30451	23763	78.0	17206	13180	76.6	5278	3906	75.2	7110	6128	86.2	857	549	64.1
1968	31719	24217	76.3	18130	13828	76.3	5545	3878	69.9	7166	6005	83.8	878	506	57.6
1969	32922	22122	67.2	18978	12448	65.6	5787	3506	60.6	7244	5694	78.6	913	474	51.9
1970	34347	21066	61.3	20009	12149	60.7	6061	3435	56.7	7321	5049	69.0	956	433	45.3
1971	35877	20740	57.8	21084	11850	56.2	6370	3270	51.3	7436	5205	70.0	987	415	42.0
1972	37182	20413	54.9	22007	11685	53.1	6619	3194	48.3	7517	5139	68.4	1032	395	38.3

Table 5. Crude Birth Rate by ethno-religion, 1962-1972.

	Crude Birth Rate					Crude Birth Rate Index (1962 = 100.0)				
Year	Total	Hindu	Muslim	General	Chinese	Total	Hindu	Muslim	General	Chinese
1962	38.0	40.8	38.9	32.9	30.2	100.0	100.0	100.0	100.0	100.0
1963	40.2	43.6	41.9	33.5	30.7	105.8	106.9	107.7	101.8	101.7
1964	37.9	40.4	38.6	33.4	29.1	99.8	99.0	99.2	101.5	96.4
1965	35.4	36.7	37.2	32.5	25.5	93.2	90.0	95.6	98.8	84.4
1966	34.9	37.9	34.4	30.7	23.3	91.9	92.9	88.4	93.5	77.2
1967	30.6	32.7	30.3	27.3	21.9	80.5	80.1	77.9	83.0	78.5
1968	30.6	33.5	29.5	26.6	20.2	80.5	82.1	75.8	80.9	66.9
1969	27.7	29.7	26.3	25.4	18.9	72.9	72.8	67.6	77.2	62.6
1970	25.9	28.3	25.3	22.3	17.2	68.2	69.4	65.0	67.8	57.0
1971	25.1	27.2	23.8	22.9	16.5	66.1	66.7	61.2	69.6	54.6
1972	24.4	26.3	22.9	22.6	15.7	64.2	64.5	58.9	68.7	52.0

Table 6. Gross Reproduction Rate by ethno-religion, 1962-1972.

	Gross Reproduction Rate					Gross Reproduction Rate Index (1962 = 100.0)				
Year	Total	Hindu	Muslim	General	Chinese	Total	Hindu	Muslim	General	Chinese
1962	2.889	3.194	2.977	2.334	2.686	100.0	100.0	100.0	100.0	100.0
1963	3.069	3.482	3.351	2.345	2.622	106.2	109.0	112.6	100.5	97.6
1964	2.906	3.191	3.067	2.432	2.289	100.6	99.9	103.0	104.2	85.2
1965	2.691	2.900	2.845	2.326	2.118	93.1	90.8	95.6	99.7	78.9
1966	2.655	2.961	2.696	2.227	1.777	91.9	92.7	90.6	95.4	66.2
1967	2.281	2.544	2.187	1.938	1.624	79.0	79.6	73.5	83.0	60.5
1968	2.254	2.509	2.127	1.947	1.563	78.0	78.6	71.4	83.4	58.2
1969	1.958	2.150	1.773	1.818	1.184	67.8	67.3	59.6	77.9	44.1
1970	1.795	2.000	1.669	1.562	1.299	62.1	62.6	56.1	66.9	48.4
1971	1.685	1.818	1.597	1.562	1.076	58.3	56.9	53.6	66.9	40.1
1972	1.602	1.734	1.465	1.519	0.912	55.5	54.3	49.2	65.1	34.0

3. By far the largest drop in fertility occurred among Chinese; the Muslim drop was the next largest; that among Hindu followed not far behind; while the drop among General Population was the smallest. The figures below show the percentage drop in the rates in 1972 compared to 1962:

	Births	CBR	GRR
Hindu	46.9	35.5	45.7
Muslim	51.7	41.1	50.8
General	31.6	31.3	34.9
Chinese	61.7	48.0	66.0

Fertility, as measured by the indices used here, was lower in 1962 among General than among Hindu or Muslim, but the differential drop closed the gap between the three major population groups. Chinese fertility, however, followed its own course of much more rapid decrease. In 1962, Chinese fertility rates were on the whole higher than those of General but lower than those of Hindu or Muslim. In 1972, Chinese fertility was by far the lowest of all groups. The drop in Chinese fertility is spectacular indeed: the crude birth rate dropped by 48% to 15.7 and the gross reproduction rate by 66% to 0.912.

4. The decline in fertility started at about the same time among the three major population groups but probably somewhat earlier among Chinese. Between 1962-1972, the only year when there was evidence of a non-negligible increase in fertility was 1963. The rise in that year affected the Hindu and Muslim, but only little the General or Chinese whose fertility rates were similar to those of 1962. By 1964, fertility rates of all major groups were only back to about their 1962 levels, but those of the Chinese had already begun the rapid decline that was to continue throughout the period. In 1965, the first large cuts appeared in the Hindu and Muslim rates while in 1966 the General rates were also reduced. For all three major groups, however, the largest drop occurred in 1967. This was followed by virtually no change in 1968 and by a further large drop in 1969. Between 1970-1972, the decline continued but at generally lower levels.

Annual age-specific birth rates from 1962-1972 and for each population group are shown in Table 7. Although there are some differences of emphasis between the age groups, the age-specific rates present the same general features as the summary measures. Two further points emerge:

Table 7. Age-specific birth rates by ethno-religion, 1962-1972.

ETH-REL	AGE	RATES 1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
TOTAL	15-19	108.4	111.3	91.6	83.6	84.7	74.6	72.5	67.3	57.9	53.6	51.1
	20-24	299.0	323.7	303.1	287.4	279.8	245.3	242.0	210.7	185.2	183.9	174.4
	25-29	302.6	305.4	306.3	279.3	277.6	239.2	238.9	213.2	202.9	186.5	180.4
	30-34	233.9	256.4	239.9	225.7	211.8	188.1	180.8	155.9	145.8	139.1	128.6
	35-39	160.8	174.2	169.1	155.8	155.9	132.4	125.8	110.8	106.9	90.0	87.2
	40-44	58.7	67.4	60.1	56.7	56.7	45.3	45.5	37.9	36.6	34.9	30.7
	45-49	8.6	8.0	7.9	7.0	7.6	6.7	7.4	4.9	5.1	4.1	3.7
HINDU	15-19	136.8	139.3	110.8	97.6	99.3	87.2	86.5	76.0	66.7	60.9	57.8
	20-24	341.6	380.3	337.0	320.5	320.3	275.2	272.7	231.0	203.6	200.6	187.8
	25-29	324.5	345.7	337.2	284.6	303.6	252.3	265.5	228.5	221.9	196.3	190.5
	30-34	253.3	282.8	264.0	241.1	235.0	208.1	196.8	169.5	162.8	149.6	135.8
	35-39	179.5	193.0	186.4	163.6	169.7	146.0	137.0	122.2	118.3	99.1	96.6
	40-44	65.6	73.2	67.3	59.0	61.3	46.4	51.0	39.8	40.5	34.3	30.4
	45-49	9.7	10.0	5.9	7.5	9.2	6.6	6.3	5.3	4.8	4.4	3.4
MUSLIM	15-19	115.4	116.6	92.6	82.2	81.4	71.5	61.2	58.6	51.3	43.3	42.7
	20-24	323.9	350.6	327.1	296.8	268.8	217.1	234.7	191.5	176.8	164.4	162.0
	25-29	314.3	319.5	307.5	297.0	278.5	241.5	220.8	198.9	189.8	167.5	152.1
	30-34	239.6	280.7	235.7	245.6	206.6	172.3	169.7	146.4	138.2	134.3	121.9
	35-39	150.8	184.2	174.1	169.1	156.0	139.5	133.4	107.2	109.5	90.6	83.5
	40-44	53.6	69.6	54.4	60.5	57.3	47.9	40.3	42.7	36.2	39.5	29.2
	45-49	6.2	4.9	11.0	6.9	5.4	6.8	6.6	4.8	6.4	2.8	3.1
GENERAL	15-19	59.8	61.2	60.6	63.3	63.8	56.2	56.4	61.2	49.6	50.1	48.2
	20-24	229.6	236.2	243.3	237.3	228.6	205.8	196.0	190.6	162.2	171.1	165.8
	25-29	264.4	239.5	262.5	264.2	242.1	222.4	213.8	201.5	181.9	186.5	185.5
	30-34	205.8	210.6	212.0	200.2	185.7	170.2	165.9	143.2	124.6	127.7	124.6
	35-39	136.3	141.6	142.5	137.9	139.2	112.2	112.6	99.9	93.5	79.4	76.9
	40-44	49.0	56.1	50.6	51.8	50.4	43.1	39.5	33.2	32.0	35.3	32.8
	45-49	7.2	6.3	7.4	5.9	4.8	6.7	9.1	4.4	4.9	4.0	4.4
CHINESE	15-19	33.2	40.7	28.8	25.6	26.3	28.1	27.1	19.4	17.1	19.0	10.8
	20-24	227.8	220.7	229.0	179.2	146.8	150.9	141.5	137.2	96.3	98.7	77.2
	25-29	319.8	301.1	287.6	263.2	235.1	197.6	179.5	159.9	150.5	136.8	137.8
	30-34	227.3	263.9	214.3	175.5	167.0	150.1	139.2	121.0	135.5	110.2	104.3
	35-39	186.1	163.8	148.1	150.8	120.1	115.3	67.7	72.9	63.1	50.5	60.2
	40-44	84.2	97.2	87.8	56.3	49.0	35.7	45.5	31.6	21.5	16.0	21.3
	45-49	21.8	11.0	32.2	11.8	27.0	8.5	9.1	2.9	5.8	8.1	4.8

1. Although there may be a slight tendency for the size of the drop to increase with age, on the whole there was little difference in the proportionate change for women aged 25 or more.

2. Among younger women, marriage postponement was a major cause of fertility decline.

The decline in the birth rate of the 15-19 age group had in fact begun even before 1962, as shown by a comparison of the rates between 1958 (the first year age-specific birth rates became available from registration data) and 1962:

1958	1959	1960	1961	1962
140.0	121.5	122.5	117.9	107.3

This is especially revealing because other age-specific rates remained virtually unchanged in that period:

	20-24	25-29	30-34	35-39	40-44	45-49
1958	303.8	282.8	237.5	156.8	54.2	6.0
1962	299.0	302.6	233.9	160.8	58.7	8.6

The drop in the 15-19 rate must therefore have occurred very largely as a result of the decreasing proportion of married women in that age group. As it was shown in Table 3, the trend to later marriage intensified and covered a wider age range in the later 1960s and early 1970s. Its effects on fertility will be discussed in section 4 of this paper.

3. FAMILY PLANNING

In the period under consideration, two organizations provided family planning services in Mauritius: the Action Familiale (AF), which dealt only with the rhythm method, and the Family Planning Association (FPA), which covered all other methods. To the end of 1972, the total number of acceptors was almost 14,000 for the AF and 50,000 for the FPA. Cumulated percentage rates of acceptance among women aged 15-49 are shown in Table 8, by ethno-religious group, age and parity.

Among FPA acceptors, by far the most common method adopted was the pill (about 38,500 new acceptors to the end of 1972), followed by the condom (10,000), while only a small number had IUD inserted (1,500).

Table 8. Cumulative percentage acceptance rates among women in the reproductive ages, by ethno-religion, age and parity, end 1972.

	FPA	AF
Total	26.3	6.8
Ethno-religion		
Hindu	25.8	3.9
Muslim	26.3	3.7
General	28.7	13.4
Chinese	16.2	11.5
Age		
15-19	4.9	1.1
20-24	27.3	6.2
25-29	50.6	11.6
30-34	50.2	13.6
35-39	41.1	10.8
40-44	22.1	7.4
45-49	6.4	3.1
Parity		
0	1.6	1.6
1	35.0	14.1
2	43.0	12.6
3	44.1	11.8
4-6	46.8	10.1
7+	43.6	6.7

In the assessment of any family planning program, the level of subsequent pregnancies among acceptors is especially important. The effect of length of use on termination rates can be measured by multiple decrement life table techniques, differentiating between pregnancies and various other reasons for drop-out.

Table 9 shows 12 and 24-month percentage pregnancy rates by method, demographic characteristics and whether the pregnancy occurred while the method was still supposed to be used or after termination of use.

Table 9. Cumulative gross pregnancy rates of FPA acceptors and of AF acceptors (FPA: all segments by 1st method).

		PILL	IUD	CONDOM	ALL FPA	RHYTHM	PILL	IUD	CONDOM	ALL FPA	RHYTHM
		PREGNANCIES WHILE USER					ALL PREGNANCIES				
12 MONTHS											
TOTAL		6.5	4.6	9.5	7.3	14.3	10.6	5.9	16.0	12.0	17.7
ETHNO-RELIGION	HINDU	6.3	4.2	9.9	7.3	14.5	10.8	5.9	16.8	12.4	17.8
	MUSLIM	6.7	4.9	8.9	7.2	19.3	11.4	6.2	16.4	12.6	21.6
	GENERAL	6.7	5.8	9.0	7.3	14.1	10.0	5.8	14.5	11.1	17.7
	CHINESE	7.4	0	10.8	8.0	8.3	10.8	0	14.4	11.3	13.4
AGE	15-19	9.6	0	10.7	9.5	27.2	16.9	1.8	18.9	16.9	31.0
	20-24	8.1	4.7	12.2	9.1	18.8	13.3	6.3	21.1	15.4	23.5
	25-29	6.2	5.3	10.8	7.6	14.1	10.3	6.3	16.9	12.1	18.2
	30-34	5.9	6.2	9.3	6.9	11.9	9.7	7.9	14.7	11.1	14.7
	35+	4.8	2.5	4.5	4.6	7.3	6.9	3.3	9.2	7.4	8.7
PARITY	0	6.9	0	20.4	10.8	22.3	15.8	25.0	29.5	19.8	25.3
	1	8.1	4.9	10.5	8.7	23.6	14.1	4.9	18.7	15.2	28.5
	2	7.1	4.8	10.2	7.9	15.1	11.9	5.6	17.2	13.2	18.7
	3	7.5	5.7	11.1	8.5	12.1	10.9	7.8	17.3	12.7	15.2
	4-6	6.4	4.9	8.5	6.9	11.5	10.3	6.2	14.9	11.4	14.7
	7+	5.2	3.5	8.3	6.2	10.8	8.6	4.7	14.2	10.5	13.5
24 MONTHS											
TOTAL		10.9	8.1	13.2	11.5	23.2	21.3	10.9	26.6	22.4	34.5
ETHNO-RELIGION	HINDU	10.9	7.0	13.7	11.6	24.2	22.4	10.2	27.2	23.3	34.3
	MUSLIM	11.0	8.5	12.9	11.4	31.5	22.2	9.8	28.0	23.4	40.7
	GENERAL	10.8	11.2	12.2	11.2	23.6	19.4	13.5	24.8	20.7	34.1
	CHINESE	12.1	10.5	14.7	12.6	18.0	19.6	10.5	21.9	19.9	28.9
AGE	15-19	15.3	3.4	15.3	14.7	45.3	30.7	11.3	30.2	29.6	59.0
	20-24	13.0	9.8	16.4	13.8	32.7	26.1	11.9	33.3	27.7	44.7
	25-29	11.3	8.6	14.6	12.1	23.8	22.0	11.3	27.7	23.2	36.0
	30-34	10.2	8.5	12.6	10.8	21.1	19.4	12.4	24.5	20.6	29.9
	35+	7.9	6.3	7.8	7.7	11.7	14.8	7.6	18.5	15.6	17.4
PARITY	0	12.3	0	21.6	14.8	41.2	30.1	25.0	33.2	30.9	52.3
	1	14.1	8.3	13.3	13.6	36.0	28.1	14.6	33.6	29.4	50.7
	2	10.9	12.9	14.8	12.1	26.6	23.5	13.6	28.5	24.6	36.8
	3	12.2	11.4	15.4	13.1	21.1	22.0	17.9	28.3	23.7	31.2
	4-6	11.1	7.8	11.6	11.0	20.0	20.8	10.0	29.3	21.6	29.5
	7+	8.8	6.0	12.5	9.8	18.5	17.7	8.1	23.4	19.0	27.0

Some of the 12-month rates are extracted and shown below:

	Pill	IUD	Condom	Rhythm
Pregnancies (user)	6.5	4.6	9.5	14.3
All pregnancies	10.6	5.9	16.0	17.7

Total termination rates (irrespective of reason) were fairly high, as shown below for each method (first segment of use only):

Length of use	Pill	IUD	Condom	Rhythm
12 months	52.5	30.4	76.1	31.0
24 months	73.1	47.6	90.0	63.0

4. BIRTHS AVERTED

The very sharp drop in fertility in Mauritius and the parallel expansion of family planning services raises the question: To what extent are the two related? However, as explained above, major changes had been taking place not only in fertility but also in marriage patterns.

It was shown in Table 3 that, between the 1962-1972 censuses, there was a very substantial drop in the proportion of ever-married women aged under 30, and it is clear that the younger the women the greater the decline. The related changes in fertility can be assessed using the data shown in Table 10. It shows age-specific birth rates by marital status and ethno-religious group in 1962 and 1972. When the 1972 rates have been expressed as percentages of those for 1962, it emerges that, reflecting the pattern of marriage changes, there is little difference in all ethno-religious groups between the "all women" and the "ever-married women" sets for ages 30 or more. Among younger women, however, differences are important. This is especially so in the 15-19 age group where it is shown that (except among the Chinese) there has been almost no decline at all in marital fertility, and that the 53% drop in the birth rate of that group taken as a whole can be almost totally accounted for by the smaller proportion of married women. In the 20-24 and, to a smaller extent, the 25-29 age groups, marriage changes account for some of the drop in the birth rates, but in both groups considerable reductions have also occurred in marital fertility. Among women aged 30 or more, marriage changes had an almost negligible effect on fertility decline. In summary, for all ethno-religious groups taken as a whole, marital fertility had changed little among women aged 15-19 but it had dropped very substantially and by a proportion increasing with age among those aged 20 or more. Finally, as shown in Table 11, it is now possible to allocate the estimated number of births averted during the whole of the 1962-1972 intercensal period to each of the main factors:

- marriage postponement, and
- marital fertility drop
    - among family planning acceptors and
    - among non-acceptors.

The first part of the table shows the actual number of births in each year from 1962 to 1972 and the projected number on each of the following two hypotheses:

- constant 1962 rates for all women, and
- constant 1962 rates for all ever-married women.

The difference between the projected total under the 1962 "all women" rates and the actual total is 65,705, which is an estimate of the total number of births averted through all causes. The difference between the two projected totals is 33,033, which is an estimate of the number of births averted because of marriage postponement. Births averted associated with family planning acceptors were calculated under two alternative sets of birth rates: the current rates of non-acceptors and adjusted pre-acceptance rates of acceptors (details on the method of calculation of these two sets of rates can be found in the main study on which this paper is based). Conclusions are summarized below:

	Current rates of non-acceptors	Adjusted rates pre-acceptance
Total births averted 1962-1972	65,705	65,705
- Marriage postponement	33,033	33,033
- Fertility decline, acceptors	25,607	37,816
- Fertility decline, non-acceptors	7,065	-5,144

The figures above indicate that if the current rates of non-acceptors are used to estimate births averted, 50% of all such births may be attributed to marriage postponement (but only 36% in the second half of the period), 39% are associated with fertility decline among family planning acceptors, and 11% with fertility decline among non-acceptors. If, on the other hand, the adjusted pre-acceptance rates are used, fertility decline associated with acceptors is the main element, with marriage postponement not far behind, while non-acceptor fertility had slightly increased. Further, if the adjusted pre-acceptance rates are used, it can also be calculated that while the actual number of births to acceptors was 65.6% below the projected number, births to non-acceptors were 2.4% higher than projected. Although the nature of the data does not permit a categorical assertion that fertility among non-acceptors had slightly risen, viewed as a whole, the estimations based on the two hypotheses strongly suggest that there has been almost no change in non-acceptor fertility.

Table 10. Age-specific birth rates by marital status and ethno-religion, 1962 and 1972.

	Rates										Rates in 1972 as % of those in 1962				
	Total		Hindu		Muslim		General		Chinese		Total	Hindu	Muslim	General	Chinese
Age	1962	1972	1962	1972	1962	1972	1962	1972	1962	1972					
All women															
15-19	108.4	51.1	136.8	57.8	115.4	42.7	59.8	48.2	33.2	10.8	47.1	42.3	37.0	80.6	32.5
20-24	299.0	174.4	341.6	187.8	323.9	162.0	229.6	165.8	227.8	77.2	58.1	55.0	50.0	72.2	33.9
25-29	302.6	180.4	324.5	190.5	314.3	152.1	264.4	185.5	319.8	137.8	59.6	58.7	48.4	70.2	43.1
30-34	233.9	128.6	253.3	135.0	239.6	121.9	205.8	124.6	227.3	104.3	55.0	53.3	50.9	60.5	45.9
35-39	160.8	87.2	179.5	96.6	150.8	83.5	136.3	76.9	186.1	60.2	54.2	53.8	55.4	56.4	32.3
40-44	58.7	30.7	65.6	30.4	53.6	29.2	49.0	32.8	84.2	21.3	52.3	46.3	54.5	66.9	25.3
45-49	8.6	3.7	9.7	3.4	6.2	3.1	7.2	4.4	21.8	4.8	43.0	35.1	50.0	61.1	22.0
15-49	179.1	102.0	200.0	111.6	186.4	93.3	145.5	93.8	158.0	61.6	57.0	55.8	50.1	64.5	39.0
Ever-married women															
15-19	368.9	387.3	342.0	354.6	380.5	352.9	502.5	523.9	560.6	337.5	105.0	103.7	92.7	104.2	60.2
20-24	412.0	323.5	395.4	312.0	410.4	309.8	446.6	371.7	493.7	249.0	78.5	78.9	75.5	83.2	50.4
25-29	341.8	218.1	337.9	218.5	344.3	190.1	342.9	244.4	384.8	180.1	63.8	64.7	55.2	71.3	46.8
30-34	250.8	139.6	259.0	141.2	252.6	133.2	238.1	142.9	239.9	115.6	55.7	54.5	52.7	60.0	48.2
35-39	169.1	91.8	182.4	98.8	156.2	87.4	151.7	85.0	195.4	63.0	54.3	54.2	56.0	56.0	32.2
40-44	61.7	32.1	66.4	30.9	54.9	30.4	55.2	35.8	86.4	22.0	52.0	46.5	55.4	55.4	25.5
45-49	9.1	3.8	9.8	3.4	6.3	3.2	8.2	4.8	23.0	5.0	41.8	34.7	50.8	50.8	21.7
15-49	235.4	159.6	241.5	167.6	241.5	150.7	218.5	154.8	256.5	114.10	67.8	69.4	62.4	62.4	44.5

Table 11. Actual and projected live births and live births averted by cause, 1962-1972.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	Total (mid-62-mid-72)
Births												
Actual	25934	28225	27343	26278	26622	23763	24217	22122	21066	20740	20413	244812
Projected												
1962 age- specific rates for all women	25934	26663	27542	28580	29595	30451	31719	32922	34347	35877	37182	310517
1962 age- specific marital rates	25934	26181	26530	26950	27275	27397	27872	28220	28740	29290	29598	277484
Births averted												
Total		- 1562	199	2302	2973	6688	7502	10800	13281	15137	16769	65705
Marriage postponement		482	1012	1630	2320	3054	3847	4702	5607	6587	7584	33033
Marital fertility drop												
Total		- 2044	- 813	672	653	3634	3655	6098	7674	8550	9185	32672
Current rates of non-acceptors												
Family Planning acceptors		-	-	-	385	1032	2840	3569	5549	7489	9485	25607
Non-acceptors		- 2044	- 813	672	268	2602	815	2529	2125	1061	- 300	7065
Adjusted pre-acceptance rates												
Family planning acceptors		-	-	-	546	1770	4094	5915	8403	10723	12730	37816
Non-acceptors		- 2044	- 813	672	107	1864	- 439	183	- 729	- 2173	- 3545	- 5144

To conclude, it has been demonstrated that the fertility drop in Mauritius in the period 1962-1972 was almost exclusively the result of two factors: marriage postponement, and birth control through the family planning program. Each of these two factors was responsible for almost one-half of all births averted in the period as a whole. Fertility change outside the family planning program appears to have been almost nil.

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Chapter 6

MAURITIUS: FERTILITY DECLINE AND POPULATION POLICY

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Social policies have been used widely to regulate growth of population. Traditionally, the aim has been to increase the birth rate by providing family allowances, housing subsidies and health services. There are, however, also cases where the improvements in social security, health and welfare have been planned - not to increase - but to slow down the rate of population growth. The work of the Titmuss Commission in Mauritius in the early 1960s is one example.

The Titmuss Program was an example of what might be called a social population policy. It contained family and maternity benefit schemes, marriage benefits and other forms of family aid. It suggested new legislation for old age pensions and workmen's compensation as well as new forms of social insurance policies covering the risks of unemployment and sickness. All of this was needed - as the Commission claimed - to create a healthier and more secure family life, a necessary condition for the motivation to have smaller families.

The Titmuss Program was never implemented as such. The Legislative Council of Mauritius rejected most of it.[1] Nevertheless, the decline in fertility rates in Mauritius has been remarkable during the last three decades. The total fertility rate for Mauritius was 5.9 in 1960 but only 2.7 in 1980 and 1.9 in 1988 (Grant, 1990, p. 93). This means that the average annual reduction in the total fertility rate has been 3.9 per cent in 1960-1980 and as high as 4.4 per cent in 1980-1988! Very few countries have attained such good results in their efforts to promote fertility decline (see Table 1.). In fact, in most of the Third World fertility rates have declined by less than 1 per cent per year in the 1980s and the reduction rate was even lower in the 1960s and 1970s.

In 1985, Robert J. Lapham and W. Parker Mauldin published the results of an extensive comparative study of family planning programs in 100 developing countries (Lapham and Mauldin, 1985, pp. 117-137). What they were interested in was the family planning program effort. By family planning program is meant organized programs designed to provide the information, supplies, and services of the modern means of fertility control to those interested (Freedman and Berelson,

[1]Would it have worked if put into effect? This question has always interested me so much that I started my academic career by writing my doctoral thesis on it in 1982. (Salo, 1982).

1976, vol 7, pp. 3-40). Family planning program effort, as defined by Barbara Entwisle, is "the degree of commitment to these goals, in the private and public sectors" (Entwisle, 1989, vol. 26, pp.53-76).

Table 1. Ten countries with the world's highest average annual rates of total fertility rate reduction in 1980-1988 (Grant, 1990, p. 93).

Country	Total fertility rate (TFR)	Average annual rate of reduction (%) of TFR	
	1988	1960-80	1980-88
Mauritius	1.9	3.9	4.4
S. Korea	2.0	3.9	3.3
Thailand	2.5	2.5	5.6
Indonesia	3.2	1.1	4.0
Sri Lanka	2.6	2.1	3.7
Guyana	2.7	2.9	3.6
Jamaica	2.8	1.7	3.5
Tunisia	4.0	1.5	3.5
Mexico	3.5	2.1	3.1
Vietnam	4.0	0.7	3.3
Mean	2.9	2.2	3.8

Lapham and Mauldin based their measurements on a 30-item scale. They described their method as follows:

> Our measures of program effort, for 1982 ... are based on ... a study conducted in the last half of 1983 and early 1984, in which some 400 population specialists[2] around the world provided information on 30 items related to family planning programs... We are confident that programs with higher scores are relatively better programs, and that those with low scores are not as good.

The items on the scale covered many aspects of family planning programs: policies, resources, and stage-setting activities; service and service-related activities; record-keeping and evaluation; and availability and accessibility of fertility regulation supplies and services. The rating of each criterion was on a scale from zero to four, with four indicating a strong policy or much activity on an item. Thus, with 30 items, the scoring range was from zero to 120. Countries which

[2]Population specialists whose estimations and opinions Lapham and Mauldin collected were "high level program administrators, representatives of bilateral and multilateral funding agencies, and a variety of other qualified experts" (see Entwisle, 1989, p. 54.).

had a score of 80 or more were considered as having been able to implement a strong program effort. Scores of less than 25 were assumed to indicate that the program effort was very weak or nil.

Mauritius ranked very high on program effort in 1982. In fact, there were only nine countries which had a score higher than 80. Mauritius was one of them (see Table 2.). Most of the developing countries had much "weaker" program efforts.

Table 2. Countries with a Lapham-Mauldin family planning program effort score higher than 80.

Country	L-M score
China	101.1
S. Korea	94.8
Taiwan	94.3
Singapore	93.4
Indonesia	89.9
Colombia	85.3
Hong Kong	82.8
Mauritius	82.0
Sri Lanka	80.4

According to Barbara Entwisle's recent re-analysis of Lapham's and Mauldin's results a program effort measure can be divided into eight components.[3] Mauritius had a maximum score on one of them, namely on official policy (POLICY) which refers to governmental commitment to family planning (see Table 3.). In fact, this is close to a world record because only two other countries (China and India) ranked so high on this component.

Maximum values on the official policy component score were given by the evaluators if (1) the governmental policy strongly supported family planning activities; (2) the head of the government and other high officials spoke publicly and favorably about family planning at least once or twice a year; (3) the import laws and legal regulations facilitated the importation of contraceptive supplies; and (4) the advertising of contraceptives in the mass media was allowed with no restrictions.

Mauritius' score on governmental sponsorship (GSPON) was 8.7 out of a possible 16. This component variable refers to the strength of the relationship between

[3]Mauldin and Lapham themselves distinguished four components. More recently, Barbara Entwisle (1989) has re-analysed their results and proposed eight. This paper follows the Entwislean model.

the government and the administration of the program, and it had three indicators: (1) the level of the governmental position held by the family planning director; (2) the extent to which ministries and government agencies other than the one with primary reponsibility for the delivery of family planning services assist in these efforts; (3) the portion of the total family planning budget coming from in-country sources; and (4) the involvement of the civil bureaucracy in carrying out family planning program directives.

Table 3. Family planning program effort component scores: Mauritius and the theoretical maximum values.

Program effort component	Scores		
	Mauritius	Maximum	Proportion of maximum (%)
Official policy (POLICY)	16.0	16	100
Governmental sponsorship (GSPON)	8.7	16	54
Private sponsorship (PSPON)	2.7	4	68
Program organization and management (POM)	24.3	32	78
Innovative delivery systems (IDS)	10.4	16	65
Demand generation (DG)	7.4	12	62
Supplementary methods (ASUPP)	11.1	12	93
Conventional methods (ACON)	1.3	12	11

There were twelve countries which had higher scores for this component, e.g. China (15), Indonesia (14.5), Singapore (12.3), South Korea (12.0), India (11), etc. Mauritius' score was, nevertheless, more than twice the average governmental sponsorship score among all 100 countries.

The third dimension of a family planning program, private sponsorship (PSPON), is a measure of the extent to which private-sector groups and agencies assist with family planning activities and other population activities. Mauritius' ranking for this component was also high. Only eleven countries had higher scores than Mauritius. Two Latin American countries, namely Brazil and Colombia, gained maximum points here.

Program organization and management (POM) is probably the most important program effort component. This refers to the degree to which the organization, support, supervision, and activities of program personnel facilitate the delivery of family planning activities. Several indicators were in use here. Some were measures of (1) the adequacy of administrative structure and staff for the implementation of plans regarding the delivery of services; (2) the adequacy of training for each category of staff; and (3) the extent to which staff carried out assigned tasks. Some indicators were evaluations of the sufficiency of the logistics and transportation systems for the provision of contraceptive supplies and related equipment to service points. And finally there were indicators for (1) the degree to which record-keeping systems had been organized and implemented; (2) the adequacy of the collection, analysis and dissemination of data pertinent to family planning program activities; and (3) the extent to which program managers used the results of evaluations to improve the program.

Mauritius had a score of 24.3 out of a possible 32 on POM. Only Hong Kong (29.8), Indonesia (29.5), Singapore (29.1), Taiwan (29.0), South Korea (26.7) and Thailand (25.1) ranked higher.

Also the extent to which channels other than traditional family planning clinics, innovative delivery systems,[4] were used to provide family planning services was estimated to be quite large in Mauritius. Its score for IDS was 10.4 out of 16. Sri Lanka got 15 and there were five other countries with somewhat higher scores than Mauritius (i.e. China, Colombia, Cuba, Fiji and Jamaica).

The degree to which strategies to increase the demand for family planning services are implemented is called the demand generation (DG) component of program effort. This has three indicators: (1) the coverage of the frequency of mass media messages providing information about family planning; (2) the proportion of the population covered by home-visiting workers; and (3) the use of incentives and disincentives to promote small family sizes and the adoption of family planning.

Mauritius gained a score of 7.4 out of a possible 12 on DG. China was estimated to reach the maximum level. Taiwan was very close to it (11.5).

Finally, there are two components covering the availability and accessibility of fertility control methods. Conventional methods (ACON) refers to the ease of access to contraceptive pills, injectables, IUD and condoms. Supplementary methods (ASUPP), in turn, refers to the availability of medically adequate abortion and sterilization services.

Mauritius was reported to have an extremely high score for ASUPP (11.1 out of 12) but a surprisingly low score on ACON (1.3 out of 12). The limited availability of conventional contraceptive methods is an interesting part of Mauritian population policy.

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[4]i.e., (1) coverage of new mothers by a postpartum program; (2) proportion of the country covered by a social marketing program; (3) proportion of country covered by community based distribution programs; and (4) the coverage and frequency of mass media messages providing information about family planning.

The z-values of the program effort component scores in Table 4 show clearly that Mauritius mostly has points well above the average values calculated for the 100 countries under study. The ACON component is the only exception.

Does this justify a conclusion that the decline in Mauritian fertility rates is due to its strong family planning program effort?

Table 4. Z-values of program effort component scores for three countries.

Country	Mauritius	China	Guyana
POLICY	1.79	1.79	-0.50
GSPON	1.42	3.17	-0.49
PSPON	1.16	-1.17	0.19
POM	1.81	1.63	-0.12
IDS	1.92	2.35	0.02
DG	1.61	3.10	-0.03
ASUPP	1.66	1.63	0.89
ACON	-0.44	2.58	-0.38

The relationship between fertility decline and family planning effort seems to be somewhat more complicated. As shown above, China was the country which ranked highest for program effort. Nevertheless, its average annual rate of total fertility rate reduction in 1980-1988 was only 1.0 per cent. Guyana, on the other hand, had a total effort score of only 32 and five of its component scores fell below the mean level, as shown in Table 4. Guyana's total fertility rate, however, declined by 3.6 % per annum in the 1980s. Thus, a strong family planning program effort does not seem to have been a sufficient nor a necessary condition for a fast decline in fertility in the Third World of the 1980s. Fertility rates can stay high in spite of it and they can collapse without it.

This does not mean, however, that there is no connection at all. As Table 5 shows there seems to be a statistical correlation between the program effort and the rate of fertility decline. The stronger the effort the faster the decline. The mean of the average annual rates of total fertility was only 0.4 per cent among the 47 countries where the program effort was weak or nil but 2.8 per cent among the countries where the effort was strong. Consequently, the means for total fertility rates are much lower and the means for contraceptive prevalence much higher where the effort was strong.

Thus, in spite the lesson given us by the cases of China and Guyana, it seems very plausible that the role of the family planning program effort has been crucial in the developments which have resulted in the swift fertility decline in Mauritius. More theoretical and empirical research is, however, needed to determine the importance and coinfluence of other social and economic factors.

Table 5. Means of program effort scores 1982 (L-M), total fertility rates 1988 (TFR), average annual rates of TFR reduction (%) in 1980-1988 and contraceptive prevalences in 1980-1987 (%) for 100 developing countries classified by family planning program effort levels.[5]

Program effort	L-M 1982	TFR 1988	TFR red 1980-88	Contraceptive prevalence
"Strong" (N=9)	88.4	2.5	2.8	68
"Moderate" (N=16)	65.3	3.6	2.5	48
"Weak" (N=28)	36.0	5.2	1.3	28
"Very weak or none" (N=47)	10.5	6.2	0.4	9

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[5]This table has been derived from the demographic data provided by Grant, 1990.

Chapter 7

THE HEALTH STATUS OF THE MAURITIAN POPULATION AND PROSPECTS FOR CHANGE[1]

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1. INTRODUCTION

Developing countries throughout the world are experiencing marked changes in the pattern of disease within their populations. The decline in the incidence of the major infectious diseases seems almost inevitably to be associated with a rise in the incidence of non-communicable diseases (NCD) such as cancers, ischemic heart disease, cerebro-vascular disease, hypertension, and non-insulin-dependent diabetes mellitus.

These NCDs can exact a considerable toll on health service resources. In fact, the incidence rates of many NCDs are now higher in some developing countries (still beset with other economic, social, and health problems) than in the major developed nations. Developing nations can ill-afford the associated costs.

However, experience in some developed countries over the last few decades, where there have been marked falls in mortality rates from cardiovascular disease and certain cancers, suggest that NCDs are not an inevitable accompaniment of modern life-style. In this respect, developing countries might be able to use some of the lessons already learnt by developed populations to both prevent the appearance of NCDs as major problems, and to control them once they have appeared.

Mauritius has already reached that point where NCDs have become its major health problem, with indications that the burden will increase unless effective action is taken.

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[1]This report was prepared only for the Task Force Meeting on Population and Sustainable Development in Mauritius held at IIASA, 3-5 September 1990. The authors wish to acknowledge that all material is abstracted form existing published and unpublished sources listed in the bibliography.

2. TRENDS IN ROUTINE HEALTH STATISTICS

Mortality

Over the last 40 years, against a background of increasing wealth, nearly full literacy rates in young age-groups, a highly successful family planning program, marked declines in infant mortality rates (26.3 per 1,000 live-births in 1986), and similarly impressive increases in the expectation of life, there have been major changes in the profile of diseases from which Mauritians die.

The most striking feature has been the decline in total death rates due to infectious and parasitic diseases in the late 1940s (from 45% of total deaths in 1942 to 23.6% in 1952). The major component of this early reduction was the virtual eradication of malaria. Since that time, with continuing improvements in hygiene and health care systems, the rate has continued to fall, and in 1986 represented only 2.8% of total deaths.

However, along with the decreases in total death rates, and in both death rates and the proportion of deaths due to infectious and parasitic diseases, there have been considerable rises in death rates due to other causes. For instance, deaths from neoplasms have increased from 16.4 to 54.0 deaths per 100,000 population, representing respectively 0.6% and 8% of all deaths, over the period 1942 to 1986. More alarming have been rises in the broad category of "diseases of the circulatory system," which have increased from rates of 114.2 to 297.0 deaths per 100,000 population (3.9% and 44.5% of total deaths respectively) between 1942 and 1986.

Trends of major causes of death during the period 1972-1980 are shown in Figure 1. During this period circulatory diseases were the leading cause of death and with neoplasms, showed an upward trend whilst the other causes examined generally declined.

The short period 1982-1986 has also seen a dramatic, over three-fold rise in deaths attributed to diabetes mellitus from 13.4 to 43.6 deaths per 100,000 population (representing 2.0% and 6.5% of total deaths respectively) (Figure 2). It seems unlikely that either the incidence or case-fatality of a disease such as diabetes could increase so markedly over such a short period. In all probability, the trend in mortality statistics is related to case ascertainment and death certification practice. Notwithstanding this reservation, the magnitude of the figures presents considerable cause for concern.

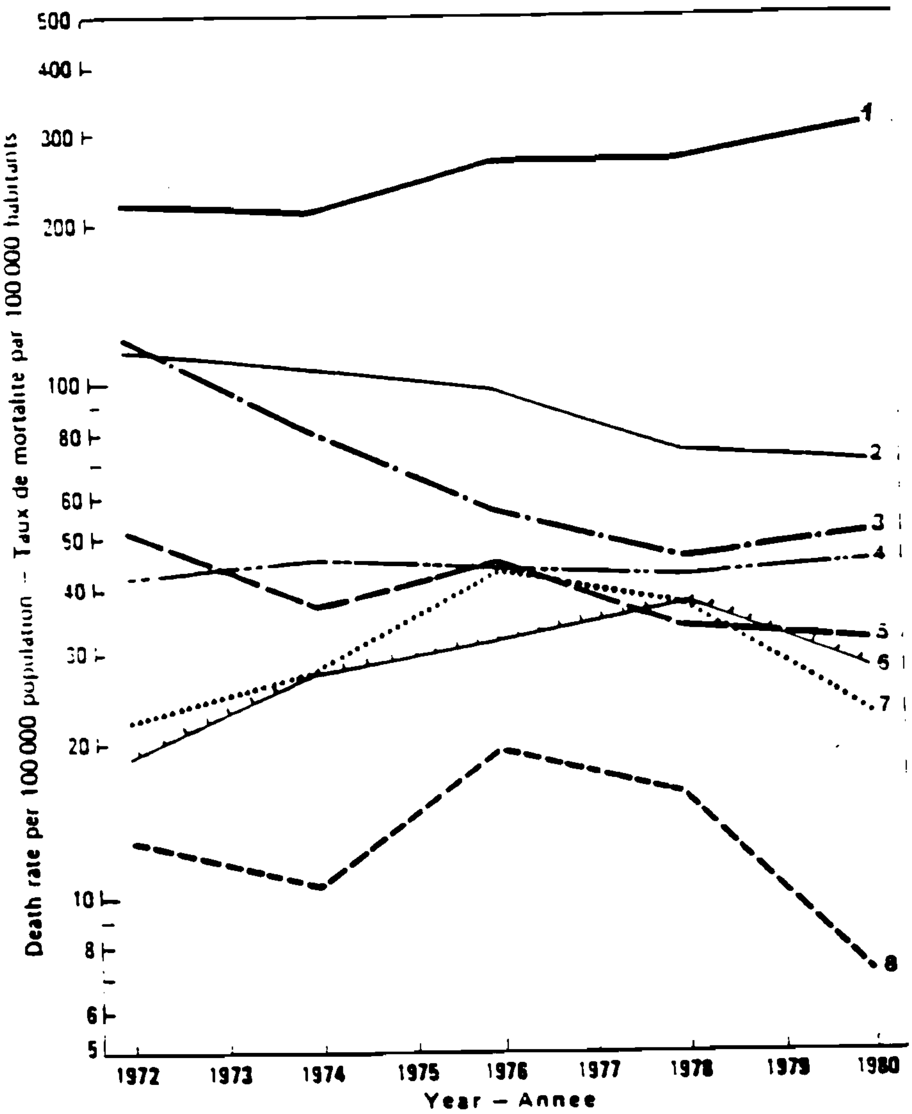

Figure 1. Trends of major causes of death (ICD-8), Island of Mauritius, 1972-1980.

1. Diseases of the circulatory system.
2. Diseases of the respiratory system.
3. Infective and parasitic diseases.
4. Neoplasms.
5. Causes of perinatal mortality.
6. Diseases of the digestive system.
7. Endocrine, nutritional and metabolic diseases.
8. Diseases of the nervous system and sense organs.

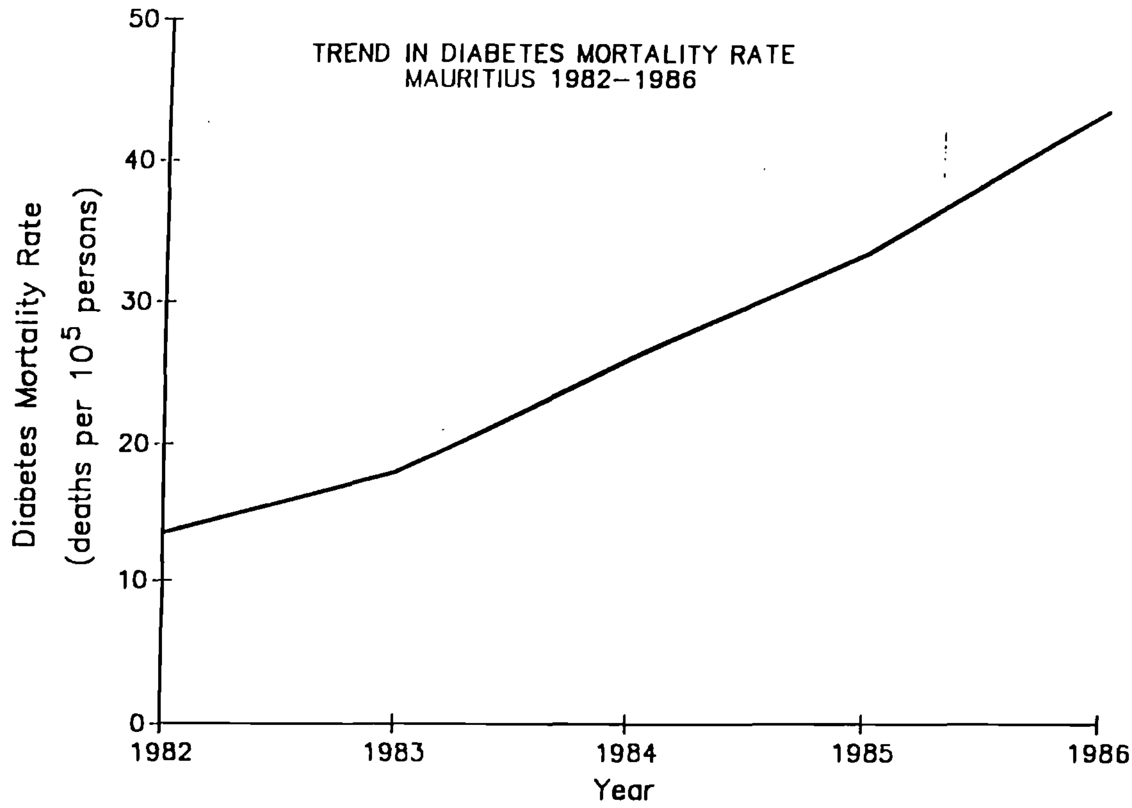

Figure 2. Mortality from diabetes, 1982-1986.

Morbidity

Diseases of the circulatory system, comprising mainly heart (ischemic and other), hypertensive and cerebro-vascular disease accounted for 9.2% of all discharge diagnoses from general (regional and district) hospitals in 1986, the third largest group after obstetric and related conditions (23.9%), and "ill-defined conditions" (9.6%). Infections and parasitic diseases were responsible for 5.1% of total discharges.

The trends in morbidity for major non-communicable diseases over the period 1982-1986 are shown in Table 1. Although all increased, this pattern was most marked for ischemic heart disease and diabetes, although hypertension was the most common of these diseases overall.

Table 1. Trends in morbidity per 100,000 persons due to selected diseases, non-communicable diseases for the period 1982-1986, Mauritius.

	Hypertensive disease (ICD 401-5)	Cerebrovascular disease (ICD 430-8)	Ischemic heart disease (ICD 410-14)	Diabetes Mellitus (ICD 250)
1982	276	97	119	206
1983	291	93	138	212
1984	320	95	141	213
1985	336	106	155	222
1986	318	103	171	262

3. RESULTS OF THE MAURITIUS NON-COMMUNICABLE DISEASE (NCD) AND RISK FACTOR PREVALENCE SURVEY, 1987.

Of the population aged 25 years and over, 12.7% (i.e. 62,000 people) have diabetes and a further 17.5% (i.e. 83,000 people) have impaired glucose tolerance (approximately one in three people with this condition will develop diabetes within five years, and they are all at increased risk of coronary heart disease). Thus 145,000 adults either have diabetes or are at very high risk of developing it. Age-specific prevalence of diabetes mellitus in the Mauritian ethnic groups is shown in Table 2.

Table 2. Prevalence (%) of diabetes mellitus, Mauritius, 1987.

	Hindu	Muslim	Creole	Chinese
Males				
25-34	4.3	3.6	0.4	2.4
35-44	12.9	4.1	7.9	14.0
45-54	24.5	28.1	13.0	20.8
55-64	23.7	34.5	11.2	24.4
65+	27.7	15.4	27.1	35.5
25+	14.0	12.7	7.7	13.5
Females				
25-34	3.4	2.2	2.8	2.3
35-44	7.6	8.3	12.0	7.4
45-54	15.2	15.9	21.2	9.1
55-64	25.6	37.0	23.9	20.7
65+	25.4	47.8	33.3	36.7
25+	10.9	13.8	13.0	9.5

Hypertension is more common in Mauritius than in most other developing and developed countries. Of the population aged 25 years and over, 14.8% (i.e. 71,000 people) have hypertension. Of the population aged 45 and over, 28% (i.e. 51,000 people) have hypertension. Thus one in four Mauritians in this age group is affected. Age-specific prevalence of hypertension is shown in Table 3. The analysis of electrocardiograph data from the 1987 survey shows high rates of coronary heart disease in people 35 years and over - the rates are higher than in other developed and developing countries. Thirteen percent of males and 39% of females are overweight by international standards.

Table 3. Prevalence and effectiveness of treatment of hypertension, 1987 survey, Mauritius.

	Age group (years)				
	25-34	35-44	45-54	55-64	65-
Prevalence (%)	2.7	9.4	21.6	29.9	38.6
New-known ratio	1.7	1.3	0.5	0.7	0.4
% known not treated	35	26	17	12	14

4. ACTIONS TAKEN BY NCD PROGRAM, JANUARY 1989 TO MARCH 1990

Anti-Smoking Activities

On the occasion of the second world "No Smoking Day," the NCD organized a series of activities to highlight the anti-smoking campaign. An Oral Health Campaign was also launched in September 1989; an Anti-Alcohol Campaign was launched in November 1989.

Legislative Measures

- The Anti-Smoking Task Force had recommended a series of legislative measures to curb the habit of smoking among Mauritians. This has resulted in a set of new regulations on smoking. In addition to prohibition of smoking in public transport and cinema halls, it is illegal to smoke in certain areas in schools, hospitals, and in sports and recreation halls and gymnasiums, and it will be illegal to sell cigarettes to minors.

- The law on pre-packed food labelling has been enacted under the Fair Trading Act of the Ministry of Commerce and Shipping. This law will also be included under the Food and Drug Act of the Ministry of Health. The implementation of this law will then be by inspectorate of both Ministries.

- The Anti-Alcohol Task Force has drafted a series of laws which the Crown Law Office is at present considering.

Fiscal Measures

The Ministry of Finance has agreed to remove taxation on whole wheat flour and to subsidize this item to the same extent as white flour. In 1989, the milling factory in Mauritius was producing both kinds of flour for local consumption. As Mauritians are not used to consuming brown bread, the NCD Office will soon launch a campaign to create a demand from the public for this commodity.

A list of fiscal measures which the NCD team has drafted for implementation by the Ministry of Finance has been sent to the cabinet of Mauritius for approval.

Task Forces

Seven of the eight task forces of the NCD office - viz. Anti-Smoking, Nutrition, Exercise, Screening (renamed Action and Detection), Accidents, Cancer, Oral Health, Alcohol and Substance Abuse have produced some concrete proposals for implementation by the NCD office.

Training

The Medical personnel of the NCD office has been involved in the training program for nurses and community health workers. Through these important members of the health team, the NCD office has been able to influence the promotion of health, screening activities, and better management of NCDs in the community.

Outcome Evaluation

Outcome evaluation will be done in 1992, that is, five years after the first NCD survey and four years after intervention started.

5. FORECASTING FUTURE TRENDS IN THE HEALTH EXPERIENCE OF THE MAURITIAN POPULATION

Using survey data on NCD risk factor levels in Mauritius, Tanzania, and several other populations, the NCD office of WHO in Geneva has been studying the likely future trends in mortality in these populations and comparing them on the basis of posited changes in the risk factor levels, from those observed during the surveys, to higher or lower levels in the future.

In Table 4, demographic and epidemiologic characteristics of Mauritius are shown alongside those for two contrasting populations. In terms of expectation of life, the Mauritian community is closer to that of the developed world than to Tanzania. Mauritius demonstrates low mortality from cancers but a high mortality from cardiovascular disease and an intermediate mortality from other causes. Tanzania shows a much lower rate of cardiovascular mortality, and a higher rate of mortality from other causes, which is compatible with its younger population structure and its disease patterns which emphasize high prevalence of infections, parasitic, and nutritionally related diseases.

Table 4. Demographic and epidemiologic characteristic of three countries - males.

Country	Population size 1986 (millions)	Per cent 15-64 yrs	Expectation of life at age			Proportional mortality (%) for those over 30 years		
			0	15	30	Cancers	CVD	Other causes
Mauritius[a]	1.1	65.0	65	53	43	10	45	45
Tanzania[2]	23.3	49.0	50	42	37	19	22	59
Developed[3]	-	67.0	71	57	44	25	50	25

(a) World Health Statistics Annual, 1987.

(b) Estimates for Tanzania from United Nations Population Division (e_0, e_{15}, e_{30}) and from WHO internal working documents (proportional mortality for those over 30 years).

(c) The "developed" country combined USA and Finnish national data. The risk factor dynamics and the risk equation coefficients were computed from studies in these countries.

Table 5 shows levels of several of the major risk factors for cardiovascular diseases and cancer from the health surveys carried out in Mauritius and Tanzania in 1987 and 1988 respectively, and from USA and European Cardiovascular Disease Follow-up Studies carried from 1950 through 1970.

Table 5. Mean levels of risk factors in three developing countries for males aged 30-35 years.

Country	Risk factors means				
	Systolic BP mm/Hg	Diastolic BP mm/Hg	Quetelet Index kg/m^2x10	Total cholesterol mg/dl	Cigs/day
Mauritius[7]	121	76	215	215	3.7
Tanzania[8]	124	75	210	135	4.0
"Developed"[a]	125	80	260	215	10.0
"High risk"[b]	165	95	300	280	15.0
"Ideal"[c]	120	75	250	200	0

[7][8] See bibliography.

[a] "Developed country": average of risk factor levels for males aged 30-35 from Framingham, Finnish East, Finnish West, Kaunas USSR studies.

[b] "High risk": those values for which there is scientific consensus (e.g. WHO criteria) that there is an elevated risk for total mortality.

[c] "Ideal": target values generally accepted when a reduction in mortality from all causes is desired.

Also included are "high risk" and "ideal" values of these risk factors for all cause mortality as determined from the clinical and epidemiological literature. Mauritius risk factors are close to the "developed" country risk factors except for the Quetelet Index and cigarettes smoked per day. The Tanzanian population, in addition, have total cholesterol levels much lower than either the Mauritius or "developed" country cholesterol levels.

A model which incorporates risk factor levels and risk factor changes into cause specific and total mortality risks, and which provides life table-based parameters of the impact of risk factor change on mortality, has been developed by Manton and Stallard (1988), and used to forecast risks in developing countries by Dowd and Manton (1990).

Figures 3(a), 3(b) and 3(c) show the model-predicted life table survival for all-cause mortality, cancer, CVD and other diseases (residual) for Mauritius, Tanzania and "developed" country respectively. These curves and median survival times are computed using the baseline risk factor means from Table 5. Note that these curves reflect the proportional mortality and expectations of life at age 30 as shown in Table 4.

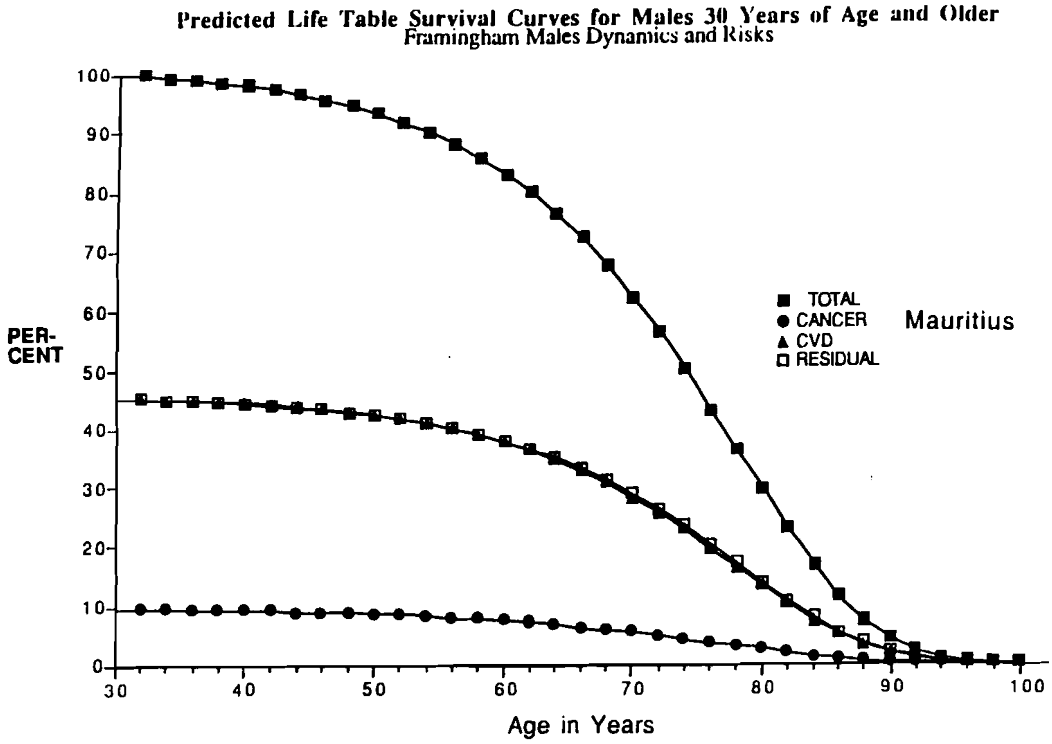

Figure 3(a).

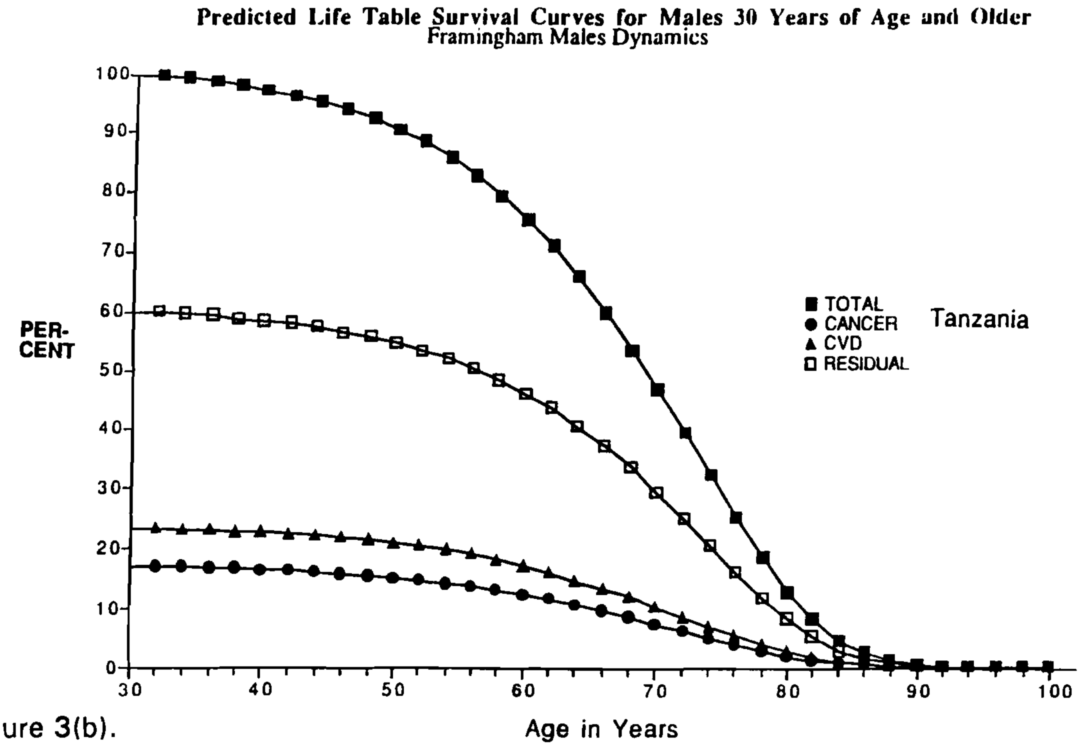

Figure 3(b).

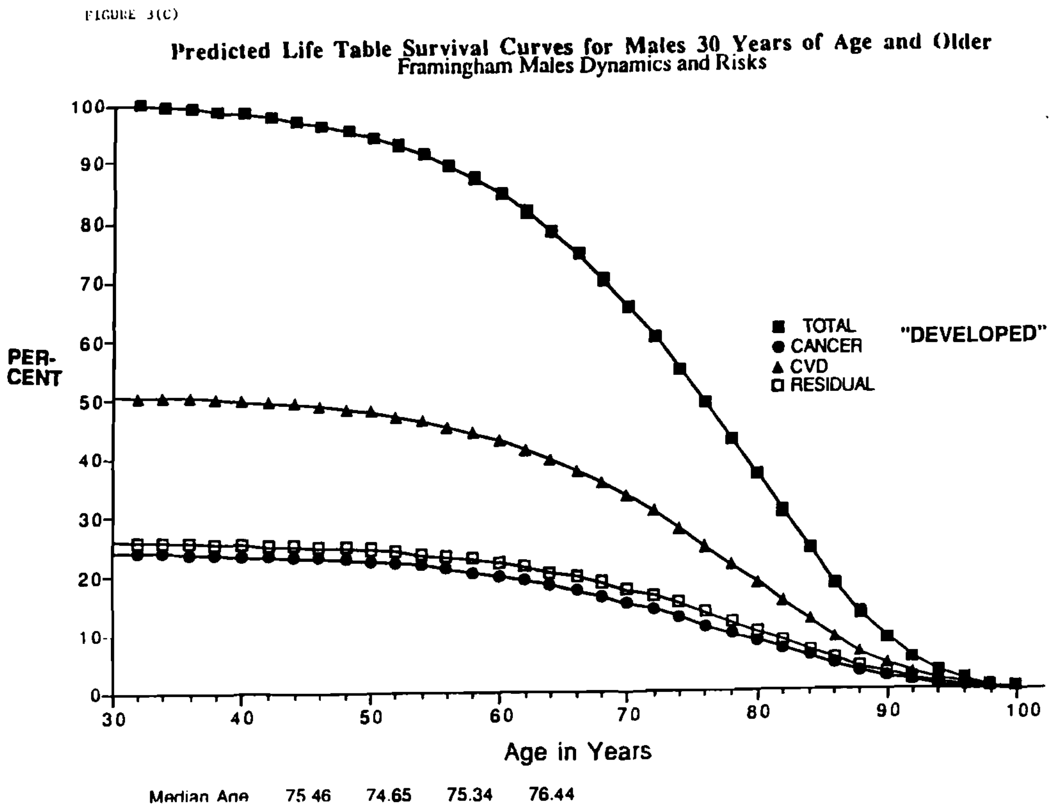

Figure 3(c).

Table 6 shows the median ages at death and proportional mortality for the three countries under the three risk factor scenarios: baseline, "high risk" and "ideal".

The changes from baseline to "high risk" scenario are more drastic for Mauritius and the "developed" country than for Tanzania, due both to the higher proportions of CVD mortality and the higher levels of risk factors at baseline in the two former countries. The major change in median age at death for Tanzania is from cancer with a relatively smaller drop in CVD.

However, the impact of increasing risk factor levels is important for Mauritius since it implies a decrease in median age at death from all-causes of about five years. Reduction of Mauritius baseline levels of risk factors to "ideal" levels produces a predicted increase in median age at death of about two years.

As seen from Table 7, the predicted indirect costs of the "high risk" scenario (those associated with loss of national income due to premature death in the male population of five years because of increase in risk factor levels) amount to US$ 581.70 per capita or 52.9% of the Mauritius per capita GNP. If risk factor levels can be changed towards the "ideal" scenario, indirect costs will decrease by US$ 163.32, a saving over the baseline situation of approximately 15%.

Table 6. Projected changes in median age at death and in percentage of total mortality when risk factors take on "high risk" and "ideal" values.

	Mauritius	Tanzania	"Developed"
		Median age at death	
		Total mortality	
Baseline	73.90	68.78	75.65
"High risk"	68.93	66.59	68.65
"Ideal"	75.99	74.37	77.45
		Cancer mortality	
Baseline	72.36	68.23	74.91
"High risk"	64.46	64.28	68.01
"Ideal"	74.42	73.56	75.90
		Cardiovascular mortality	
Baseline	73.84	68.06	75.53
"High risk"	69.14	66.38	68.69
"Ideal"	75.72	73.83	77.60
		Residual mortality	
Baseline	74.27	69.24	76.57
"High risk"	69.73	68.43	69.29
"Ideal"	76.52	74.92	78.37
		Percentage mortality	
Baseline	10.0	19.0	24.0
"High risk"	7.8	14.5	17.0
"Ideal"	9.5	14.0	20.0
		Cardiovascular	
Baseline	45.0	22.0	50.0
"High risk"	72.0	62.0	71.0
"Ideal"	45.0	34.0	45.0
		Residual	
Baseline	45.0	59.0	26.0
"High risk"	20.2	23.5	13.0
"Ideal"	45.5	52.0	35.0

Table 7. Predicted indirect costs associated with changes from baseline scenario to a) "High risk" scenario and b) "Ideal" scenario as a percentage of the 1985 Gross National Product (GNP) for three countries.

	Mauritius	Tanzania	Developed (U.S.A.)
1985 GNP US$	1,100	280	16,720
Loss in US$	581.70	38.43	9,107.20
"High risk" scenario % GNP	52.9	13.7	54.5
Gain in US$	163.32	83.64	2,680.44
"Ideal" scenario % GNP	14.9	29.9	16.0

6. CONCLUSIONS

Taken together, the routine statistics and survey data suggest that there have been profound shifts in the patterns of disease in the Mauritian population in the period since the Second World War, associated with the control of infectious diseases, increasing longevity and improved life-style.

The most important conditions in this modern epidemic are cardiovascular diseases and diabetes mellitus.

Mathematical prediction of future trends suggests that if the risk factor levels in the Mauritian population were to progress to a typical "high risk" pattern, there would be a decrease in median age at death from all causes of about five years, with predicted indirect costs of US$ 582 or slightly over one-half of the Mauritius GNP.

Reducing risk factor levels in the Mauritian population to a theoretically "ideal" level would produce a predicted increase in median age at death of two years with a decrease in indirect costs of US$ 163 or approximately 15% of GNP.

Clearly, the development of appropriate health strategy and the degree to which the population accepts the need for risk factor modification could have a profound influence on the future health and prosperity of all Mauritians.

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Chapter 8

SCENARIOS FOR FUTURE DEMOGRAPHIC TRENDS IN MAURITIUS

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IIASA

1. INTRODUCTION

Population projections are an important product of demographic analysis. For several obvious reasons it is useful to "know" how many people there will be, and what the characteristics of the population will be, in the years to come.

Of particular concern is the delicate relationship between people and their physical and natural environments. As the number of people grows, so does the usage of resources and space, as well as the amount of by-products -- often in the form of wastes -- of that resource use. In this paper several alternative population-growth scenarios for Mauritius are examined for the coming decades. This will be an essential input to the intended study of the population-economy-environment interaction in the future of Mauritius.

The components of population dynamics are straightforward and few in number: births, deaths, and net migration which is the balance of in- and outmigration. If we add to assumptions on these three components an additional category of information, namely the size and structure (by age and sex) of an initial population, it is a straightforward exercise to compute the future population structure in any year to come. An overview of what has become a standard tool for population projection can be found in chapter 11 of Keyfitz (1982).

Despite the standardization of methods for population projection, forecasts remain an error-ridden undertaking, and do so for the simple reason that it is impossible to correctly guess the future path of fertility, mortality, and net migration. It is only possible to make guesses -- especially for the near-term future -- based on past trends and a combination of various views on future demographic trends.

2. METHOD

The calculations given in this paper use the usual cohort-component approach, in which the initial population is represented in terms of counts by 5-year age groups and sex. The projection is carried out in 5-year calendar time units. In each time period, the proportion of each sex and age group surviving until the next period is

determined by the application of survival probabilities, which are in turn a function of age-specific mortality rates.
Similarly, the number of newly-born people is determined by applying the appropriate age-specific fertility rates to women in the age groups for which childbearing is possible. The survivorship until the end of the 5-year period of babies born during the period must also be determined. Finally, the balance of immigrants and emigrants in each age-sex group must be added to the population.

The calculations were performed using IIASA's interactive microcomputer program called DIALOG, a full description of which can be found in Scherbov and Grechucha (1988). The DIALOG program is especially well-suited to the problem at hand, namely the examination of alternative scenarios. Each pattern of fertility, mortality and migration rates can be summarized through a single index, such as the total fertility rate (TFR) for fertility, or life expectancy at birth, for mortality. For these calculations scenarios were specified as trends in the respective indices, rather than in their individual age-specific components, assuming the age-pattern of mortality and fertility remaining constant. The DIALOG program translates these assumptions into new birth or death rates by scaling up or down, as appropriate, the respective array of rates until the associated index agrees with the assumptions of the specified scenario.

3. DATA SITUATION AND SCENARIO ASSUMPTIONS

The projections were based on the estimated total mid-year population of the Island of Mauritius for the year 1987 -- given by sex and in 5-year age groups up to 85 and over. This population again is based on the 1983 census total population, adjusted for under-enumeration of young children, natural increase due to births and deaths, and international arrivals and departures of Mauritians and non-Mauritians (Digest of Demographic Statistics, 1987, p. 19, Table 1.14). In order not to loose any information it was decided to take this latest available population figures as starting population.

At the same time the decision was made to take average period occurrence/exposure rates for births and deaths for the period 1983-1987 (Digest of Demographic Statistics, 1987, pp. 34 and 49-50, respectively). Because of the small population of Mauritius and having 34 sex-age groups, it is absolutely necessary to take average rates to avoid accidental irregularities. Moreover, since 1983, improvements in mortality and changes in the fertility behavior have only been very limited, a fact that may justify the use of the 1983-87 average rates instead of the most recent 1987 rates.

Looking at past trends in Mauritius and the demographic development in other newly industrialized countries we came up with 8 alternative scenarios (see Table 1). The objective of these scenarios is to mark out the range of possible future demographic trends rather than answering the question "what will happen in the future?" Hence, readers may choose the scenario that appears to them the most likely. Nevertheless, the true value of this multi-scenario approach lies in viewing it as a whole. Elements common to all scenarios point to trends that are largely independent of any assumption and are therefore nearly certain to come about. Conversely, elements that vary widely from scenario to scenario reveal demographic uncertainties.

The 8 scenarios are:

1. **Benchmark** -- Used as a reference scenario. Keeping fertility and mortality rates constant, it shows how much change is already embodied in the age structure of the population. Migration is assumed to be nil.

2. **UN-Projection** -- Used as a second base scenario. It takes the assumptions of the UN-medium variant (at the same time it is similar to the assumptions used in variant III of the Mauritius population projections (Digest of Demographic Statistics, 1987, p.87ff). According to the UN, fertility will remain constant at the current level, and life expectancy will increase to 74 and 79 years for men and women, respectively. Migration is nil.

3. **European** -- It assumes that within the next 15 years Mauritius will reach current average Western European level with respect to fertility (TFR = 1.52) as well as mortality (life expectancy of 72 and 79 years). Moreover, it is similar to the assumptions used in variant II of the Mauritius population projections. Migration is again nil.

4. **Fertility Decline** -- It assumes the same decrease in the total fertility rate as scenario 3, but life expectancy will remain constant. Migration is still nil.

5. **Extreme Mortality Decline** -- Mortality is assumed to decrease substantially - life expectancy goes up to 80 and 85 years for men and women, respectively, by the year 2022. On the one hand these figures correspond roughly to a continuation in the increase in life expectancy over the last 35 years; on the other hand 80 and 85 years may be considered a maximum possible under current medical conditions. To explore the effect of decreasing mortality only, fertility will remain constant and migration is again nil.

6. **Fertility Increase** -- As a counterpart to scenario 4 an increase in fertility back to a TFR of 3.0 shall be investigated. As in scenario 4, life expectancy will remain constant and migration is nil. Scenario 4 and 6 enable a sensitivity analysis of the Mauritian population with respect to fertility.

7. **Immigration** -- Among several possibilities it was decided that immigration will most probably take place in case of a future fertility decline. Therefore, assumptions of scenario 3 (European) were combined with the assumption of having 5000 immigrants per year (this corresponds to about 0.5% of the current Mauritian population). Experience of European countries shows that

immigration is now solely responsible for the increase or at least stabilization of the total population figure.

8. **Emigration** -- Opposite to scenario 7 emigration will most probably continue (or take place) in case of a fertility increase. Therefore, assumptions of scenario 6 (Fertility Increase) were combined with the assumption of having 5000 emigrants per year. Comparison of scenarios 6 and 8 as well as of scenarios 3 and 7 show the impact of negative and positive migration balance, respectively.

Table 1. Fertility, mortality and migration assumptions of eight Mauritius population scenarios.

		Fertility (total fertility rate)	**Mortality** (male/female life expectancy)		**Migration** (migrants per year)
Observed data:					
	1983-1987	2.05	65	72	-2728
Assumptions:					
Scenario 1	1987-2047	constant	constant		none
Scenario 2	1987-2047	constant			none
	2022		74	79	
Scenario 3	1987-2047				none
	2012	1.52	72	79	
Scenario 4	1987-2047		constant		none
	2012	1.52			
Scenario 5	1987-2047	constant			none
	2022		80	85	
Scenario 6	1987-2047		constant		none
	2002	3.00			
Scenario 7	1987-2047				+5000
	2012	1.52	72	79	
Scenario 8	1987-2047		constant		-5000
	2002	3.00			

Changes are assumed to occur linear until the year indicated, and remain constant after the years indicated.

4. SELECTED RESULTS

When studying the interaction between population, development and environment it is essential to have a time horizon that goes beyond the immediate future. For this reason we chose to project the population 60 years into the future. The population paths implied by each of the scenarios is pictured in figures 1-4. In Figure 1, which shows the total population of Mauritius as well as the TFR throughout the projection period, we see that, due to fertility assumptions, in 2017 the total population figure will be between 1.25 and 1.5 Million, and in 2047 the range will roughly be 1 to 2 Million -- the UN-projection being exactly in between. After 2017 the total population size varies intensely with scenario. But, as with another fertility increase emigration is rather likely, and with a further fertility decline down to European level immigration may take place, a population size around 1.5 Million seems to be rather likely for the long-term future of Mauritius.

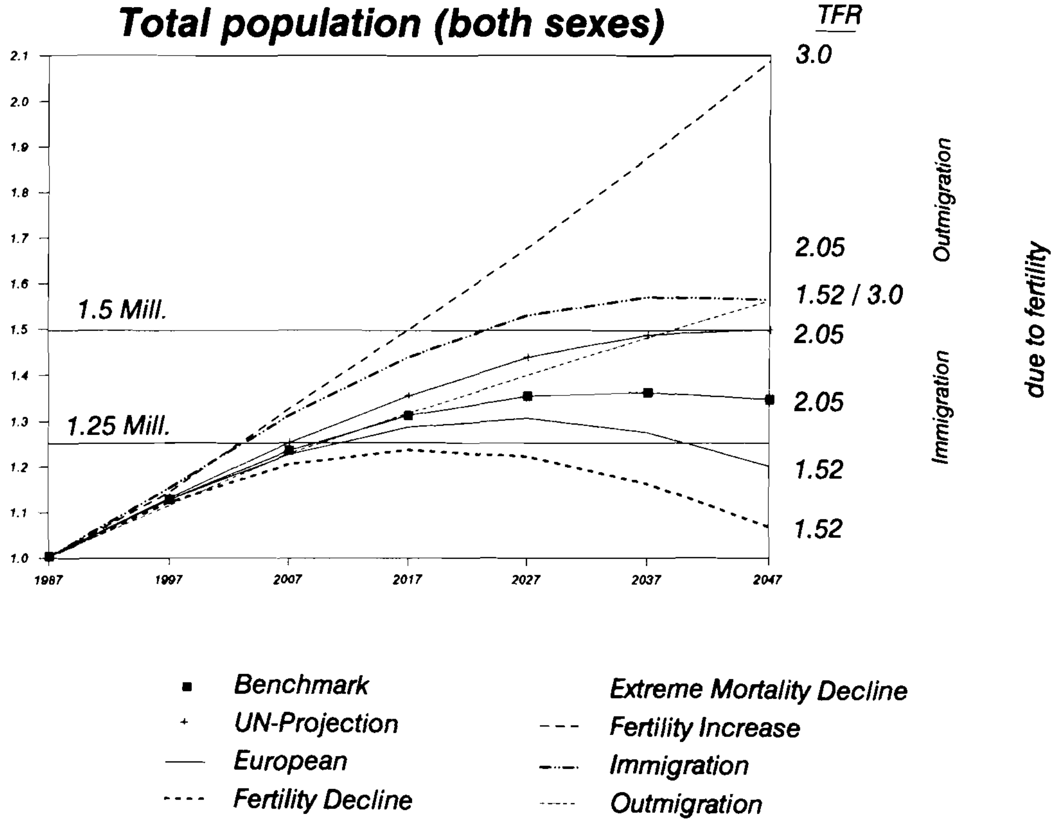
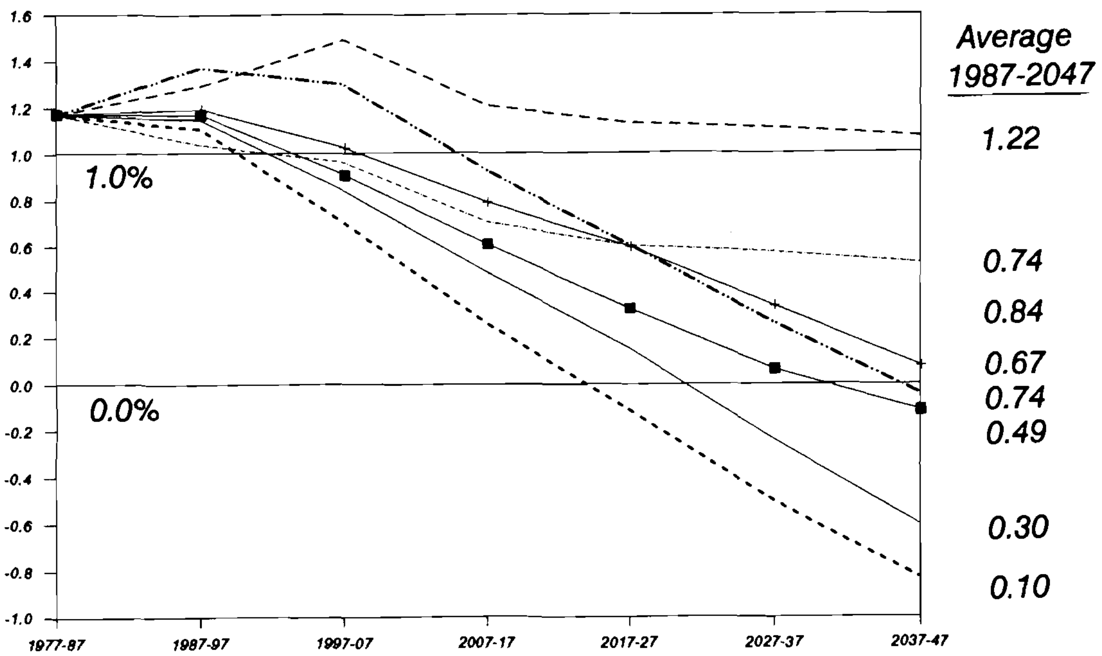


Figure 1. Projected total population of Mauritius in Million and assumed total fertility rate by scenario.

It is interesting to note that in 2047 scenario 7 (European fertility and mortality plus Immigration) and scenario 8 (Fertility Increase plus Emigration) lead to the same population size (around 1.56 Million) following different paths. Comparing scenarios with and without migration (scenario 3 versus 7 and scenario 6 versus 8) shows that in the long run migration changes the size of the total population by 25-30% -- assuming around 0.5% of the 1987 population annually moving in or out of the country.

In Figure 2, which shows the average annual growth rate of the population of Mauritius, it becomes evident that until the end of this century the growth of the population is determined by the given young age structure of the population and hardly depends on future demographic settings. Thereafter in all scenarios except scenario 6, the growth rate will steadily decrease.

Average annual growth rate of the population



■ *Benchmark*
\+ *UN-Projection*
—— *European*
\- - - - *Fertility Decline*
Extreme Mortality Decline
\- - - *Fertility Increase*
—··— *Immigration*
------ *Outmigration*

Figure 2. Projected average annual growth rate of the population by 10-year period and average 1987-2047.

We can also see that only two of the scenarios -- scenario 5 (Extreme Mortality Decline), and scenario 6 (Fertility Increase up to 3.0) -- imply a growth permanently higher than the growth of the UN-(medium)-projection. For scenario 6 it is above 1% per year throughout the entire projection period. A strong fertility decline not accompanied by any mortality improvement (scenario 4) would lead to a negative growth from 2017 on. Together with a further mortality decline to European level (scenario 3) the population size would start to decrease some 10 years later. In the short run higher growth rates are reached by immigration (see scenario 7), in the long run definitely only a fertility increase leads to a strong and continued growth of the population (scenarios 6 and 8). Since this is unlikely, after 2050 a decrease in population size can be expected.

The age composition of Mauritius' future population differs significantly across alternative scenarios. Nevertheless, the main trend, the aging of the population, is quite certain.

As shown by Table 2 and Figure 3 the main structural trends of the population -- for the moment disregarding fertility increase scenarios 6 and 8 -- are the following:

For the period 1987-2017:

- a doubling in the percentage of elderly (from 4.7% up to a maximum of 10.9% in the Extreme Mortality Decline scenario),
- a strong decrease in the percentage of children (from 30.4% down to around 18% in the low fertility scenarios),
- an increase in the proportion of active people by 3-8 percentage points.

For the period 2017-2047:

- another doubling in the percentage of elderly (up to 25.7% in the Extreme Mortality Decline scenario, but only 14.6% in the Benchmark scenario),
- a further, but limited decrease in the proportion of children (down to 13.4% in the European scenario, but still 20.3% in the Benchmark scenario),
- a decrease in the proportion of active people by 5-11 percentage points, in 2047 on average being somewhat lower than in 1987.

In addition to the percentage of elderly, Figure 3 indicates the mean age of the population in 2047. Starting from 27.7 years in 1987 this mean age goes at least up to 31.3 years (Fertility Increase scenario), or even up to 45.1 years (European scenario). It is interesting to note that the mean age of the population under the Fertility Decline and the Extreme Mortality Decline scenario is almost equivalent, whereas the proportion of elderly differs significantly (18.4% versus 25.7% in 2047, respectively).

Table 2. Population in broad age groups, selected years.

	Scen1 (BM)	Scen2 (UN-Proj.)	Scen3 (Euro.)	Scen4 (Fert. Dec.)	Scen5 (Mort. Dec.)	Scen6 (Fert. Inc.)	Scen7 (Imm)	Scen8 (Em)
a. Proportion of children (0-14)								
1987	30.4							
2017	22.0	21.6	18.0	18.5	21.1	28.7	18.7	28.5
2047	20.3	18.8	13.4	14.6	17.3	29.3	14.8	29.1
b. Proportion of active (15-64)								
1987	64.9							
2017	70.1	69.2	71.9	73.2	68.1	64.4	72.0	64.0
2047	65.2	61.4	62.6	67.0	57.0	61.3	64.5	60.8
c. Proportion of elderly (65+)								
1987	4.7							
2017	7.9	9.3	10.2	8.4	10.9	6.9	9.3	7.5
2047	14.6	19.9	24.0	18.4	25.7	9.4	20.7	10.2

With scenarios 6 and 8 (fertility increase up to TFR=3.0) the age structure of the population will look very different:

- the proportion of children will remain almost stable over the next 60 years,
- the proportion of elderly will only double until 2047.

Another indicator of the process of aging is the number of people aged 85 and over, people who are frequently in need of help. Changes in the number of very elderly people are especially important in the context of health care and hospital costs. As shown by Table 3, in 1987 only 2,200 Mauritians were older than 85. Until 2047 this number will increase to around 15,000 with constant mortality assumptions, around 45,000 with a further mortality decline, or even 111,000 with extremely low mortality (scenario 5).

The Total Dependency Ratio, measuring the ratio of dependent people in nonworking ages, namely children plus elderly, to people in working ages (aged 15-64), is the most often used measure of the "burden" on the working age population. Its trend is especially important for the calculation and maintenance of social security systems. In 1987 in Mauritius there were 54.1 dependent per 100 active people.

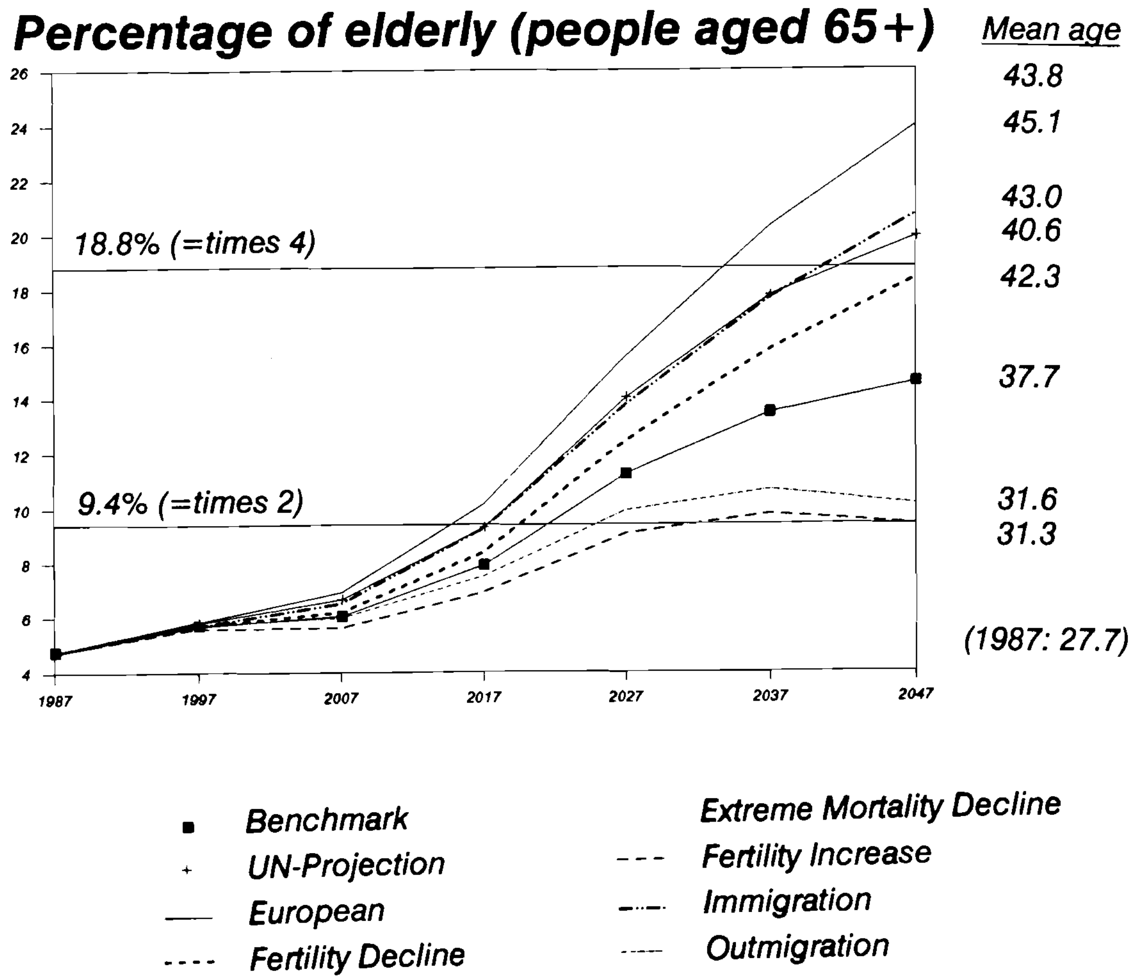


Figure 3. Projected percentage of elderly people (aged 65+ and mean age of the population in 2047 by scenario.

Table 3. Population aged 85 and over, 2017 and 2047 (index: 1987 = 100 = 2,200 people).

	2017	2047
Benchmark	270	700
UN-Projection	490	2100
European	550	1970
Fertility Decline	270	700
Mortality Decline	860	5060
Fertility Increase	270	700
Immigration	550	2060
Emigration	270	630

As shown by Figure 4 the period 1987-2017 will be dominated by the decrease in the proportion of children. Therefore, the total dependency ratio will decrease drastically until 1997 (around 45 dependent per 100 active) and will continue to decrease somewhat until 2017 -- except for the high fertility scenarios, where it will already increase up to the level of today. The period 2017-2047 will be dominated by the increase in the proportion of elderly, the total dependency ratio starting to increase steadily. Depending on scenario in 2047 the ratio will go back to the 1987 level (Benchmark and European settings/Immigration scenario), or will still be below 50 (Fertility Decline scenario), or it will be around 64. Only Extreme Mortality Decline conditions lead to a strong continued increase up to 75 dependents per 100 active in 2047).

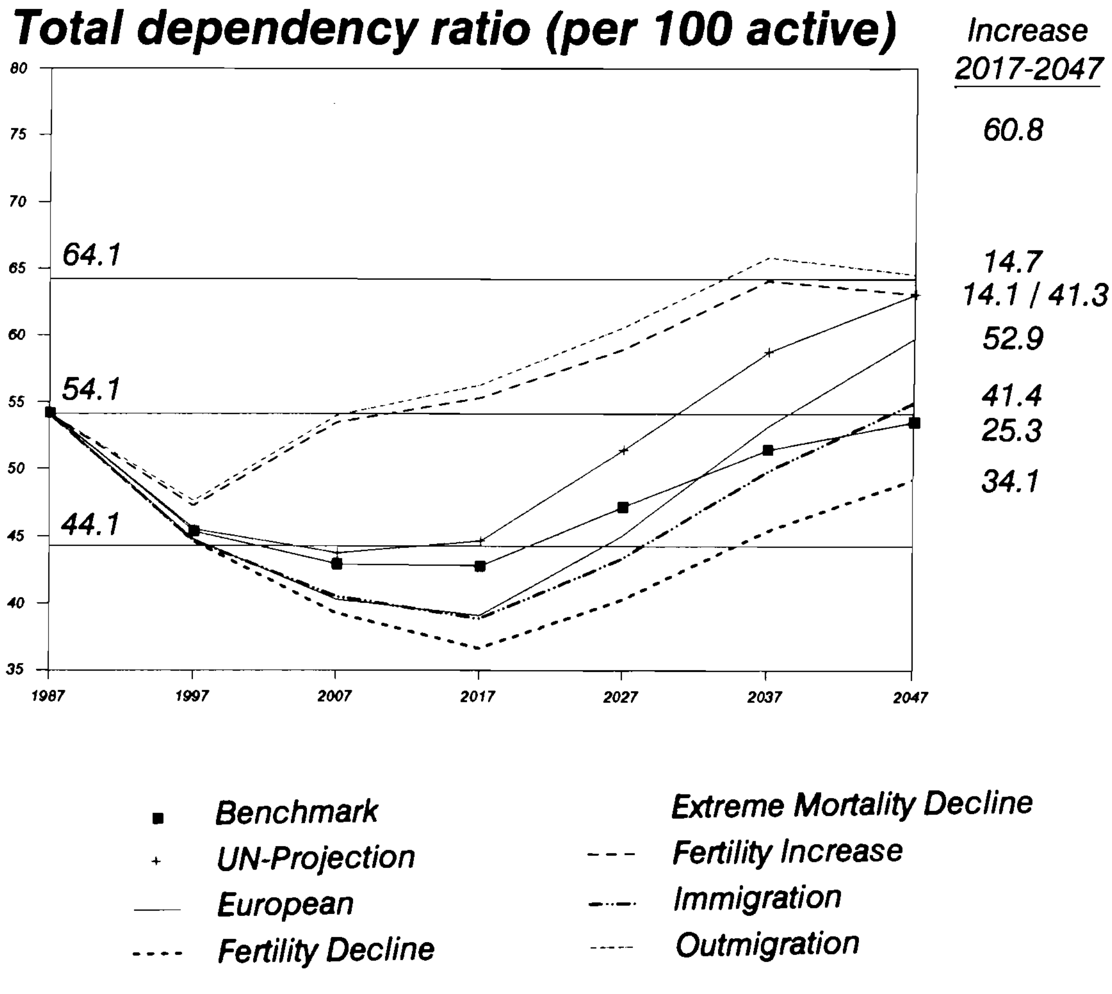


Figure 4. Projected total dependency ratio (per 100 active) and increase of this ratio from 2017-2047 by scenario.

One has to take into account, however, that the total dependency ratio itself is only a crude measure of the process under consideration. For instance, a population with high youth and low elderly dependency (e.g. Fertility Increase scenario) and a population with low youth and high elderly dependency (e.g. UN-projection scenario) could have the same total dependency ratio (both around 63 in 2047) despite their diverging age structures.

Figure 4 also indicates the increase in the ratio during the period 2017-2047. Obviously, the total dependency ratio will continue to increase beyond 2050, unless the assumption of a fertility increase becomes true.

Looking at Figure 4 one could get the impression that the burden of the working age population will not increase that much during the following 50 years. In fact, the maintenance of the current social security system will be difficult. In aged societies pensions represent the biggest part of total social security expenditure -- as an average among European countries pensions amount to almost 50% of total social security expenditure (1985). These pensions should usually be and at the moment are covered by contributions, paid as a certain percentage of the salary of the active population. Therefore, disregarding the peculiarities of the Mauritian pension system, confronting the total active population and the retired population is more important. In this simplification we assume that everybody is going to retire at the legal retirement age of 60 years.

Hence, the old age dependency ratio is more relevant than the total dependency ratio. Moreover, the second important part of social security expenditure, namely health costs, is also to a large extent consumed by the elderly population. In European countries health costs amount to 35% of total social security expenditure (unweighted average).

According to Table 4 the old age dependency ratio -- and therefore the burden on the working age population -- will already until 2017 increase by 70% or so, rather independent of demographic settings (compared to a decrease of around 20% in the total dependency ratio). After 2017 the increase in the old age dependency ratio will be even more remarkable, except for fertility increase scenarios. Otherwise the ratio will increase by at least 158% with the Benchmark scenario, 253% with the medium variant UN-Projection scenario, or even 368% with the Extreme Mortality Decline scenario (2047 compared to 1987). This means that in 1987 eight actives have to pay contributions for one retiree, but in 2047 there are only two or three actives per retiree. From that we can conclude that especially the pension system cannot remain as it is today.

Further results can either be found in the Appendix tables or can be received directly from the author (especially results on the population by sex and 5-year age group).

Table 4. Old age dependency ratio (population aged 60 and over per 100 of active population), 2017 and 2047.

Ratio in 1987 amounted to 12.6

	2017	2047
Benchmark	19.7	32.6
UN-Projection	22.5	44.5
European	23.5	53.8
Fertility Decline	20.1	40.7
Mortality Decline	25.7	59.0
Fertility Increase	18.7	21.8
Immigration	21.4	45.5
Emigration	20.2	23.5

5. SUMMARY

This paper has discussed the possible path of Mauritius' population to the year 2047, employing an alternative-scenario approach. The objective has been not to guess what the most likely path of population growth will be, but rather to identify a range of possible paths of population development.
Some of the assumptions (e.g. the Fertility Increase scenario) turn out to make a big difference in Mauritius' future -- compared with the Benchmark and the UN-projection scenario --, but most of the trends and consequences are close to each other, e.g. decreasing population growth and strong aging of the population.

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APPENDIX. Selected results for Mauritius by scenario.

Results for Mauritius – Scenario 1

	total population			sex ratio (/100 females)	natural events		natural increase
	both sexes	males	females		births	deaths	
1987	1004000	501200	502600	99.7	19550	6730	12820
1997	1128000	561000	566500	99.0	20230	8620	11610
2007	1235000	612100	623200	98.2	19950	10720	9230
2017	1312000	646800	665000	97.3	19270	13400	5870
2027	1355000	664400	690500	96.2	19200	16860	2340
2037	1363000	666000	697500	95.5	18780	19860	-1080
2047	1347000	657400	690100	95.3	18390	21010	-2620

	average annual growth rate (%)	population density (km^2)	mean age (in years)	depend. ratio (/100 active)	pop. in broad age groups (%)		
					active (15–64)	children (0–14)	elderly (65+)
1987	–	538	27.7	54.1	64.9	30.4	4.7
1997	1.16	605	30.1	45.3	68.8	25.5	5.7
2007	0.91	662	32.4	42.9	70.0	24.0	6.0
2017	0.60	703	34.7	42.7	70.1	22.0	7.9
2027	0.32	726	36.5	47.1	68.0	20.8	11.2
2037	0.06	730	37.4	51.4	66.1	20.5	13.5
2047	-0.12	722	37.7	53.5	65.2	20.3	14.6
1987–2047	0.49						

Results for Mauritius - Scenario 2

	total population both sexes	males	females	sex ratio (/100 females)	natural events births	deaths	natural increase
1987	1004000	501200	502600	99.7	19550	6730	12820
1997	1131000	562900	567700	99.2	20240	7380	12860
2007	1253000	622900	629900	98.9	19990	8320	11670
2017	1356000	673700	681900	98.8	19370	9670	9700
2027	1439000	715700	723600	98.9	19410	12650	6760
2037	1488000	740000	747700	99.0	19100	16550	2550
2047	1499000	746000	752900	99.1	18820	19210	-390

	average annual growth rate (%)	population density (km^2)	mean age (in years)	depend. ratio (/100 active)	pop. in broad age groups (%) active (15–64)	children (0–14)	elderly (65+)
1987	–	538	27.7	54.1	64.9	30.4	4.7
1997	1.19	606	30.2	45.4	68.8	25.4	5.8
2007	1.02	671	32.8	43.7	69.6	23.8	6.6
2017	0.79	727	35.5	44.6	69.2	21.6	9.3
2027	0.59	771	38.0	51.4	66.1	19.9	14.0
2037	0.33	797	39.8	58.7	63.0	19.2	17.8
2047	0.07	803	40.6	63.0	61.4	18.8	19.9
1987–2047	0.67						

Results for Mauritius – Scenario 3

	total population			sex ratio (/100 females)	natural events		natural increase
	both sexes	males	females		births	deaths	
1987	1004000	501200	502600	99.7	19550	6730	12820
1997	1126000	560200	565500	99.1	18140	7110	11030
2007	1225000	607400	617200	98.4	15860	7830	8030
2017	1286000	635800	650500	97.7	14020	9870	4150
2027	1306000	642100	663600	96.8	12880	13420	-540
2037	1275000	623200	651900	95.6	11230	17080	-5850
2047	1200000	583000	616700	94.5	9930	19270	-9340

	average annual growth rate (%)	popu-lation density (km^2)	mean age (in years)	depend. ratio (/100 active)	pop. in broad age groups (%)		
					active (15–64)	children (0–14)	elderly (65+)
1987	–	538	27.7	54.1	64.9	30.4	4.7
1997	1.15	603	30.3	44.8	69.1	25.1	5.8
2007	0.84	656	33.5	40.3	71.3	21.8	6.9
2017	0.49	689	37.3	39.1	71.9	18.0	10.2
2027	0.15	700	40.6	45.0	69.0	15.5	15.5
2037	-0.24	683	43.3	53.2	65.3	14.4	20.3
2047	-0.61	643	45.1	59.8	62.6	13.4	24.0
1987–2047	0.30						

Results for Mauritius – Scenario 4

	total population			sex ratio (/100 females)	natural events		
	both sexes	males	females		births	deaths	natural increase
1987	1004000	501200	502600	99.7	19550	6730	12820
1997	1122000	558300	564000	99.0	18140	8590	9550
2007	1204000	596200	608200	98.0	15820	10620	5200
2017	1236000	607700	628000	96.8	13920	13230	690
2027	1222000	596200	625900	95.3	12710	16600	-3890
2037	1162000	562800	599700	93.8	11000	19460	-8460
2047	1069000	514700	554200	92.9	9680	20360	-10680

	average annual growth rate (%)	population density (km^2)	mean age (in years)	depend. ratio (/100 active)	pop. in broad age groups (%)		
					active (15–64)	children (0–14)	elderly (65+)
1987	–	538	27.7	54.1	64.9	30.4	4.7
1997	1.11	601	30.2	44.6	69.2	25.1	5.7
2007	0.71	645	33.1	39.3	71.8	22.0	6.2
2017	0.26	662	36.3	36.7	73.2	18.5	8.4
2027	-0.11	655	39.0	40.3	71.3	16.3	12.5
2037	-0.50	623	41.0	45.4	68.8	15.4	15.8
2047	-0.83	573	42.3	49.2	67.0	14.6	18.4
1987–2047	0.10						

Results for Mauritius – Scenario 5

	total population			sex ratio (/100 females)	natural events		natural increase
	both sexes	males	females		births	deaths	
1987	1004000	501200	502600	99.7	19550	6730	12820
1997	1134000	564800	569200	99.2	20250	6020	14230
2007	1272000	633600	638500	99.2	20040	6000	14040
2017	1401000	698600	702600	99.4	19490	6500	12990
2027	1522000	760100	761500	99.8	19620	8580	11040
2037	1613000	806900	806000	100.1	19390	12370	7020
2047	1665000	833500	831200	100.3	19190	15790	3400

	average annual growth rate (%)	population density (km^2)	mean age (in years)	depend. ratio (/100 active)	pop. in broad age groups (%)		
					active (15–64)	children (0–14)	elderly (65+)
1987	–	538	27.7	54.1	64.9	30.4	4.7
1997	1.22	608	30.3	45.6	68.7	25.4	5.9
2007	1.15	682	33.2	44.7	69.1	23.5	7.3
2017	0.97	751	36.5	46.9	68.1	21.1	10.9
2027	0.83	816	39.6	56.3	64.0	19.1	16.9
2037	0.58	864	42.2	67.3	59.8	18.1	22.2
2047	0.32	892	43.8	75.4	57.0	17.3	25.7
1987–2047	0.84						

Results for Mauritius - Scenario 6

	total population			sex ratio (/100 females)	natural events		
	both sexes	males	females		births	deaths	natural increase
1987	1004000	501200	502600	99.7	19550	6730	12820
1997	1143000	568900	574000	99.1	26480	8700	17780
2007	1327000	659200	667700	98.7	29180	11000	18180
2017	1498000	742600	755700	98.3	30340	13780	16560
2027	1678000	830400	847600	98.0	36670	17520	19150
2037	1876000	929100	947200	98.1	40640	20930	19710
2047	2089000	1037000	1052000	98.6	45440	22810	22630

	average annual growth rate (%)	population density (km^2)	mean age (in years)	depend. ratio (/100 active)	pop. in broad age groups (%)		
					active (15–64)	children (0–14)	elderly (65+)
1987	–	538	27.7	54.1	64.9	30.4	4.7
1997	1.30	613	29.7	47.3	67.9	26.5	5.6
2007	1.49	711	30.6	53.5	65.2	29.2	5.6
2017	1.21	803	31.6	55.3	64.4	28.7	6.9
2027	1.13	899	32.0	59.0	62.9	28.0	9.1
2037	1.12	1005	31.7	64.1	60.9	29.3	9.8
2047	1.08	1120	31.3	63.1	61.3	29.3	9.4
1987–2047	1.22						

Results for Mauritius – Scenario 7

	total population			sex ratio (/100 females)	natural events		natural increase
	both sexes	males	females		births	deaths	
1987	1004000	501200	502600	99.7	19550	6730	12820
1997	1152000	573600	578800	99.1	18790	7170	11620
2007	1312000	651100	660800	98.5	17420	8030	9390
2017	1440000	712500	727200	98.0	16270	10290	5980
2027	1530000	753700	776000	97.1	15970	14290	1680
2037	1571000	770300	801100	96.2	14940	18650	-3710
2047	1565000	763700	801600	95.3	14190	21850	-7660

	average annual growth rate (%)	population density (km^2)	mean age (in years)	depend. ratio (/100 active)	pop. in broad age groups (%)		
					active (15–64)	children (0–14)	elderly (65+)
1987	–	538	27.7	54.1	64.9	30.4	4.7
1997	1.38	617	30.1	44.7	69.1	25.2	5.7
2007	1.30	703	33.0	40.6	71.1	22.4	6.5
2017	0.93	772	36.4	38.9	72.0	18.7	9.3
2027	0.61	820	39.3	43.4	69.8	16.5	13.8
2037	0.26	842	41.5	49.8	66.8	15.6	17.7
2047	-0.04	839	43.0	55.0	64.5	14.8	20.7
1987–2047	0.74						

Results for Mauritius – Scenario 8

	total population			sex ratio (/100 females)	natural events		natural increase
	both sexes	males	females		births	deaths	
1987	1004000	501200	502600	99.7	19550	6730	12820
1997	1114000	554500	559800	99.1	25580	8610	16970
2007	1227000	609300	618200	98.6	26640	10570	16070
2017	1317000	651700	665000	98.0	26410	12760	13650
2027	1399000	691300	708100	97.6	30150	15520	14630
2037	1482000	732600	749500	97.7	31650	17680	13970
2047	1562000	774500	787700	98.3	33580	18250	15330
	average annual growth rate (%)	popu-lation density (km^2)	mean age (in years)	depend. ratio (/100 active)	pop. in broad age groups (%) active (15–64)	children (0–14)	elderly (65+)
1987	–	538	27.7	54.1	64.9	30.4	4.7
1997	1.04	597	29.8	47.6	67.7	26.5	5.7
2007	0.97	658	30.8	54.0	64.9	29.1	6.0
2017	0.71	706	32.0	56.3	64.0	28.5	7.5
2027	0.60	750	32.4	60.6	62.3	27.8	9.9
2037	0.58	794	32.1	65.9	60.3	29.0	10.7
2047	0.53	837	31.6	64.6	60.8	29.1	10.2
1987–2047	0.74						

Chapter 9

LABOR SUPPLY, EMPLOYMENT, AND SUSTAINABLE DEVELOPMENT IN MAURITIUS

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1. INTRODUCTION

A country's labor force is an important consideration in its search for sustainable development. Labor is an essential ingredient in the production process, and an adequate labor supply is necessary for a country's economic growth. At the same time, the availability of jobs and the wage scale determine the standard of living of the labor, and are therefore tied into the quality of life in a country. The issues of labor supply and employment are particularly important in small, developing countries where other factors of production, viz. capital, land and natural resources, are limited. In these countries, labor can be a major force behind economic development, and can quickly transform itself by such development. A country like Mauritius, consequently, provides an excellent case study for the examination of the interactions between labor supply, employment, and development.

This paper examines the trends in Mauritius' labor market focusing mainly on the period between 1962 and 1983. The paper seeks to relate labor supply and demand patterns to the broader development of the Mauritian economy. In particular, the paper tries to examine the sustainability of Mauritius' development in the light of trends in labor supply, demand and wages. Section 1 discusses the theoretical background on the links between economic development and labor supply and demand. A historical background about labor issues in Mauritius is provided in Section 2. Sections 3 and 4 examine recent trends in Mauritius' labor supply and demand, respectively. The final section consists of a summary and concluding comments.

2. LABOR FORCE AND DEVELOPMENT

There are strong theoretical links between development on the one hand and labor supply and demand on the other. The complex socioeconomic changes associated with development transform the supply of and the demand for labor. Changes in the labor market, in turn, influence the development process. This section summarizes some of the principal areas of interaction between labor and economic development processes.

Demographic Change

The linkages between economic development and demographic change have been well established in the theory of the demographic transition. Observed first in the European context, this transition from a preindustrial stage of high birth and death rates to the stage of low birth and death rates in post industrial societies is thought to be a result of a number of proximate and environmental factors associated with modern economic development. Although the applicability of the demographic transition theory to many developing countries including Mauritius is questionable, there are clear links between demographic changes, the size of the working age population, and the labor supply. Thus, high levels of fertility are, all else being constant, associated with a swelling of the working age population. In the long run, however, there is a reduction in the size of the working age population due to lowered fertility rates.

The demographic changes in a country are also theoretically linked to its migration levels. Periods of high natural increase of the population are associated with low levels of in-migration due to government policy restricting migration and/or the perceived difficulty of obtaining jobs by potential immigrants. Periods of low fertility where natural increase fails to keep up with labor demand are frequently associated with an increase in migration and a growth of the labor force.

Social Change

Economic development is associated with improvements in literacy, education and health care, and with increasing levels of consumption. These in turn raise the labor force participation rates and the overall labor supply. These changes also directly impact the quality of the
labor force, i.e. there is a shift from unskilled to skilled labor, and the labor is likely to be healthier and therefore more productive.

Economic development and the social changes that accompany it greatly impact the role of women in society. Here, however, there are two schools of thought. The modernizing perspective suggests that rising educational levels amongst women together with lowered fertility and a growth of "modernizing values" combine to increase female labor participation in the labor market. An opposing perspective was put forth by Boserup (1970) who noted that industrial development generally favors male employment because the separation of the home and workplace in the secondary sector makes women's work and family roles less compatible.

Changes in Consumption and Production

Economic growth or the rise in incomes per capita increases the per capita level of consumption. This in turn increases per capita production levels and the demand for labor. Besides its impact on overall consumption, economic development is associated with changes in the relative consumption of products of the three main sectors: primary (agriculture, mining, forestry, fishing), secondary (manufacturing, construction, utilities), and tertiary (all services, including government). Studies have shown that with rising GNP per capita, there is a decline in the relative demand for primary sector goods, an increase and subsequent decline in the relative demand for secondary sector goods, and a monotonic increase in the relative demand for services (Clark, 1940; Fisher, 1939). Evidence from the industrialized countries has shown that production and labor force patterns generally follow these trends.

Technological Change

Modern economic development brings about technological change and a growing substitution of capital for labor. Increases in the capital intensity of production raises labor productivity. Since the same production levels can be achieved with a smaller labor input, the net effect of technological change is an overall decline in labor demand.

The rate of technological change is not the same in all sectors. Productivity increases in the service sector have been shown to be generally slower than those in the agricultural and manufacturing sectors. This implies that if all else is held constant, the service sector employment will increase relative to employment in the other two sectors with economic development.

Increasing technological levels are also associated with a growth in demand for skilled workers, rising scale of production, and increasing energy inputs. These trends contribute to a shift of employment from the small-scale, individual and family enterprises collectively referred to as the "informal sector" to the larger scale, wage activities requiring greater education and skills characteristic of the "formal sector" (Mazumdar, 1976; Oberai, 1978).

International Trade

The theoretical connections between international trade and economic development are not entirely clear. However rising levels of development are generally associated with an increase in exports (through the production of better and higher valued items) and imports (through higher domestic demand and purchasing power). Export and import levels have a definite impact on domestic production, and by extension, labor demand. An increase in a country's exports stimulates domestic production and employment even if consumption levels are held constant. Conversely, rises in imports satisfy domestic demands without stimulating local production and employment.

With the rise in global protectionism, there has been an increasing tendency for foreign direct investment to substitute trade relations. The amount and type of foreign direct investment influences the size and structure of production and employment.

3. THE LABOR FORCE AND MAURITIAN DEVELOPMENT

Mauritius had no native population. The Dutch took possession of the island in the late sixteenth century and built the first settlement in 1638. The years of Dutch settlement are not significant in terms of Mauritius' population or labor; by the early eighteenth century there were only 169 Dutch people and 67 slaves on the island (Addison and Hazareesingh, 1984). After the island ceased to be of use to them, the Dutch abandoned it in 1710.

The French claimed the island in 1715, and began to develop its agricultural and commercial potential intensively. This development was supported by large numbers of slave laborers brought in from Madagascar and West Africa; as many as 50,000 slaves were brought into Mauritius by the end of the eighteenth century (Titmuss and Abel-Smith, 1968). The French eventually lost Mauritius to the British in 1810 following the Napoleonic Wars.

Two major changes introduced by the British following their conquest of Mauritius had profound impacts on the island's labor patterns. First, they abolished slavery, and freed the slaves brought in during the French occupation. Second, they began a large scale development of the island as a source of sugar for the European market. Sugar cane plantations require relatively large numbers of unskilled laborers throughout the year. Facing an enormous shortage of labor (given the reluctance of the former slaves to working on the plantations), the British began to bring in indentured laborers from India. The inflow of South Asian labor grew rapidly; by the end of the 1800s they numbered 370,000. In comparison, the number of slaves that had worked on the plantations prior to emancipation had been only 34,000 (Addison and Hazareesingh, 1984).

Between 1815 and 1860 there was a tremendous expansion in Mauritius' sugar industry. By 1860, Mauritius had surpassed Trinidad and Jamaica in sugar cane production to become the leading sugar cane exporter in the British Empire (Alladin, 1987). Wages however remained low even during this boom period; because of the abundance of available labor, there was little incentive to increase labor productivity through technological innovation.

The sugar industry in Mauritius began to face problems in the latter part of the nineteenth century. First, with the development of sugar beet in Europe, sugar demand and prices began to drop. Second, there was a slowdown in the immigration of Indian laborers which, together with the malaria epidemic of 1867, created labor shortages and increased production costs. The stagnation of the sugar economy led to changes in landownership patterns whereby agricultural lands were either leased or sold to the indentured classes. While the small cane cultivators soon emerged as a new middle class in Mauritius, they also constituted a reserve labor pool that could be tapped by the large plantation owners during the peak seasons (Alladin, 1987).

The decades of the 1930s and 1940s were characterized by political unrest. Part of the disturbance was caused by worker dissatisfaction with wages. The resulting Industrial Association Ordinance of 1938 recognized trade unions and made strikes legal. A Minimum Wages Board was established the same year to ensure that workers were able to meet their basic needs. However the implementation of the ordinance was far from ideal, and in subsequent years workers had to go on strike to demand the minimum wage itself.

Until the mid-1900s, the sugar industry provided dependable employment for the masses. In the post World War II era, however, a number of factors began to change this reality. First, dramatic declines in the mortality rate following the government's successful campaign against malaria caused the rates of natural increase to escalate in the mid-1900s. This in turn led to an enormous increase in labor supply in the 1960s and 1970s. The post World War II years also saw rapid mechanization in agriculture as the sugar industry tried to keep globally competitive. The two trends together meant the sugar industry was no longer able to absorb the bulk of the entrants to the labor force as before, and unemployment soared (Alladin, 1987).

The security of the sugar industry was also closely tied to the sugar protocol of the Lome Convention. Under the protocol, the European Community guaranteed a number of sugar-producing Third World nations including Mauritius a fixed market for sugar at prices linked to the price of sugar beet within the Community (Addison and Hazareesingh, 1984). Without this market, earnings from sugar exports were likely to be volatile, and too great a reliance on this export could make for an unstable economy.

In light of these considerations, the government began to stimulate manufacturing activity and employment by creating an Export Processing Zone (EPZ) in 1970. The EPZ consisted of a number of industrial firms, domestic and international, that produced purely for the export market. Foreign investment was attracted to the EPZ by means of various incentives including the promise of a cheap, adaptable, and largely non-unionized labor force. In the area of labor legislation, the government ensured that strikes were "legal" only under certain restrictive conditions. The wage legislation also ensured a lower minimum wage for women than for men. Kearney (1990) notes that the minimum wage legislation served more to keep labor costs down than to ensure the welfare of the workers. Beginning with four firms in 1971, the EPZ grew rapidly to include about 100 enterprises by 1980, and 586 enterprises by 1989 (Kearney, 1990). A large percent of their employees were young women, and over half of the EPZ firms were engaged in the production of clothing and textiles (Alladin, 1987).

4. TRENDS IN LABOR SUPPLY

The Working Age Population Size

The size of the population between 15 and 59 years of age at a given time gives the maximum theoretical size of the labor force. Figure 1 shows the growth of the working age population in comparison to the total population of Mauritius for the period 1851 to 1983. Both show fairly similar trends. The period of rapid population increase in the years after 1950 following the successful malaria eradication program is evident in the graph. This increase has important implications for the size of the working age population.

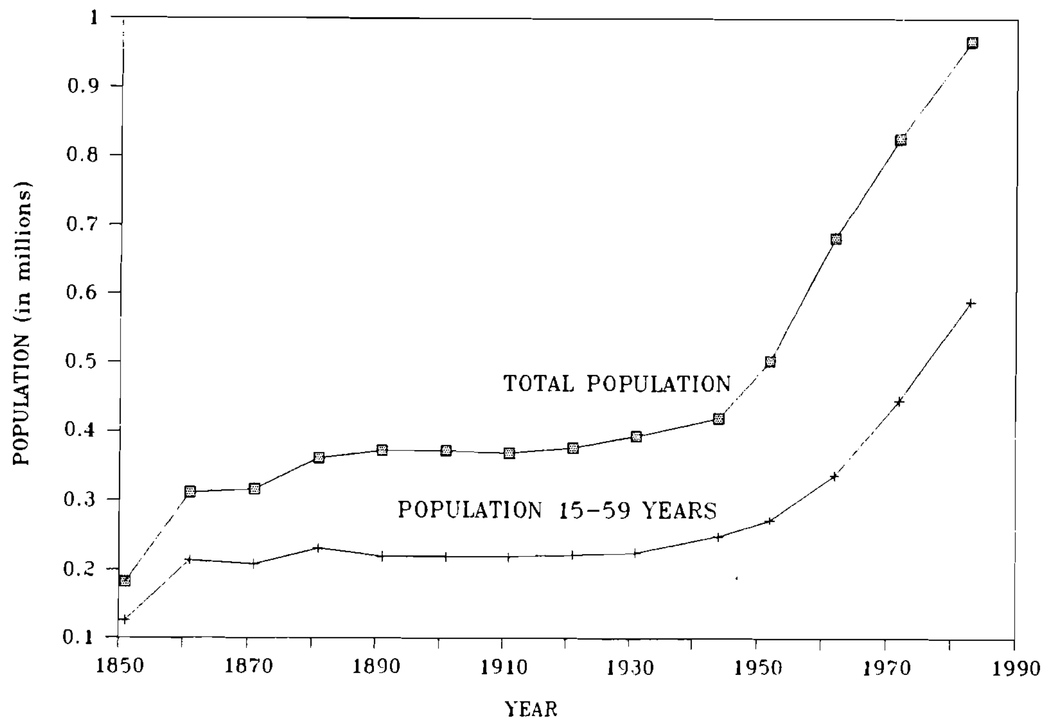

Figure 1. Trends in Mauritius' total population and population between 15 and 59 years of age, 1850-1990. Source: CSO (1956).

Figure 2 graphs the changing share of the Mauritian population falling into the 15-59 age category broken down by gender. Overall, the share was very high in the mid-1800s at the time of heavy labor in-migration. The graph confirms that almost half of Mauritius' population at this time was made up of males between the ages of 15 and 59 - mainly the indentured laborers brought in from South Asia. With the end of the policy to import labor to the island, the share of working age males in the population declined sharply, and reduced the overall share of the working age population in the total. It is interesting to note that the share of women in the working age population shows a gradual rise as processes of natural increase replace migration as the prime source of working age population. By the mid-1900s the sex ratio was close to 1:1.

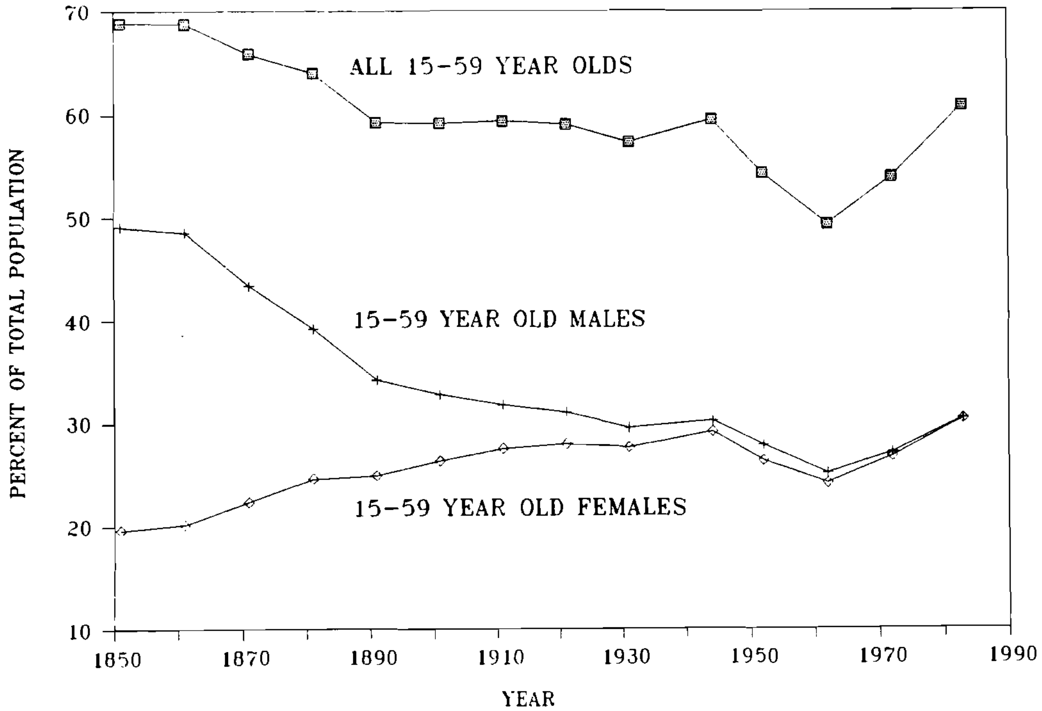

Figure 2. Share of the total population between 15 and 59 years, 1850-1990, by sex. Source: CSO (1956).

The trends in the share of the population between 15 and 59 years of age after 1940 reflect the effects of the dramatic rise in the rates of natural increase. This rise contributed to a swelling to the very young population, and to a commensurate reduction in the share of the working age population between 1940 and 1960. The sex-specific trends in Figure 2 confirm this; as opposed to the earlier decline, the decline in the working age population share after 1940 affects the male and female populations equally.

The increase in the working age population share after 1960 reflects the effect of the large youth cohort, born in the 1940s and 1950s moving into their working age years. The 1970s also saw the beginning of an active population control program by the government following the publication of the Titmuss Report (Titmuss and Abel-Smith, 1968). Important reductions in the fertility rate that followed in the 1980s (Jones, 1989) additionally boosted the share of the population in the working age group.

The Economically Active Population

The economically active population or the labor force is made up of those people who are available for work. The labor force includes individuals who are employed as well as those that are unemployed and looking for a job. Unemployed persons who are not searching for a job, students and retirees are not considered to be a part of the economically active population.

Table 1 presents recent trends in the size of Mauritius' labor force by sex. The table indicates that the labor force size has been growing, something consistent with the increasing size of the working age population. The economically active males greatly outnumber the economically active females, although the share of females in the total labor force shows an increasing trend.

Table 1. Size of the economically active population 1962, 1972, 1983, by sex.

Year	Labor force (000s)			
	Total	Male	Female	% Female
1962	192.36	159.92	32.44	16.9
1972	254.73	204.13	50.60	19.9
1983	355.96	163.09	92.87	26.1

Source: CSO (1987).

The age structure of the labor force is presented in Figure 3 for 1962, 1972, and 1983. With time there is an increase in the labor force at each age level paralleling the overall increase in the labor force. However there is a trend towards a younger labor force, reflecting Mauritius' positive rate of natural increase. The most prominent feature of the figure is the large number of 25-34 year old individuals in the 1983 labor force. This peak is caused by the cohort born in the high fertility period of the 1950s and 1960s entering the labor force.

Labor Force Participation Rates

The ratio between the economically active population and the working age population is given by the labor force participation rate (LFPR). For the computation of the LFPR, the working age population was defined as all persons over 15 instead of just 15 to 59 year olds. This was done because a notable, albeit declining share of the population over 60 is still economically active.

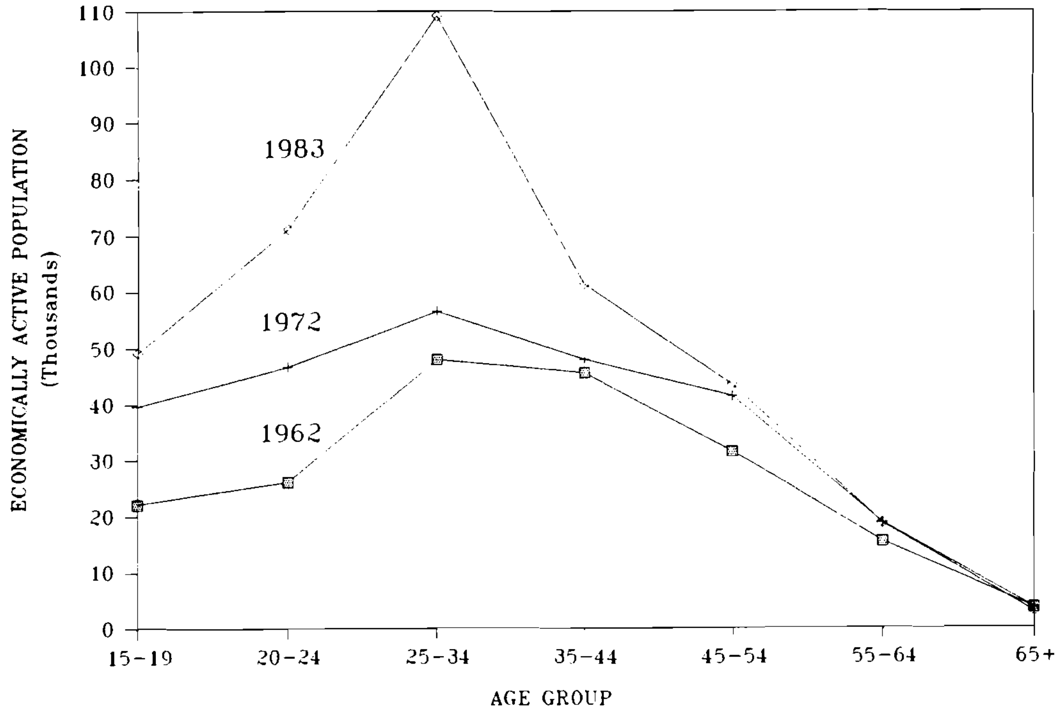

Figure 3. Labor force composition by age group, 1962, 1972, 1983. Source: CSO (1987).

Table 2 shows the total, male and female labor force participation rates for years 1962, 1972, and 1983. Overall, the LFPR remained stable between 1962 and 1972 with a little over half of the population over 15 years participating in the labor force. Between 1972 and 1983 the participation rate grew slightly to 54.7 percent. The total LFPR however masks the gender differences in participation rates. Participation levels amongst males was significantly higher than amongst females; in 1962 approximately 86 percent of men over 15 years were economically active in comparison to only 17 percent of the women over 15. Since 1962, however, the male LFPR has shown a slow decline while the female labor participation rate has grown fairly rapidly. Despite this increase, only 28 percent of women over 15 were economically active in 1983.

Further insight into the trends in the male and female labor participation rates can be gained by comparing their age-specific LFPR schedules. This is done in Figure 4 which shows, for each sex, the age-specific LFPR rates for 1962 and 1983. Clearly, the level of male labor participation is significantly higher than the corresponding female levels. The male schedules are virtually identical for the two time periods; the prominent exception is the participation rate of older men. The LFPR of males over 55 years of age was significantly lower in 1983, possibly due to the improvements in retirement benefits. This decline is largely responsible for the overall fall in male activity rates from 1962 to 1983 seen in Table 2.

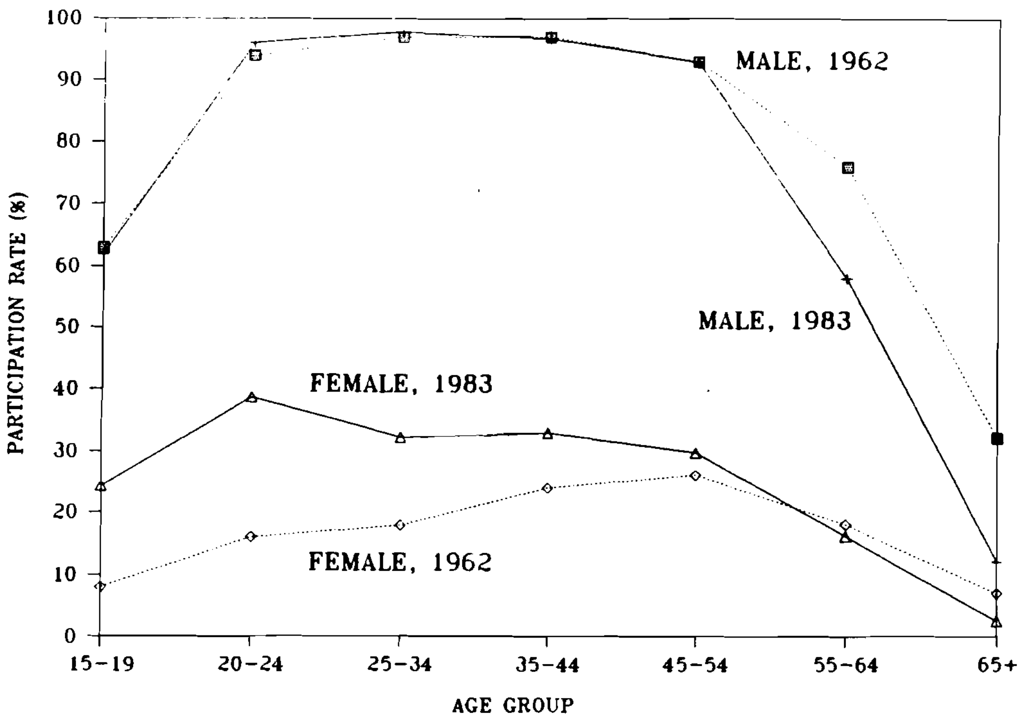

Figure 4. Age-specific labor force activity rates for males and females, 1962 and 1983. Source: CSO (1987).

Table 2. Total, male, and female labor force participation rates 1962, 1972, and 1983.

Population group	Labor force participation rate		
	1962	1972	1983
Total	51.59	51.50	54.68
Males	85.65	82.96	82.46
Females	17.42	20.35	27.98

Source: CSO (1987).

The female labor force participation schedules, in contrast, show a high degree of variation between the two time periods. The 1962 LFPR schedule was characterized by an inverted-U shape: the rates were the lowest amongst the very young and very old and peaked in the 45-54 age category. The pattern suggests that in 1962 women deferred their entry into the labor force due to marriage and childbearing obligations, but joined the labor force for a short period after raising their children. The 1973 pattern shows higher participation rates in almost all age categories. The most dramatic increase is seen in the younger age groups; the participation rates of the 20-24 year old females, for example, increased from 15 percent in 1962 to almost 40 percent in 1983. Much of this growth has been attributed to the establishment and growth of export-processing industries in the 1970s and 1980s which employed young women soon after their schooling. However the figure also shows a drop in the LFPR for the 25-30 year age category, suggesting that a significant proportion of these women may drop out of the labor force after a few years possibly to get married. Alternatively, the dip in the LFPR in the 25-30 year age category could be due to the fact that this group maintained its lower participation rates from an earlier time period. The only group that showed a decline in the participation rate from the 1963 levels was the over 55 year category, paralleling the trend seen amongst older men.

It is also of some interest and policy value to examine the makeup of Mauritius' inactive population. Table 3 presents a breakdown, for 1983, of the male and female inactive population over 15 years by principal reasons for inactivity. Not surprisingly, inactive women greatly outnumber inactive men in Mauritius. Amongst males, the top reason for economic inactivity was retirement - over 45 percent of the inactive males over 15 years of age were retirees or pensioners. The second most frequent reason, accounting for 36 percent of the male inactive population, was education. These are fairly standard explanations for the lower activity rates in the very young and the very old populations.

Table 3. Population over 15 years not economically active by reasons of inactivity and sex, 1983.

Reason for Inactivity	Male		Female	
	Number	%	Number	%
Student	20950	36.0	17695	7.4
Homemaker	1217	2.1	199980	83.7
Institutionalized	281	0.5	405	0.2
Disabled	5060	8.7	2720	1.1
Rentier	775	1.3	453	0.2
Retired/Pensioner	26383	45.3	15142	6.3
Other	3200	5.5	2353	1.0
Not stated	385	0.6	106	0.0
Total	58251	100.0	238854	100.0

Source: CSO (1987).

The overwhelming majority - almost 84 percent - of the economically inactive women in Mauritius were homemakers. As compared to the figures for men, significantly smaller shares of women were inactive for reasons of education (7.4 percent) or retirement (6.3 percent). In absolute terms, however, the number of female students and retirees amongst the inactive population is about the same as for males.

Educational Levels

Besides the quantity of available labor, its quality or educational level is an important aspect of labor supply. Figure 5 shows the breakdown of Mauritius' 1983 labor force by the highest educational level attained. As much as 17.8 percent of the labor force had not been educated beyond the pre-primary level. The majority of the economically active population had only primary level education. About one-third had completed the secondary educational level, and only a little over 2 percent had completed one or more years of post-secondary education.

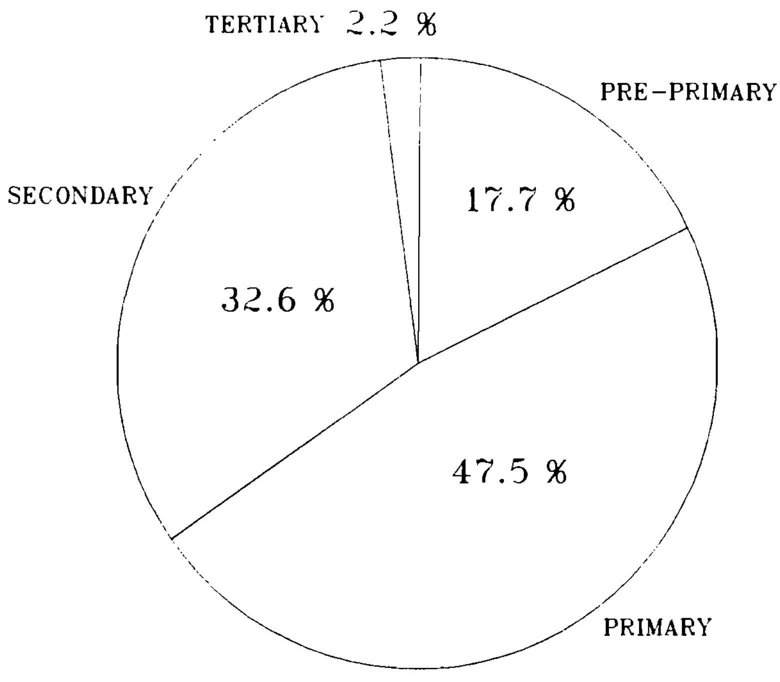

Figure 5. Labor force composition by highest level of schooling completed, 1983. Source: CSO (1987).

An important relationship for policy makers to evaluate is that between educational levels and degree of labor participation or labor inactivity. Since educational outlays per capita increase with years of schooling, the same level of labor force inactivity is increasingly costly to the state when it occurs at successively higher levels of educational attainment. Further, for a country such as Mauritius that is attempting to base its future economic growth on the availability to a large, well-trained labor pool, it is important to pinpoint the population groups that make up the untapped labor potential. This is done in Figure 6 which shows, for 1983, the educational attainment of the adult population broken down by sex and labor force status.

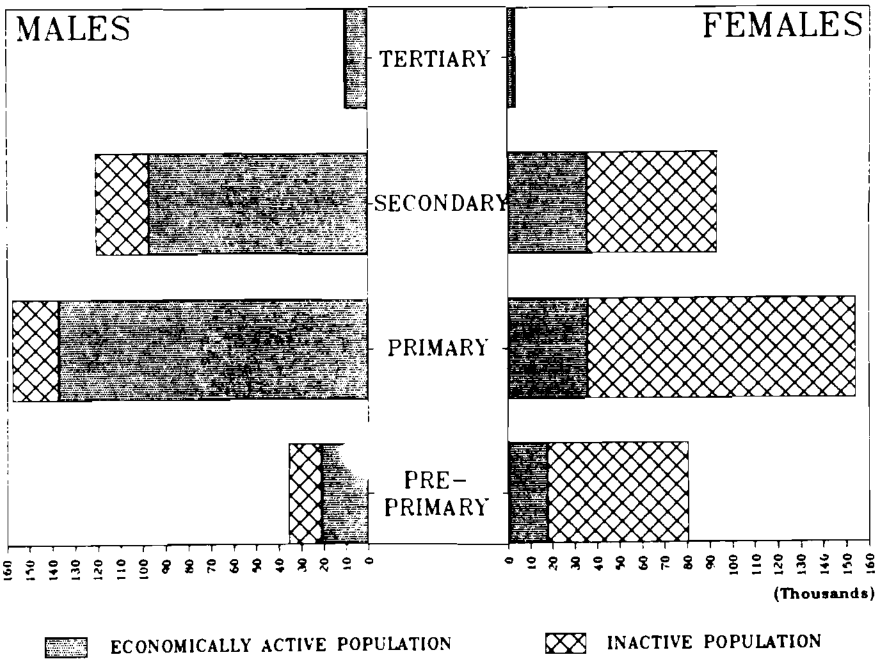

Figure 6. Highest educational attainment of the adult population, 1983, by labor force status and sex. Source: CSO (1987).

Examining first the educational levels for the population as a whole, the statistical mode is at the primary educational level; close to half of the population terminated its education after the sixth standard. About a third of the population over 15 years of age had completed its secondary education in 1983. The figure shows that only a very small percent of the adult population goes on to complete tertiary education. Educational levels are generally lower amongst women than men, i.e. fewer women complete each schooling stage.

Turning to the labor force status by educational level, the graph bears out the observation made in the previous section that participation rates amongst women are lower than amongst men. In fact economically inactive women outnumber the active women at every educational level except the tertiary. The fact that over half of the women completing their secondary education do not join the labor force has serious implications for a country attempting to develop a large and well-trained labor pool.

5. TRENDS IN LABOR DEMAND

Theoretically, labor demand should be estimated by examining a country's economic activity together with its technological level, viz. capital-labor ratio. However precise data are difficult to obtain, and the process involves making a number of frequently arbitrary assumptions. In this section labor demand is examined by looking at employment statistics. Although not ideal in the theoretical sense, i.e. the employment level reflects the interaction of a number of factors including wages, it provides a good estimate of the current labor needs of the economy.

Total Employment

Trends in employment and labor force size for the 1962-1987 period are given in Figure 7. Growth rates of employment and labor force by gender are provided in Table 4. Between 1962 and 1983, the growth of the labor force outpaced employment growth in Mauritius. The periods after 1983 show a reversal in the earlier pattern; the average annual growth rate of employment exceeded that of the labor force. The 1983-1986 period in particular witnessed an increase in employment at the dramatic rate of 13.3 percent per annum. Much of this growth reflected the aggressive export-oriented trade strategy of the government which was able to attract large numbers of foreign firms to Mauritius. The gender-specific figures show that the female growth rates for both labor and employment were higher than the corresponding male rates. This was largely due to rising labor participation by women and a high demand for young women in the EPZ sector.

Table 5 presents trends in the unemployment rate. Unemployment grew in the 1960s and 1970s as the gap between the labor force growth rate and the employment growth rate widened. By 1983, the unemployment rate was almost 30 percent. The dramatic growth of the EPZ sector in the 1980s stimulated employment growth, and by 1987 the accelerated labor absorption had brought down unemployment to around 5 percent. Trends in male and female unemployment rates are qualitatively similar, but the male unemployment rates are generally higher than those for females.

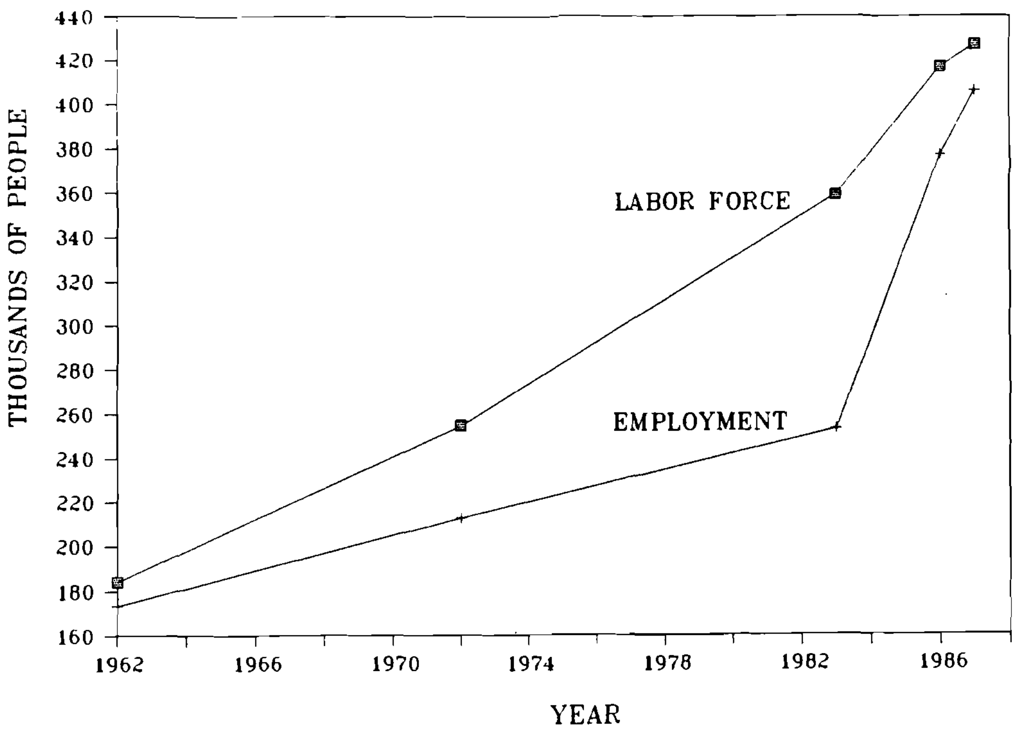

Figure 7. Trends in employment and labor force, 1962-87. Sources: CSO (1987); Bheenick and Hanoomanjee (1988).

Table 4. Average annual growth rates of labor and employment 1962-1987, by sex. Based upon estimates of 1986 and 1987 labor force and employment.

	Average annual growth rates			
	1962-72	1972-83	1983-86	1986-87
Total				
Labor force	3.3	3.1	5.0	2.4
Employment	2.0	1.6	13.3	7.4
Male				
Labor force	3.0	2.4	*	*
Employment	1.8	0.9	*	*
Female				
Labor force	4.4	5.5	*	*
Employment	3.2	3.9	*	*

* data not available. Sources: CSO (1987); Bheenick and Hanoomanjee (1988).

Table 5. Unemployment rates for selected years, by sex.

Unemployment rate	196 2	1972	1983	1986	1987
Total	5.8	16.4	29.5	9.6	4.9
Male	6.3	17.0	30.1	*	*
Female	3.4	14.0	28.0	*	*

* data not available. Source: CSO (1987).

Employment by Industry Group

The industrial structure of the employed population in 1972 and 1983, by sex, is presented in Table 6. Looking at the total employment first, the figures indicate that in 1972, the largest share (43%) was engaged in the tertiary sector followed by the primary sector (33%), the latter consisting of mainly sugar cane farming. The remainder (24%) was engaged mainly in manufacturing. Between 1972 and 1983, the primary sector lost employment to both other sectors. By the end of the period, less than 25% of the workers were engaged in farming making it the smallest of the three sectors. The tertiary sector increased its employment share to 45% and remained the leading sector. It was the secondary sector, however, that saw the most impressive gains; between 1972 and 1983 employment in this sector grew at an average annual rate of 3.5 percent. By 1983, over 30 percent of the workers were engaged in the secondary sector.

The changes in Mauritius' sectoral structure are generally consistent with the type of shifts that Clark (1940) and Fisher (1939) theorized would accompany economic development. The decline in the farm population was mainly due to the growing mechanization of sugar cane farming. Expansion of the livestock and fishing industries however reduced the severity of primary sector employment decline. The strong growth of the secondary sector reflected the Mauritian government's export-oriented manufacturing strategy introduced in 1970. Within the tertiary sector, the largest number of workers were employed in the category entitled "community, social, and personal services." This subsector is inflated largely due to the inclusion of government employees. The most rapid gains between 1972 and 1983 however were seen in the finance, insurance and real estate subsector. The growth of business services such as these is closely associated with rising industrial development and GNP per capita.

Turning to the sex-specific figures, Table 6 reveals that the structure of the male worker population is very similar to the overall structure; this is hardly surprising given that the bulk of the employment and labor force consists of males. The sectoral structure of the female workers, while qualitatively similar to the overall trends, shows interesting differences. In 1973, female employment shares in the primary and tertiary sectors were much higher than the corresponding male employment shares, and the secondary employment share was considerably lower. These differences are consistent with patterns in other developing countries, and are attributed to the fact that agricultural and service activities are more compatible with women's traditional household roles.

Table 6. Sectoral structure of employment, 1972 and 1983, by sex.

	1972 Employment		1983 Employment		Average growth rate 1972-83
	Number	%	Number	%	
Total					
Primary	70198	32.97	62036	24.54	-1.123
Secondary	51892	24.37	76628	30.31	3.544
Tertiary	90809	42.65	114159	45.15	2.080
All sectors	212899	100.00	252823	100.00	1.562
Males					
Primary	53914	31.84	46480	24.99	-1.348
Secondary	47243	27.90	55962	29.96	1.540
Tertiary	68179	40.26	83552	44.72	1.848
All sectors	169336	100.00	185994	100.00	0.853
Females					
Primary	16284	37.38	15556	23.28	-0.415
Secondary	4649	10.67	20666	30.92	13.562
Tertiary	22630	51.95	30667	45.80	2.745
All sectors	43563	100.00	66829	100.00	3.890

Source: CSO (1987).

The 1972-1983 period brought about a marked change in the female labor force structure. A dramatic growth of 13.6 percent per annum in female employment in the secondary sector boosted the share of women employed in that sector from 10 percent in 1972 to over 30 percent in 1983. The increase was pronounced enough to reduce the tertiary sector's share of female workers from 52 percent to 45 percent, despite a healthy 2.7 percent per annum growth of service employment. The primary sector share of all female employment fell drastically from 37 percent to 23 percent, although the female employment in the primary sector declined at only a modest rate. By 1983, the sectoral structure of female employment as very similar to that of male employment.

The growth in female manufacturing employment, although unusual in most developing countries, reflects the widespread use of young women in export industries of newly industrializing countries such as Taiwan, South Korea, Thailand and Singapore. Numerous factors have been cited for this phenomenon including the willingness of women to work for lower wages, and the subordinate position in society which makes them docile, easily manipulated, and willing to do repetitive assembly work (Hein, 1984; Fuentes and Ehrenreich, 1987). The increasing use of women in global assembly parts has been viewed alternatively as a liberating and modernizing trend or as a creation of a giant reserve army that is exploited by a male-dominated capitalist class. Case studies of Mauritius tend to lean towards the latter viewpoint; Hein (1984) and Alladin (1987), for example, have pointed out some of the negative conditions of work faced by women in the EPZ sector.

Formal Sector Employment

Examination of employment in the formal sector of the economy is of some interest. The formal sector consists of economic activities that are regulated by the state, carried out on a large scale, and require a minimum level of qualifications and education. The informal sector (Hart, 1973), in contrast, consists of small scale, unregulated individual and family activities such as domestic service and street vending. Given that with development there is a tendency for the formal sector to grow and the informal sector to decline, assessing the size and structure of formal sector enterprises can give useful insight into emerging trends.

Since 1981, there has been a bi-annual survey of employment and earnings in the large establishments of Mauritius. The survey is taken in March and September of each year and covers those enterprises that employ ten or more persons. Here, the statistics from this survey will be considered to represent the "formal" sector. It is important to note, however, that there is an ongoing theoretical and methodological debate on the concept and measurement of formal and informal sectors.

In order to assess what percent of the total employment in Mauritius fell into the informal sector, I first compared the annual employment figures given in the census with the formal sector employment data (viz. average of the March and September figures) for the same year. The year 1983 was selected for the comparison because it was the only year in which both census employment data and survey employment figures were available. The comparison is presented in Table 7 which gives the sectoral employment numbers and shares from the census and the survey, and the ratios of the employment in large establishments to the overall employment.

Table 7. Comparison of total employment to the formal sector employment for 1983, by sex.

Economic sector	Total employment (a)	Formal sector employment (b)	Ratio (b/a)
Primary sector	62036	54148	0.873
Secondary sector	76628	46285	0.604
Tertiary sector	114159	91108	0.798
Total	252823	191541	0.758

Source: CSO (1987).

The table shows that overall, formal sector employment in 1983 accounted for over 75 percent of the total employment. This is a much higher figure than seen in most developing countries where there has been a trend towards large and rapidly growing informal sectors. In terms of the sectoral division of employment, the table indicates that as much as 87 percent of primary sector employment was in the formal sector. This reflects the large scale in which sugar cane production is carried out. It is surprising to note that only 60 percent of secondary sector employment is of the formal type. This suggests that a fair amount of industrial activity is carried out in small, informal sector firms. Finally, Table 7 shows that about 80 percent of tertiary sector employment is of the formal type. This is expected since the government sector accounts for a fairly large share of the sector's employment.

Trends in formal sector employment for the March 1981-September 1988 period are given in Figure 8. The size of total formal sector employment was fairly level until 1983, after which it gradually increased. The increase was principally fuelled by manufacturing sector growth. Employment in the primary sector reflects the seasonality of agricultural labor demand.

The role played by manufacturing in formal employment generation is shown clearly in Figure 9, which graphs the trends in the annual rates of employment increase, by sector. (The rates are calculated on the basis of the average of the March and September employment figures in order to eliminate the seasonal effect in the primary sector.) In the years following 1983, secondary employment grew at dramatic rates, peaking at 26 percent in the 1985-1986 period. Manufacturing employment growth then slowed down considerably, but was still respectable at around 8 percent in 1987-1988. The primary sector lost employment throughout the period, the most severe declines being in the 1983-1984 period. The tertiary sector posted little loss or gain until the 1984-1985 period. Following this there has been a steady increase in its employment growth rate to the 1987-1988 level of 4 percent or so.

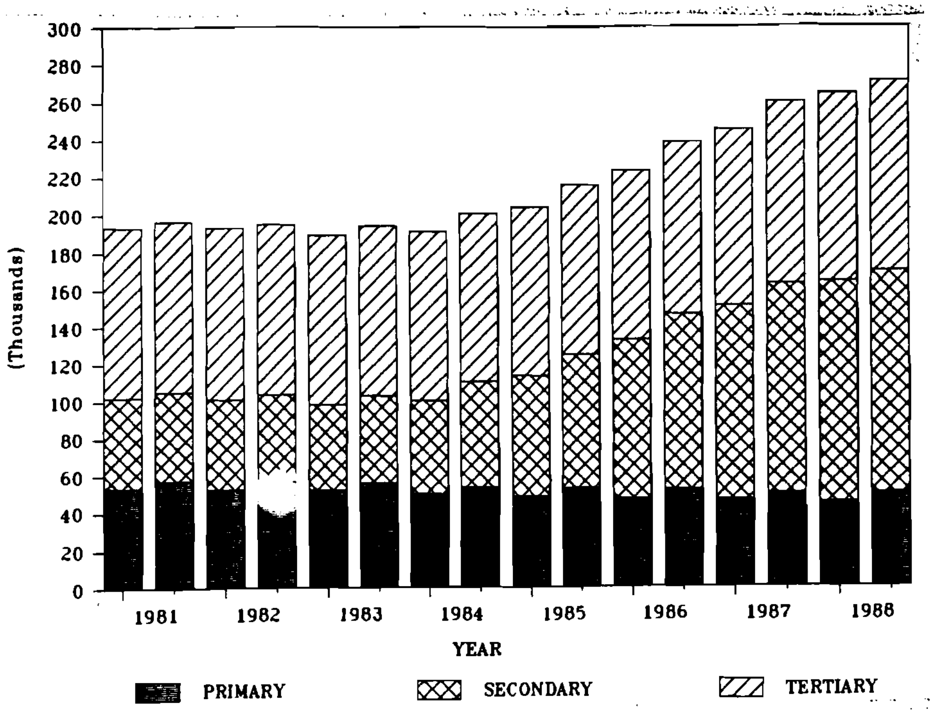

Figure 8. Formal sector employment March 1981-September 1988, by industry group. Source: CSO (1987).

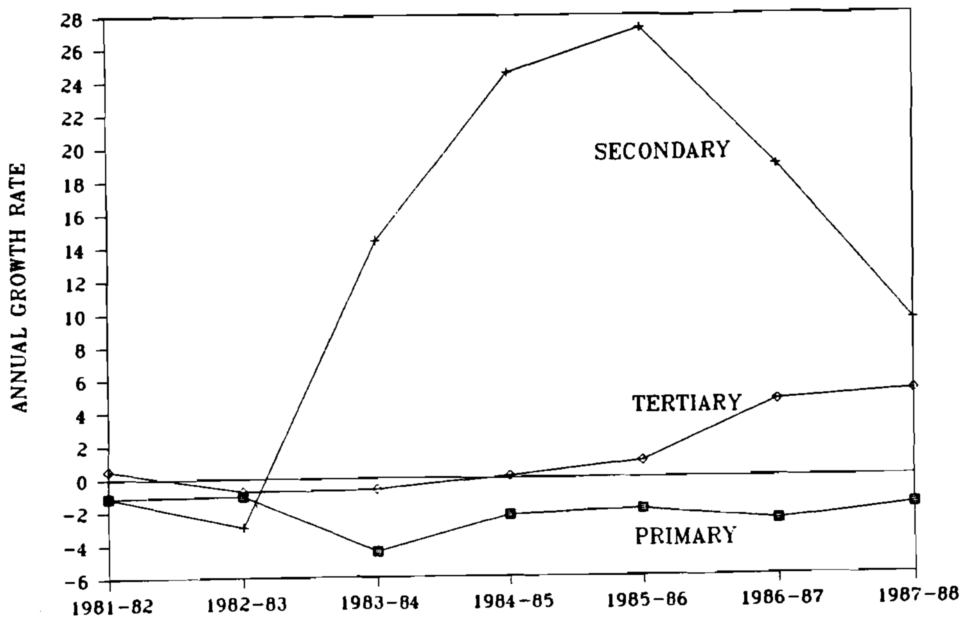

Figure 9. Annual growth rates of formal employment growth by industry group, 1981-1982 through 1987-1988. Source: CSO (1987).

The differential growth rates of the three sectors imply a changing sectoral structure of employment. Figure 10 graphs each sector's share of the employment in large establishments for the 1981-1988 period. The growing importance of the secondary sector in the overall economy is clear - the sector's share grew from about 25 percent in 1981 to about 45 percent in 1988. Agricultural employment shares show a seasonal variation as well as a general declining trend. The tertiary sector lost its worker share despite an absolute employment increase.

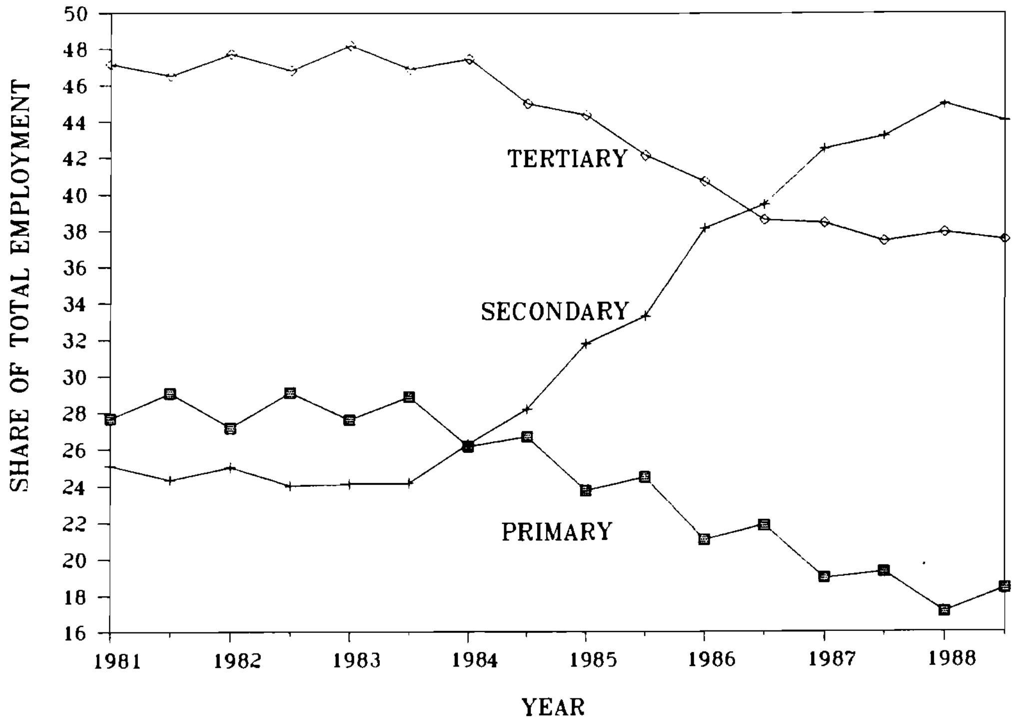

Figure 10. Sectoral shares of formal employment, March 1981-September 1988. Source: CSO (1987).

Trends in Wages

Trends in monthly wages in the agricultural, manufacturing, and community, social and personal service branches of the formal sector, are shown in Figure 11. The wage figures are given in current rupees and do not account for inflation. Consequently they are more useful for assessing sectoral differences than the changes in living standards of the workers.

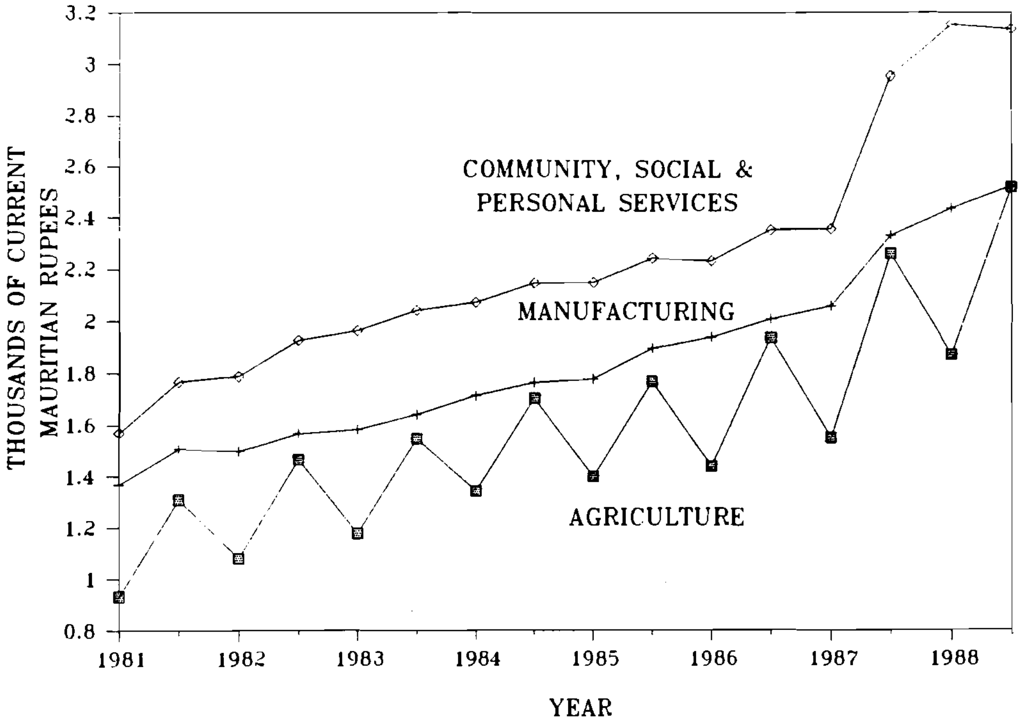

Figure 11. Average monthly wages of formal employment in selected sectors, March 1981-September 1988. Source: CSO (1988).

All three sectors show a general trend towards increasing wages. Agricultural wages, not surprisingly, show a seasonal trend with the higher wage paid in high labor demand season. It is interesting to note that the manufacturing sector wages parallel the overall trend in agricultural wages. This may be because both the sugar cane and the manufacturing sectors largely employ unskilled workers, and therefore bid for the same type of labor force. Consequently they need to be competitive in the wages they offer. The substantially higher wages paid to workers in community, social, and personal services reflect the more difficult entry into the sector. Since the bulk of the employment is in the government, workers are required to have a higher minimum education than in agriculture or manufacturing. The recent dramatic increase in service wages is largely due to a 15 percent across-the-board wage increase in late 1988.

6. EMERGING TRENDS IN LABOR AND SUSTAINABLE DEVELOPMENT

For sustainable development, Mauritius must have a labor supply that is adequate in terms of quantity and quality, and an economy that ensures a relatively steady labor demand in balance with the supply. Recent trends point to the following in terms of labor supply and demand.

1. Labor supply:

   (i) The rapid reductions in fertility in the 1980s will cause a decline in the working age population beginning the late 1990s. All else being constant, this means a commensurate decline in the size of the labor force.

   (ii) Labor force participation rates amongst males are very high, and unlikely to increase. On the contrary a continued growth in educational levels and/or further improvements in retirement benefits can actually bring down the overall male LFPR. However female labor force participation rates are currently low, despite impressive gains since 1962.

   (iii) There continue to be gains on the educational front as evidenced by rising school enrollment and university attendance rates. However amongst the females, large numbers of those completing each level of education do not join the labor force.

2. Labor demand:

   (i) The bulk of Mauritius' employment and labor demand is generated by the "formal sector" or large, regulated enterprises. This is in contrast to trends in most less-developed countries where the informal sector plays a greater role in absorbing the labor supply.

   (ii) Employment in the sugar cane industry is gradually declining, mainly due to mechanization. The future of the sugar cane industry is closely tied to the fate of the sugar protocol of the Lome Convention of 1975.

   (iii) The most rapid gains in employment in the 1980s have been in the manufacturing sector. Within the sector, the bulk of the firms and workers are in the labor-intensive clothing and textile industry.

   (iv) The Export Processing Zone firms disproportionately employ young women for a number of reasons including lower wage costs. Surveys indicate that the working conditions of the female laborers are poor and can use improvement.

   (v) Employment in the tertiary sector has been growing, albeit at slower rates than the manufacturing sector. The bulk of the tertiary sector workforce is employed by the government sector. The most rapid growth in service employment has been in the financial and business services.

The above trends have important implications for the future development of Mauritius. In terms of labor supply there is a clear declining trend based upon demographic patterns. One way in which the size of the labor force could be maintained is through measures that encourage women to enter the labor force, and to remain in the workforce even after marriage. It is possible that the presently low fertility rates may contribute to further increases in female labor participation in the future. However, it is important to note that a growth in the female labor force will have major implications for Mauritius' family and social structure, and these need to be considered.

Another possible way of increasing the labor supply is through immigration. There is recent evidence of private contractors bringing in small numbers of Indian laborers into Mauritius. While this is certainly a direct way of raising the labor supply, it has important social and political implications. Unless dealt with in the context of a comprehensive immigration policy with a national mandate, such piecemeal efforts to boost the workforce may generate resentment within the Mauritian population.

The improvements in formal education point to rising skill levels within the population. There has also been recent attention given to increasing non-formal education and industry-specific training (Bheenick and Hanoomanjee, 1988). Such a supplement to the formal schooling will enable Mauritius to shift from unskilled, labor-intensive activities to higher skilled, possibly capital-intensive industries, the latter being an appropriate response to the possible labor shortages. Further, the precise nature of the training programs will allow the country to decide the future direction of its growth.

The trends on the labor demand side also suggest some important changes. The future health of the sugar industry currently hinges on the Lome Convention's sugar protocol. Although the protocol was recently renewed in late 1989, it is subject to annual review. There is some concern that the secure quota that Mauritius enjoys may disappear with the move towards a single European market in 1992. Alternative uses for sugar cane in the absence of the guaranteed European market are currently under consideration. Regardless of whether the protocol is renewed or alternative markets developed for the sugar, the trend towards mechanization of the sugar cane industry suggests that the industry will not play an important role in future employment generation.

The recent growth of manufacturing has clearly reduced the dependence of Mauritius on sugar cane farming. At the same time, the heavy concentration of manufacturing in the clothing and textile sector can be as problematic as the dependence on a single crop. The desirability of industry diversification, together with the possibility of labor shortages in the years ahead has prompted the Mauritian government to seek out more capital-intensive industries. The increased attention to training programs should aid this effort.

Besides diversification, future sustainable development of the Mauritian manufacturing sector depends on a cooperative relationship between workers and management. Current conditions do not support harmonious interactions. The bulk of the EPZ workforce, young women, are paid a lower wage than their male counterparts. This, together with the poor working conditions, is likely to result in greater worker dissatisfaction. If a stable future is being sought for industry, these issues must be dealt with fairly and humanely.

Finally, the Mauritian economy can be further balanced by the development of the service sector. The government has already begun to develop the island's tourist potential. Emphasis is being placed on improvements in air transportation, investment incentives, and foreign advertising. This development is likely to spur service employment in retail trade, hotels, restaurants, and transportation. This development should be balanced with the broader aspects of sustainability with regards to the environment.

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Chapter 10

MANPOWER PLANNING AND TRAINING IN THE CONTEXT OF ECONOMIC DEVELOPMENT IN MAURITIUS

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1. INTRODUCTION

It is indeed a great privilege to have the occasion to address such an elite group of Mauritians and Non-Mauritians. The Non-Mauritians, I notice, are not only distinguished academics in their own fields but are also exceptionally knowledgeable of the Mauritian situation. As for the Mauritians, representing, as they all do, the apex tertiary institution in Mauritius, are highly respected in Mauritius. They are apparently adequately well-known abroad for IIASA to have roped them into this project. Before coming to my topic which is "Manpower Planning and Training in the Context of Economic Development in Mauritius," I wish briefly to show the link between Manpower Planning and Population Planning.

The preparation of population/manpower plans for Mauritius have proved to be an interesting and feasible exercise for two reasons. First the island is small; the population has remained below the one million mark up to 1986. Secondly, abundant data have been collected since early times; Mauritius had its first census in 1846 and since 1952 the population and housing census exercise has been conducted regularly every decade.

The first intervention on the population scene began in the early 1950s when the annual population growth rates struck the 3.12% level -- the highest recorded in Mauritius. Armed with facts and figures, a group of well-meaning philanthropists prophesied the imminent Malthusian doom of overpopulation and starvation. When the population issue became well-exposed after several years of public debate, the Government gave its support to the non-governmental organizations spearheading population control activities and subsequently officially adopted population policy as part of its development planning exercise.

The step from population policy and planning to manpower planning is a logical one. In the late 1960s when Mauritius was in the throes of mass unemployment -- a peak of 25% was reached in 1969 -- Mauritius resorted to manpower planning. Since then, three detailed manpower plans have been prepared. Consequently, while an analysis of employment and labor supply trends continues to form part of the regular planning exercise, the attainment of full employment had been a major objective of all the earlier national plans.

The first manpower report published by the government of Mauritius (1969) and prepared at the height of the unemployment problem advocated two main solutions. The first was the adoption of an active family planning policy to which government scrupulously adhered. Mauritius has been successful on the population front and the annual population growth rate has been brought down to the current level of about one percent. The second recommendation was to reform the educational system to bring it more in line with the requirements of the labor market. Attempts to vocationalize the education system have proved to be more difficult. Education is seen by all as a vehicle for social mobility with academic education being the only means to attain the highest ranks of the social hierarchy. This deference shown to learning is only being slowly replaced by a healthy respect for the higher income which technical education now commands.

The second report published by the Ministry of Economic Planning and Development (MEPD) in 1974 projected the attainment of full employment by 1980. Due to a variety of factors, the most important being the world recession caused by the oil price hikes of the 1970s, this objective was unrealizable. In addition to external factors, Mauritius was also hit by one of the worst cyclones which devastated the sugar crop. The last manpower report (MEPD, 1985) was therefore prepared when economic conditions were bleak and forecast a more realistic reduction in the unemployment rate from the then level of 18% (1983) to 11% in 1994. The recent economic miracle and the move from a "labor-surplus" economy to a "labor-short" economy in 1988 was a phenomenon which could not have been predicted by the most erudite manpower, and which repudiated the last set of manpower planners forecasts.

The recent experience in manpower planning would, by alcynic, be interpreted as a failure. Is there then a role for manpower planners in the Mauritian economy? Before proceeding further with this address which, "inter alia" defends the need for continued manpower planning, I wish to present its main scope. Given that the next paper will trace the recent economic development in Mauritius in detail, I will only refer to employment trends over the past decade as part of this talk, which covers three main issues. I begin with a description of the manpower plan for the period 1983 to 1994, and the role of manpower planning in a labor-deficit economy. I will then highlight the role of training as a means of increasing productivity and thereby offsetting the quandary of labor shortages. Finally, given the importance of export-led development in the Mauritian economy, I conclude this presentation with a review of world market production thus setting the stage for Mauritius in the international context.

A word of warning is appropriate from the outset. In spite of the abundance of labor and employment data, and the regular study of the problem, in-depth data on the educational and skill structure of the labor market are available only for census years. Therefore, it has been difficult to keep track of changes in the quality of manpower in the inter-censal period.

2. THE ROLE OF MANPOWER PLANNING

Mauritius is, to a large extent, an extreme example of an "open economy." From being a major exporter of sugar, it has become an exporter of knitwear and made-up garments. Export earnings (gross) constitute around 50% of the GDP. Given, therefore, that economic activity in Mauritius is geared for an export market, the tastes, fashion and demand in its export markets and the production complexities of Mauritian competitors play a determining role in the development of the country. Hence, for projecting the type of employment opportunities that will become available in Mauritius, one has to look outside the island. It is no longer possible to base domestic projections of employment and unemployment on past growth parameters or technology currently in use. Changes in the technology of producing sugar for export have occurred slowly. The past two hundred years of sugar culture have witnessed only a dozen (at the most) major upheavals in technology. The same is not true in industrial development.

A distinctive feature of industrialization is the rapid rate at which technology changes and the relative ease with which one can expand the range of products manufactured. While firmly entrenched in the knitwear and garment sectors, Mauritius is making some inroads into other sectors such as footwear, leather goods, jewelry and informatics. The expansion and diversifications of the industrial base has important implications for manpower and educational planning. In addition, with the wide range of technology in use, modern industry requires skills which can only be cultivated with some years of training.

Given the complexity of market conditions, the projection of manpower needs with any accuracy is "fraught with difficulties." The objective of manpower planning is no longer to make long-term projections of skills required but to keep a tab on the labor market and to anticipate the market shortages that are likely to occur in the short-term. The emphasis also changes from the "macro level" to the "micro level." As a country attains full employment, it is buffeted by a variety of factors including competition from larger countries supporting cheap labor, capable of mass production for paltry wages. Survival for countries like Mauritius thus hinges on the ability to climb into higher technology-production and/or to resort to greater automation and mechanization to solve labor shortages. A relentless search for new markets and cheaper and more efficient technology become keywords for continued growth.

Agriculture presents an additional problem. The transition from a mono-crop agricultural economy to an industrial economy producing for the sophisticated world market is not frictionless and cannot be left to market forces alone. Thus some timely and well-defined intervention from Government to facilitate the transition will ensure, inter alia, that the requirements for both the sectors -- skilled workers for the agricultural sector and technically-qualified workers for the industrial sector -- are met.

Finally, to carry manpower planning exercise to its logical conclusion, some form of international monitoring system has to be developed. Given that the market is not domestic but international, it is imperative to monitor "developments in major lucrative markets so as to identify new emerging opportunities in terms of new products, new technologies and potential new investors" (Bheenick et al., 1988). It is by regularly analyzing economic international intelligence that entrepreneurs can decide on the leading edge technology areas which they can safely move into. Anticipating these changes, so as to keep the labor market prepared, would fall within the new role of the manpower planner.

3. MANPOWER PLANNING AND EDUCATIONAL AND TRAINING IMPLICATIONS

The principal objectives of any manpower plan are to:

1. Project the demand for labour by occupational groups and by level of education and skills.

2. Project the supply of labor by educational levels and skills.

3. Synchronize the demand for labor which is based on economic development, and in particular, the industrialization of the country, with the supply of labor which is a function of the educational and skills-training policy of the country.

As stated in the introductory remarks, manpower planning is not new to Mauritius and three manpower reports have been prepared. Mauritius -- like many other developing countries -- has used manpower forecasting to guide developments in the educational and training sectors. Without delving into the technical intricacies of manpower planning, I will explain its methodology, so as to show its relevance for formulating education and training policy, as well as warn of the pitfalls of manpower planning. The projections are based on a computerized manpower model using the Lotus 1,2,3 software. The objective is very modest. The model seeks to bring together demand and supply factors so that expected shortages and surpluses could be anticipated ahead of time.

The first step in the manpower planning exercise is the projection of Gross Domestic Product (GDP). This can be done in a variety of ways -- the most common being by assuming separate and realistic growth rates for each of the sectors. Most errors in manpower forecasting begin with the projection of GDP growth itself. Long-term employment projections made in the last round of the manpower planning exercise (1983-1994) proved to be extremely modest and were soon overtaken by the rapid developments in the Export Processing sector. GDP which was assumed to grow at 5.8% in 1985 and 4.5% over the period 1986 to 1994 to reach Rs. 16,179 million (at constant 1982 factor cost) in 1994, reached that level by 1988 or 1989. GDP currently stands at Rs. 23,000 million (at constant 1987 prices). It is consequently easy to understand why short-term projections have greater chances of being realized.

Considerable variations in the GDP growth rates have also been in evidence. The EPZ sector has proved to be the most elusive to forecast with GDP growth rates having reached 35% in 1986. The agricultural sector, on the other hand, has fluctuated. It grew by 10% in 1986 and has almost failed to grow since. Due to these variations in growth rates, agriculture has ceded its place as "King" in term of value added to the manufacturing sector. In 1990, agriculture accounted for 13% and manufacturing for 25% of total GDP. Based on the GDP growth rates used by the World Bank (1989), the shares of these sectors could move to 10% and 33% by 1994.

In addition to the share of sectoral GDP in total GDP, another main factor has to be taken into account in projecting sectoral employment. This is labor productivity. The projection of labor productivity is factious. Labor productivity, defined as value-added per worker, takes into account sectoral GDP and sectoral employment. Changes in labor productivity can be brought about by both exogenous and endogenous factors -- better organization, modern management, or improved capital equipment, changes in technology and so on.

A cursory analysis of Mauritian productivity data reveals that some increases have been registered in the manufacturing sector over the period 1984 to 1987. For example, the overall productivity has increased by about 25% from Rs. 34,000 to Rs. 42,000. The extremely disquieting feature of Mauritian industrial development is that over 90% of the jobs created in the EPZ sector are in the "wearing apparel" sub-sector, where value added per worker is only slightly higher than half the national average. The only redeeming attribute is that productivity in that sector has increased by about 40% from the 1984 figure of Rs. 19,000 per worker, thus outdoing the overall average for the EPZ sector.

The concept of labor productivity is closely linked with that of the sector-occupation-matrix (SOM). The SOM presents the occupational structure of the labor force within each economic sector for a particular year. In tables 3.1 and 3.2 SOMs for 1972 and 1983 are given. These have been based on actual data collected at the 1972 and 1983 Population and Housing Censuses (CSO, 1972, 1983). The group "production and related workers" has increased by three percentage points to 38% over the period 1972 to 1983. At the same time, the percentage of "agricultural, animal husbandry and forestry workers" declined from 32 to 24. This change mainly reflects the structural transformation that is taking place in the economy -- with the growth in the manufacturing sector overtaking that in the agricultural sector.

The projected SOMs for 1990 and 1994 have been prepared based largely on an intuitive assessment of developments in the various sectors. In addition, when projecting employment in the agricultural sector, other factors have also to be taken into account. First, the labor force in this sector is artificially propped up by legislation which requires that employment in the inter-crop period is retained at 80% of the peak-level employment. The repeal of this legislation should reduce the labor force in this sector by some 20%. The greater application of mechanical loading for sugar in particular among small sugar planters and mechanical plucking for tea will also further reduce the share of agricultural labor in the total workforce. A further plunge in the level of agricultural employment to 10% from the current level of 17% presents a very likely scenario.

In addition to the structural change in the economy, another more interesting development is in evidence. This is the skill-intensification of the labor force. As can be observed from Tables 1 to 4 the proportion of "professional and related workers" and "administration and managerial workers" has been on the increase between 1972 to 1983. The rise in the first category has been from 6.2% to 7.6%. This trend is expected to continue to reach to 7.8% in 1990 and 8.2% by 1994. The change in the second group has been more modest -- from 0.5% to 0.7% between 1972 to 1983. One reason for this wide discrepancy between the two groups is that unlike the "administrative and managerial workers" group, the former category is heterogeneous, engulfing a variety of related workers. Besides, given that most enterprises in Mauritius are small, the number of managers is limited to one on average. The next big change that is in evidence has been for "clerical workers" -- with a jump from 6.8% to 9.1% between 1972 to 1983.

Changes in the proportion of the occupational groups originate not from the structural change in the economy -- e.g. the move from agriculture to manufacturing -- but predominantly from movements within the sector. Another contributory factor is the introduction of new technology. There is much disagreement regarding the relationship between the level of technology and the skill requirements of jobs. On the one hand, based on US evidence, it is argued that new technologies with their heavy reliance on micro-computers, will require an increasingly technically-oriented workforce. This is based on the assumption that there will be a major shift to the use of more sophisticated equipment, e.g. micro-computers, in factories, offices, and retail stores (World Bank, 1983; Levin et al., 1986).

The riposte is that the major effect of new technologies is to substitute the capabilities of machines for the physical skills of workers, enabling the hiring of less skilled workers at lower cost. These scenarios have dramatically different consequences for the future. While one scenario would suggest that new technologies will improve substantially the employment prospects of the labor force for highly skilled and technical workers, the other scenario seems to indicate that high technology could do the reverse.

Having explained the demand scenario of the manpower planning exercise, let us take a look at the supply side. In many respects, this is smoother sailing. The population forecasts can be taken as given, prepared as they are by the Central Statistical Office of the Ministry of Economic Planning and Development. Based on the population data, the expected labor force by educational qualifications will next need to be projected. The two controversial assumptions pertaining to this exercise are (1) the future school enrolment factors and (2) the labor force participation ratios. Both these ratios lend themselves for adaptation to the dictates of policy. The labor force, based on a set of assumed labor force participation ratios, is expected to reach around 460,000 by 1994. This would further accentuate the current labor deficit situation, because employment or demand for labor could soar ahead to around 500,000.

Table 1. Total employment by occupational groups - 1972, 1983 and 1990 (estimated).

ISCO code	Major occupational group	1972*	1983*	1990** (estimated)
0/1	Professional, technical and related workers	13388 (6.2)	22284 (7.6)	31500 (7.8)
2	Administrative and managerial workers	11206 (0.5)	2483 (0.8)	4100 (1.0)
3	Clerical and related workers	14728 (6.8)	26634 (9.1)	39500 (9.8)
4	Sales workers	15805 (7.3)	26075 (8.9)	37500 (9.2)
5	Service workers	24636 (11.4)	33966 (11.6)	48500 (12.0)
6	Agricultural, animal husbandry and forestry workers, fishermen, etc.	68945 (32.0)	70557 (24.0)	69000 (17.0)
7-9	Production and related workers, transport equipment operators and laborers	75901 (35.2)	111739 (38.0)	174000 (43.0)
10	Workers not elsewhere classified	967 (0.5)	262 (0.1)	900 (0.2)
	Total	215576	294000	405000

Sources: * Population and Housing Censuses of Mauritius, 1972 and 1983.
** Mauritius Manpower Situation and Prospects, 1983-84.

Table 2. Estimated employment in percentages by major occupational groups and industrial activity, 1983.

MAJOR OCCUPATIONAL GROUPS	AGRICULTURE, HUNTING, FORESTRY & FISHING	MINING & QUARRYING	MANUFACTURING	ELECTRICITY GAS & WATER	CONSTRUCTION	WHOLESALE & RETAIL TRADE RESTAURANTS & HOTELS	TRANSPORT STORAGE & COMMUNICATION	FINANCING, INSURANCE, REAL ESTATE & BUSINESS SERVICES	COMMUNITY, PERSONAL & SOCIAL SERVICES	ACTIVITIES NOT ADEQUATELY DEFINED	TOTAL
PROFESSIONAL, TECHNICAL & REL WORKERS	0.4	-	1.4	4.2	1.2	1.2	2.3	12.3	26.4	1.7	7.6
ADMINISTRATIVE & MANAGERIAL WORKERS	0.1	2.1	1.6	0.3	0.3	0.8	1.2	5.8	0.6	0.8	0.8
CLERICAL & RELATED WORKERS	0.9	1.4	6.0	15.8	4.0	9.7	25.4	57.5	12.3	4.7	9.0
SALES WORKERS	0.2	0.3	1.9	0.2	0.2	66.9	1.4	7.8	0.4	4.3	8.9
SERVICE WORKERS	1.7	1.4	3.6	6.0	2.7	11.6	3.7	7.0	34.5	4.3	11.7
AGRICULTURAL, ANIMAL HUSBANDRY & FORESTRY WORKERS, FISHERMEN ETC	90.1	3.9	2.6	0.5	0.8	0.9	0.2	1.0	2.8	3.0	24.2
PRODUCTION & RELATED WORKERS, TRANSPORT EQUIPMENT OPERATORS & LABOURERS	6.6	90.9	82.9	73.0	90.8	8.9	65.8	8.6	23.0	15.4	37.7
WORKERS NOT ELSEWHERE CLASSIFIED	-	-	-	-	-	-	-	-	-	65.8	0.1
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Population and Housing Census, 1983.

Table 3. Estimated employment in percentages by major occupational groups and industrial activity, 1990.

MAJOR OCCUPATIONAL GROUPS	AGRICULTURE, HUNTING, FORESTRY & FISHING	MINING & QUARRYING	MANUFACTURING	ELECTRICITY, GAS & WATER	CONSTRUCTION	WHOLESALE, RETAIL TRADE, RESTAURANTS & HOTELS	TRANSPORT, STORAGE, COMMUNICATIONS	FINANCING, INSURANCE, REAL ESTATE& BUSINESS SERVICES	COMMUNITY, PERSONAL & SOCIAL SERVICES	ACTIVITIES NOT ADEQUATELY DEFINED	TOTAL
PROFESSIONAL, TECHNICAL & RELATED WORKERS	0.6	-	1.6	4.0	1.4	1.4	3.2	13.0	30.5	17.5	7.8
ADMINISTRATIVE & MANAGERIAL WORKERS	0.2	2.1	1.6	0.3	0.4	0.7	1.3	5.9	0.8	1.5	1.0
CLERICAL & RELATED WORKERS	1.0	1.4	6.0	16.0	5.5	10.0	26.0	58.0	13.0	11.8	9.8
SALES WORKERS	0.2	0.3	2.0	0.3	0.3	68.0	1.5	7.8	0.5	13.3	9.2
SERVICE WORKERS	1.8	1.4	4.0	6.0	3.5	15.0	5.0	9.0	37.5	14.3	12.0
AGRICULTURAL, ANIMAL HUSBANDRY & FORESTRY WORKERS, FISHERMEN ETC	88.2	4.0	2.6	0.5	0.8	0.9	0.3	1.0	2.5	9.9	17.0
PRODUCTION & RELATED WORKERS, TRANSPORT EQUIPMENT OPERATORS & LABOURERS	8.0	90.8	82.2	72.9	88.1	4.0	62.7	5.3	15.2	8.4	43.0
WORKERS NOT ELSEWHERE CLASSIFIED										23.3	0.2
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Manpower Planning and Training Division, Ministry of Economic Planning and Development (estimates).

Table 4. Projected employment in percentages by major occupational groups and industrial activity, 1994.

	Agricul., etc.	Manag.	Manuf.	Elec.	Cons.	Whol.re	Tran.	Fin.	Comm.	Other	Total
Professional, technical	2.00	0.00	3.00	5.00	2.00	2.00	3.50	15.00	31.00	0.00	8.50
Administrative & managerial	0.50	0.00	3.00	0.50	1.50	1.00	2.00	10.00	1.50	0.00	2.00
Clerical and related	1.50	0.00	7.00	16.00	5.50	12.00	26.00	36.00	13.00	0.00	10.00
Sales workers	0.50	0.00	4.00	0.50	0.50	50.00	1.50	8.00	5.00	0.00	10.00
Service workers	3.00	0.00	6.00	10.00	5.50	25.00	5.00	24.50	38.00	0.00	15.00
Agricultural, animal husbandry	80.50	0.00	2.00	0.50	0.50	2.00	0.30	1.00	11.50	0.00	16.00
Production and related workers	12.00	0.00	75.00	67.50	84.50	8.00	61.70	5.50	0.00	0.00	38.50
Workers not classified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	0.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	100.00

Manpower Planning and Training Division: Ministry of Economic Planning and Development (estimates).

4. POLICY IMPLICATIONS

I wish to conclude by highlighting the main implications of the manpower forecasting exercise which has been discussed at some length. The reason for not dealing with training and education more exhaustively is because this topic has been the subject of a separate document. Manpower planning has remained in the realm of mystery and some de-mystification is called for. The continued "labor-shortage scenario" does not need to strike alarm for the planner or the entrepreneur. With some adjustment and preparation it could be turned into a definite advantage. The main areas for reorientation are:

1. Education and training.

2. Technology and employment creation.

3. Sustainable development.

Education and Training Policy

An examination of the educational level of the labor force will interest many of you -- being for the large part educators. As seen from Tables 5 to 8 the majority of workers, according to the 1983 Population and Housing Census, had only primary education with about a third having some secondary education. As is to be expected, most of those who had some tertiary education were working as "professionals and related workers." Surprisingly, however, about 50% in this group had only completed their secondary level education and 5% had only primary education. Data collected by the National Pension Scheme indicates some improvement in the labor force educational levels, but not adequate for Mauritius to "leapfrog" anywhere.

Notwithstanding the relatively high level of the Mauritian educational system, the educational pattern of the Mauritian labor force still lags behind that of most developed countries and the more progressive developing countries. The higher the enrolment ratios in particular at the tertiary level, the better educated the labor force will be. Enrolment ratios for higher education ranges from 22% in UK to 36% in South Korea. The other Asian NICs (namely Singapore, Taiwan, Hong Kong) have figures which are slightly lower. However, the availability of technical education is much higher in the NICs, namely Taiwan, Hong Kong and therefore a substantial proportion of the labor force is technically competent. In contrast, technical education has been the "pariah" of the Mauritian education system.

The implications of the occupational-mix of the economy arising from the changes in technology, as well as the product-mix within the main industrial sectors are obvious. Given the highly fluid situation in Mauritius as regards qualified manpower flows, one reaches an impasse when trying to quantify tertiary-level enrolment ratios and the "brain drain" out of Mauritius. It is estimated that some

Table 5. Total employment by major industrial sectors.

Sector	1972 (Census) Male	1972 (Census) Female	1972 (Census) Both Sexes	1983 (Census) Male	1983 (Census) Female	1983 (Census) Both Sexes	1987 (Estimate) Male	1987 (Estimate) Female	1987 (Estimate) Both Sexes	1990 (Estimate) Both Sexes
Agriculture, Hunting, Forestry and Fishing	54,334	16,365	70,699	46,417	15,488	61,905	56,000	28,000	84,000	80,000
Mining and Quarrying	95	28	125	168	83	251	-	-	-	
Manufacturing	24,607	4,513	29,120	33,350	20,357	53,707	56,000	65,000	121,000	136,000
Electricity, Gas and Water	3,057	89	3,146	3,923	132	4,055	4,000	-	4,000	3,000
Construction	20,377	149	20,526	18,989	251	19,240	23,000	-	23,000	25,000
Wholesale & Retail Trade & Restaurants & Hotels	17,676	2,892	20,568	21,946	5,256	27,202	36,000	16,000	52,000	58,000
Transport, Storage & Communications	13,764	380	14,144	15,243	698	15,941	25,000	1,000	26,000	30,000
Financing, Insurance, Real Estate & S.Services	2,235	511	2,746	4,869	1,606	6,475	6,000	2,000	8,000	10,000
Community, Social and Personal Services	34,628	18,936	53,564	41,726	23,146	64,872	59,000	29,000	88,000	95,000
Activities not adequately defined	673	267	940	186	48	234	-	-	-	
Total	171,446	44,130	215,576	186,817	67,065	253,882	265,000	141,000	406,000	437,000

Sources: Bheenick et al., 1988; CSO, 1972, 1983; MEPD (estimates).

Table 6. Population in employment by major occupational group and educational attainment, 1983.

	Age	Profess.	Admin.	Clerical	Sales	Services	Agric.	Production	Total
Ed. at 1st level	- 12	775	256	4581	8372	8246	37316	55658	115204
Ed. at 2nd level[1]	13 - 15	95	5	51	50	36	80	260	586
Ed. at 2nd level[2]	16 - 19	6922	1148	12812	6618	7776	5795	21166	62207
Ed. at 3rd level[1]	19 - 22	4978	737	884	277	184	115	450	5625
Ed. at 3rd level[2]	postgrad.	814	105	49	15	6	8	14	1011
Total		13584	2251	18377	15332	16248	43314	77557	186663

Source: Population and Housing Census, 1983.

Table 7. Percentage of population in employment by major occupational group and educational attainment, 1983.

	Age	Profess.	Admin.	Clerical	Sales	Services	Agric.	Product.
Ed. at 1st level	- 12	5.71	11.37	24.93	54.60	50.75	86.15	71.76
Ed. at 2nd level[1]	13 - 15	0.70	0.22	0.28	0.33	0.22	0.18	0.35
Ed. at 2nd level[2]	16 - 19	50.96	51.00	69.72	43.16	47.86	13.38	27.29
Ed. at 3rd level[1]	19 - 22	36.65	32.74	4.81	1.81	1.13	0.27	0.58
Ed. at 3rd level[2]	postgrad.	5.99	4.66	0.27	0.10	0.04	0.02	0.02
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Population and Housing Census, 1983.

Table 8. Percentage of population in employment by major industrial division and educational attainment, 1983.

	Agric.	Mining	Manufact.	Elect.	Const.	Whole.	Transport	Finan.	Other services	Other activities
Ed. at 1st level [- 12]	98.38	97.59	67.48	14.39	24.30	45.35	7.60	2.68	49.01	60.98
Ed. at 2nd level[1] [13-15]	0.02	0.00	0.39	0.00	0.40	0.21	0.29	0.19	0.29	0.00
Ed. at 2nd level[2] [16-19]	1.51	2.41	31.62	81.82	70.52	52.53	86.37	89.46	41.67	39.02
Ed. at 3rd level[1] [19-22]	0.08	0.00	0.48	3.79	4.78	1.79	5.45	7.17	8.24	0.00
Ed. at 3rd level[2] [postgrad.]	0.01	0.00	0.04	0.00	0.00	0.11	0.29	0.50	0.80	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Population and Housing Census, 1983.

600 to 1,000 leave Mauritius to study and the output of the University of Mauritius stands around 500. But the return in-flows are more difficult to quantify. When assessing graduate requirements one has to take into account the upgrading of jobs and the resultant replacement of non-graduates by graduates. This skill-intensification of many jobs is a universal phenomenon experienced by even many developed countries.

As regards technology and technical areas, however, Mauritius will continue to be besieged by a major skill-shortage. The Mauritian education system which apes the British system flounders on the same slippery grounds. The marriage between academic and technical education has been weak, with academic education -- within the over-powering formal system -- bearing down on its technical partner. Attempts at strengthening the latter by building a separate edifice may prove to be equally disastrous. What is required is a strong but diversified curriculum within the formal system with adequate attention being paid to academic subjects (mathematics and one language being essential for all). The introduction of a mixed system within both the formal education system and the training system will only duplicate the mistakes.

Any form of employer-led structure driven by market forces should complement the formal education system and not try to take it over. The role of the technical training structure is to provide the broad network of learning facilities to enable drop-outs and the go-aheads to keep up with changes in technology. Training and recycling of workers will claim important dimensions as Mauritian industrialists attempt to keep up with their competitors abroad.

Technology

As explained in earlier paragraphs, Mauritius has exhausted its pool of latent labor that it had in the 1980s, mainly arising from the influx of female labor in the market. Female participation rates rose to over 30% in 1988. The labor force will continue to grow because of the past high fertility rates and the continued increase in female participation rates. Conditions being favorable, these rates could reach those prevailing in the NICs (over 50%). Even under the most favorable conditions, the tight-labor market situation will persist.

To-day's world is dominated by "technological determinism" in which technology itself determines the path of both employment and the skill needs of workers. The role of the policy planner is, therefore, to ensure that technologies are adopted which would match the skill levels of the labor force, at least in the short-term, until adjustments can be made to raise skill levels. The continued success of Mauritius depends on its ability to move into higher value-added operations. At present the majority of labor in the EPZ create only about Rs. 14,000 each per year. By improving technology within the sector, the output per worker could increase. A better understanding of technological developments within the industrial sector is important so as to initiate movement into higher technological areas. A technological/skill/occupational study of the EPZ sector would be a starting point.

Sustainable Development

Finally, no development is worthwhile unless it can be sustained. In Mauritius, sustainable development has to take into account not only the population, labor force aspects, but also energy and environment. The implications of the growth of the EPZ or specific sectors in it on both energy and environment are important. To date, these have not been the deciding criteria for the development of these sectors. The IIASA model is interesting because the different facets manpower projections, employment creation, educational requirements, and technological developments can be coordinated with energy and environment variables. More detailed studies are required on the different technological options as well as on both the environment and the energy requirements. But once the conceptual framework is provided for working on these options, detailed studies can be undertaken by the Mauritian side. We are indeed appreciative of the interest shown by IIASA in Mauritius. We have, however, to move ahead quickly to apply the theoretical models to real life before we are overtaken by events in the international industrial scene.

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PART III.

ECONOMIC DEVELOPMENT AND ENVIRONMENTAL IMPACTS

Chapter 11

AN ECONOMIC AND SOCIAL PROFILE OF MAURITIUS: A SHORT OVERVIEW

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The island of Mauritius has attained a relatively high level of economic development, to the extent of attracting international interest and attention despite its smallness, its limited natural resources and remoteness. Within a short span of time, it has transformed itself from the status of a little known underdeveloped country into the status of a middle-income earning group of nations, and has secured a niche among the enviable newly industrialized countries (NIC) - a case of developmental precociousness, with the associated, at times, inordinate adulation, high expectations and adjustment problems?

The critical question that must be asked is whether the island can sustain this momentum of economic development and at what costs both in the short and long term, let alone improving its performance, thereby unquestionably earning a place in the ranks of the Southeast Asian "Tigers." The World Bank, in its stocktaking assessment report on the Mauritian economy extolled the virtues of sound and sensible economic policies being pursued by the country, hailing it as a paradigm for developing nations (World Bank, 1989). Prudence and pragmatism have been credited to be the enduring stock-in-trade of those at the helm of government, notwithstanding the periodic shifts, alliances and ruling party permutations. But for all its merits, the Mauritian economy remains fragile and vulnerable. Ways must be sought and explored so that the country can, after making a careful analysis of its weaknesses and threats, capitalise on its strengths and opportunities.

1. NATURE OF THE MAURITIAN ECONOMY

Mauritius has always pursued an outward and liberal approach in its economic strategy. The years preceding and following political independence (1964-72) were characterized by flaccid and mediocre economic performance, the annual rate of economic growth registering 1.8%. The import substitution strategy of the mid-1960s ran into an impasse. Natural resources had reached their limit of exploitability; the realization that the main economic asset available was the abundance of predominantly young literate and cheap labor came to the fore. The potential for utilizing and capitalizing on this resource looked real and obvious.

Sugar cane production constituted the principal economic activity and accounted for over 30% of the GDP and 85% of total exports in 1968. The small private manufacturing sector catering overwhelmingly for the home market contributed a meager 12% of the GDP.[1] The way out of the economic morass and developmental malaise lay in aggressive export-led industrialization. The passing of the 1970 EPZ Act with the package of incentives extended to foreign investors paved the way for employment creation on a major scale and the revitalization of the economy. The preferential access of Mauritian goods to the EEC market under the Lome Convention[2] placed the country in a privileged position to attract foreign investors.

Agriculture, however, primarily sugar production remained the backbone of the economy. The production of sugar had to be maintained at a sufficiently high level to meet quota obligations. On the agricultural front, various measures of diversification into non-sugar activities were initiated (such as livestock breeding, fishing and floriculture). Over the period 1971-79 GDP increased sixfold from Rs 993 million to Rs 6,000 million.

However, the fillip that the economy received from the industrialization drive and diversification effort soon fizzled out. The textile sector suffered major setbacks in the late 1970s owing to both domestic and external causes. At the domestic level, competitiveness of the textile sector was dented due to wage rises prompted by trade union pressure and also as a result of government redistribution policies. Externally, events did not augur well: the onset of recession in the wake of the 1973 and 1982 oil price rises; protectionism among the industrialized nations (export share of sugar to U.S. dropped from approximately 129,000 tons in 1979 to 27,000 tons in 1983); collapse of sugar price and mounting competition from other countries. Excess demand, unfavorable climatic conditions, reduced domestic and private investment, substantial debt service obligations (debt ratio having risen to nearly 10% in 1979 from 1% in 1976), steep import prices, decline in tourism and soaring unemployment (25%) constituted additional adverse factors.

The level of foreign exchange reserves of the Bank of Mauritius dropped to a level equivalent to only a few days of imports. Consequently, Mauritius had to embark on an economic and fiscal stabilization program in 1979 with the support of the IMF and later on a structural adjustment program with the support of the World Bank.

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[1]GDP here and elsewhere in the paper will be expressed in terms of factor cost.

[2]A convention between the European Economic Community and the African, Caribbean and Pacific (ACP) countries, signed at Lome on 28 February 1975, allowed for free access to about 99.2% of all the imports from the ACP countries. The EEC-ACP convention, destined to last for five years and renewable for further periods, was expected to constitute the largest free trade zone in the world.

Other measures included reduction in public and private expenditure; more positive redirection of investments into private sectors; efficiency drive in major public sectors; bolstering export; scaling down subsidies on items of consumption; check on food, and energy imports. Both monetary and fiscal policies were geared to correct the imbalance in the economy. The Bank of Mauritius pursued a flexible exchange rate policy with a view to maintaining the competitiveness and profitability of the sugar sector.

These measures culminated in dramatic growth in the economy, in employment generation and the resultant increase in living standards. By 1987, per capita income had nearly doubled to Rs 17,300. GDP over the 1984-88 period rose by 25% (see Figure 1). The labor force grew from 282,000 in 1983 to 406,000 in 1987, the unemployment level dropped to 5%, the sugar yield attained the second best ever recorded level of 706,000 tons, tourism expanded considerably from 131,670 in 1984 to 207,570 in 1987 representing an increase in tourist earnings of 170%. During this period domestic savings and investment remained constant at about 16% of GDP, whilst the fiscal balance of payments indicated a surplus. The favorable upturn in the economy was undoubtedly helped by the decline and stabilization in the population growth to around 1.5% annually by the early 1970s, from 3% annual growth in the 1950s and early 1960s, due largely to earnest family planning.

Exports

Over the 1984-89 period, total export grew at a yearly average of 25%. In 1989 the EPZ sector grew by 10% only against 25% in 1988 with the result that net earnings from this sector declined from 30.1% in 1987-88 to about 21% in 1989. It is to be noted that exports remained confined to Europe and the U.S. overwhelmingly, accounting for 90% of total exports in 1989.

Imports

The sharp rise of 25% in imports was attributed to the expanding need of the EPZ in terms of raw materials, machinery and equipment and the propensity for the consumption of imported luxury goods in a period of prosperity (with the exception of 1986 when the balance of trade was positive by Rs 214 million; in the 1984-89 period, imports consistently exceeded exports by about Rs 1 billion). Most of the energy and food requirements were imported accounting for 20 of export earnings in 1987: freight and insurance costs being additional adverse factors.

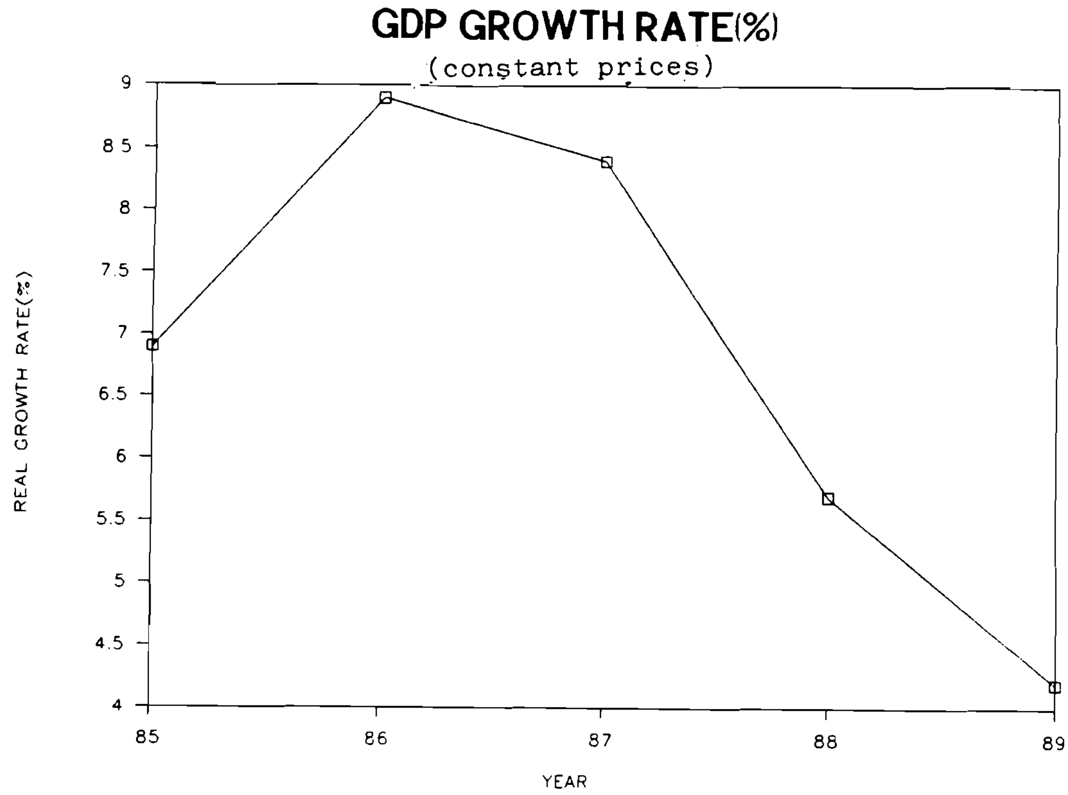

Figure 1. GDP growth rates in Mauritius, 1985-1989. Source: Central Statistical Office (CSO), 1990.

2. MAIN SECTORS OF THE ECONOMY UP TO 1987

Manufacturing

With the relaunching of the EPZ sector and the orientation towards quality, the industrial sector had surpassed the agricultural sector in terms of gross foreign exchange earnings for the first time. In 1987 EPZ alone constituted 54% of export earning; 88.7% of employment pertained to the industrial sector.

Agriculture

In its long-standing role as the backbone of the economy, sugar (an important employment sector in rural areas) retained its pride of place particularly in view of the guaranteed access to EEC markets and to a lesser extent the U.S., at a remunerative price. It also registered higher domestic value added generated; its net earnings exceeding the EPZ sector threefold since the import content of the latter amounted to over 70%. However, under existing conditions, sugar production can only attain an optimum output of around 700,000 tons in any single year.

Tourism

This sector recorded significant growth attributable to a marked expansion in international travel, improved air access (the national carrier expanding its fleet and extending joint venture flights with major airlines); increases in hotel and bed capacity, and an improved service sector. The Mauritius Government Tourist Office had been particularly vigorous in its promotion campaign, reflected in the 14% annual growth in visitors to the island over the 1984-87 period (from 139,670 to 207,560). Over this period foreign earnings in this sector rose by 180% (expenditure per tourist at current prices jumping from Rs 4,500 in 1984 to approximately Rs 8,600 in 1987).

In summary, one can say for the period 1984-87, that with a buoyant economy and rapidly expanding manufacturing sector (see Table 1), careful fiscal management, two chief positive benefits stand out. First, a marked decline in unemployment from 20% in 1983 to 9% in 1987. Second, inflation rate dropped from 42% in 1980 to 5.6% in 1983 and 0.6% in 1987 (see Figure 2). Price stability was ensured by a reduction of duties on selected consumer goods and favorable prices of import fuel and food items. Balance of payments in 1985 showed a surplus of Rs 258 million, continuing in the positive direction with a surplus of Rs 715 million in 1986 and Rs 2,788 million in 1987 (see Figure 3). The healthy balance of payments meant much reduced dependence on foreign loans, debt ratio falling substantially from 25.4% in 1985 to 13.2% in 1986 and 12% in 1987.

Table 1. Structural change in the economy.

Sector	1976	1986	1987
Agriculture	34.8	21.0	18.9
Industry	21.6	38.3	42.6
Services	43.6	40.7	38.5
Total	100	100	100

Source: Ministry of Economic Planning and Development (1989).

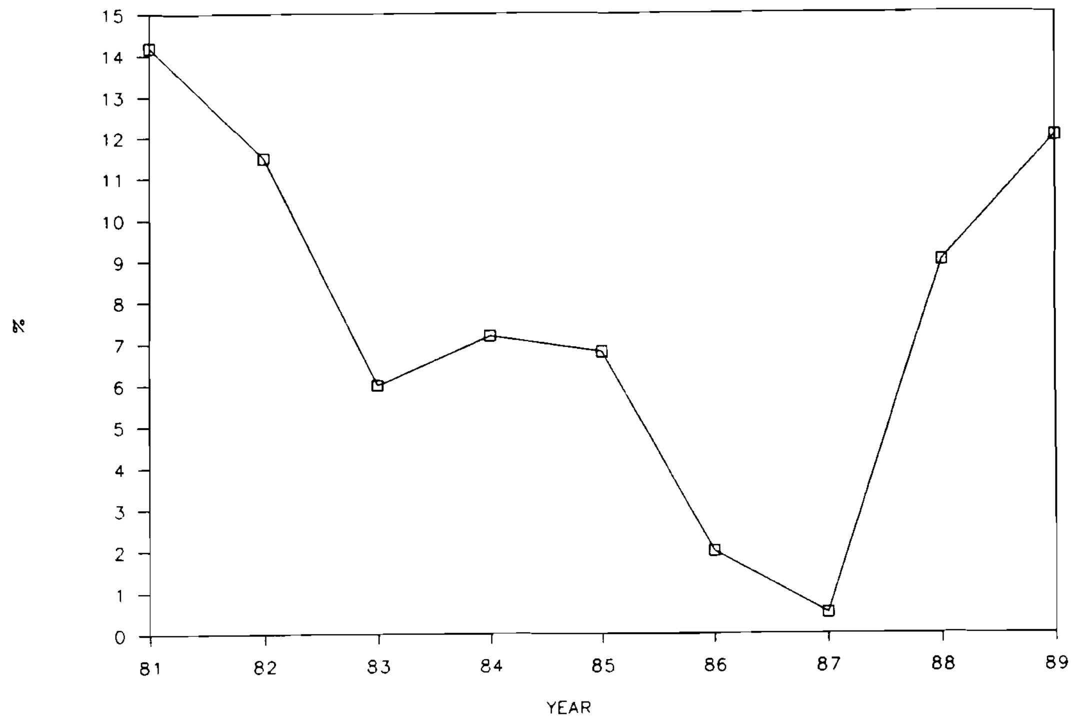

Figure 2. Inflation rates in Mauritius, 1981-1989. Source: CSO, 1990.

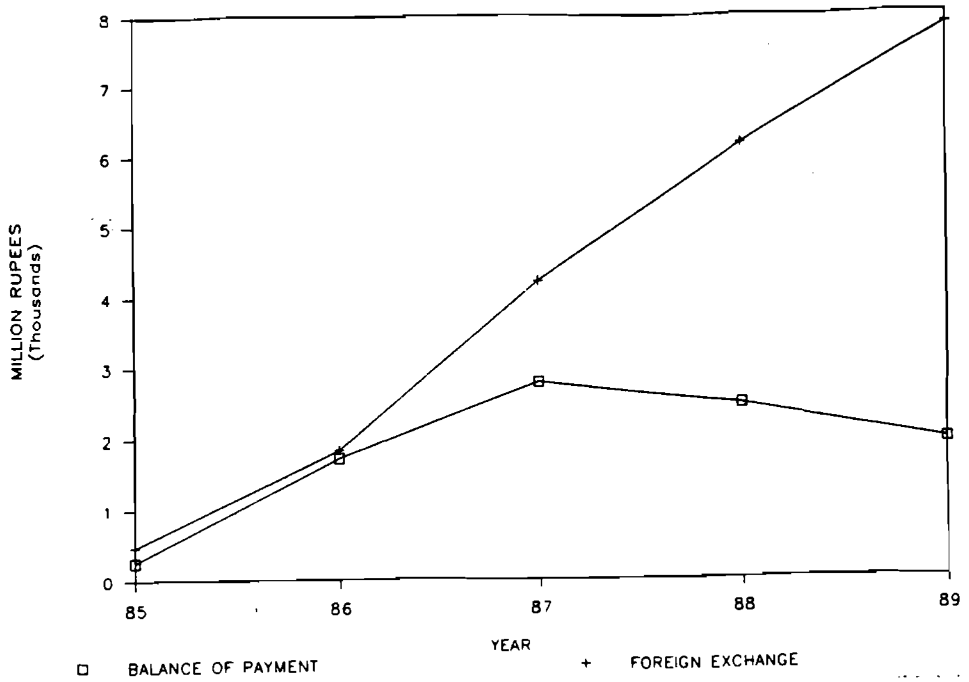

Figure 3. Trade balance in Mauritius, 1985-1989. Source: CSO, 1990.

3. THE ECONOMY IN 1988-89

The economy slowed down in 1988 and 1989 with growth rates of 5.8% as compared with higher rates in the preceding three years. This deceleration in the economy was deemed necessary because the economy had reached full employment and was constrained by capacity limitations. Therefore a reduction in growth would cut down aggregate demand (expenditure) and ensure that sustained growth would be attained in a non-inflationary manner.

Consumption

An increase of 6% in volume terms was recorded in 1989, pushed up by the high inflation rate of around 12%. Expenditure on foods and services by households amounted to Rs 20,900 million, by government Rs 3,850 million. An increase of 4 percentage points (to 79%) was the recorded ratio of consumption expenditure to GDP (at market prices) indicating a drop in savings to 21% from 25.5% the previous year.

Investment

There was an increase of 25% over 1988 in nominal terms (exclusive of aircraft acquisition, 8.5% in volume terms). Rs 4,115 million was invested for the purchase of machinery and transport equipment; construction activities represented nearly half the total (residential buildings estimated at Rs 1,470 million - 20% growth rate; non-residential buildings 16%; others 6%).

Outlook

In spite of the slowing down in economic activity during the preceding two years, the economy is projected to grow at 6% in 1990 due to better performance of the sugar sector. However, the escalating Gulf crisis is likely to cause havoc to the economy on a significant scale. The way forward for Mauritius lies in further venturing out into viable industrial diversification. The manufacture of leather products, jewelry and electronics, for example, hold attractive prospects and possibilities. A progressive and planned shift from labor intensive to capital intensive production is both desirable and inevitable to overcome the labor shortage problem of a fully employed economy and to aim at high quality, high volume and low unit cost products. Human resource development programs must be set in motion as a priority measure if Mauritius is to make a success of its second phase of industrialization.

In conclusion, characteristic of the periodic crisis-recovery cycle, Mauritius would presently appear to be again at a critical juncture (inducing a feeling of déja-vu?). The early spectacular economic growth rate seems to have been tapering off lately. There are constraints, both emergent and residual or structural in character.

A tight labor market situation tends to create wage pressure, inflexibility, and also imbalance and instability between the private and public sectors. A dire shortage of labor is reported in the agricultural sector where employment is typically seasonal. There is also a significant shortage of technically skilled labor, and manpower scarcity in managerial and professional occupations. The Human Resource Development program currently being launched to enhance labor productivity, is much called for but not timely enough.

Fresh economic policy measures have been embarked upon to perk up the economy. The World Bank in its latest report recommended further liberalization of the financial system. The government has responded positively in this regard. The introduction of the Stock Exchange, off-shore banking and various saving schemes are attempts to remove financial inflexibility and fortify the economy further.

4. AN OUTLINE OF THE SOCIAL PROFILE

This section begins with a few basic social indicators (Tables 2, 3, and 4) and then broadens out to a consideration of the important changes in the social structure of Mauritius in recent years, with a visualization of probable implications given the persistence of present trends. An objective assessment of the impact of economic development and modernization on the Mauritian society is the first step in the positing of more attractive and viable alternatives.

Table 2. Life expectancy at birth.

	1972	1983	1987
Male	61	64	64
Female	66	71	72

The population had been predicted to grow at the rate of 0.58% per annum over the 1987-1992 period to reach a level of 1,011,000.

Table 3. Labor force by major employment sectors.

	1972	1983	1987
Agriculture	32.8	24.8	20.7
Manufacturing	13.5	28.7	49.6
Services	24.9	25.4	21.7

Table 4. Labor force participation rate(%).

	1982	1983	1987	1990
Male	83	80	82	82
Female	20	28	42	44

Present unemployment rate based on registered unemployed: 5%. There has been a phenomenal expansion in female employment with industrial development, but, still trails far behind male participation rate. Most of the expansion has occurred in the textile and service sectors. Given the expansion in the service sector including the professional and administrative cadres and the likely shortage of labor, there exists a large pool of untapped potential human resource. The current drive in human resource development aims precisely to address this issue. But the time lag, before effective action is taken, can be critical.

Education

Primary. Universal primary education became available during the early 1960s. Primary schools numbered 273 in 1987, for a pupil population of 138,000; teacher ratio 22; enrolment ratio 89%.

Secondary. Secondary education became free in 1977 and numbered 123 in 1987 for a pupil population of 70,000 (44 state, 101 private); teacher ratio 19; enrolment 50%. Although there has been a sharp increase in participation rate from the 30% in 1970 to 50% in 1987 (most probably due to fees being abolished in 1977), there is still a considerable premature dropping out of the school system. The failure rate at the end of the primary cycle being excessive may be a determining factor.

Post-secondary. Various vocational and technical training institutions are in existence for the non-academically oriented. Lack of adequate training in technical skills has been highlighted as a developmental stumbling block.

Higher education. Students wanting to pursue higher education can either go abroad or study at the University of Mauritius which became non-fee paying in 1988. The University has expanded its intake capacity with the creation of new faculties. Student enrolment increased from 850 in 1987 to 1400 in 1990.

Health

A new 180 bed regional hospital (the Jawarharlall Nehru Hospital) is in the process of completion in the south of the island; 9 additional primary health care centers are also planned. Pressure on health provision rises due to increases in industrial accidents, road traffic casualties and rise in stress-related diseases particularly cardiovascular diseases. Table 5 shows some basic data on health services.

Table 5. Health services in Mauritius.

No. of hospitals	1983	1986	1987
Public	11	11	11
Private	9	9	9
Doctor/Patient ratio per 1,000 persons	27.0	71.4	79.8
Nurse/midwife ratio per 1,000 persons	143	234.6	224.9
Hospital bed ratio per 1,000 persons	238	291.7	284.6

Housing

The premium on land due to high demand and ownership concentration and the prohibitive costs of building materials will mean in all probability less and less owner occupation over time. Table 6 shows some basic data on housing conditions.

Table 6. Housing conditions in Mauritius.

	1972	1983	1987
Percent owner occupied	52	66	N/A
Percent with electricity	70	93	100
Percent with piped water	99	99	98
Percent with telephone	13	24	31

5. STRUCTURAL CHANGE IN THE MAURITIAN SOCIETY

Mauritius, the multicultural and multiethnic mosaic, has undergone definite shifts and modifications in its social structure. These social changes stem partly from recent industrialization and economic development. New lifestyles and tastes, patterns of consumption, leisure pursuits, changing aspirations can be readily associated with affluence, more conspicuous with new-found wealth. In other cases, changes have been continuous and cumulative. The spread of universal education and mass media at an early stage has facilitated receptivity to influences and ideas stimulating awareness of opportunities and options. In Mauritius, population growth slowed down dramatically and stabilized prior to rapid economic development, albeit prompted by social policy imperatives and a national consciousness sensitized to the dangers of uncontrolled population growth. The relatively well-developed social infrastructural facilities undoubtedly played a key role in striking a responsive chord amongst the relevant sections of the population.

A relatively well-educated female population was better able to think independently, make personal choices as regards education, career decisions, marriage, and family size. Indeed, the marked expansion in female labor consequent upon industrial development proves the point. Female employment on a large scale in Mauritius has set in train complex sociological transformations in the family, particularly of the traditional type. Whilst the microsociological implications here have yet to be explored and analyzed, there is evidence of growing strain and tension within marital relationships, due to the withering away of traditional lines of responsibility and authority. Role conflict is likely to be more pronounced in the early stages with a sudden shift from sex-segregated roles (with clear division and demarcation of labor in the household), to a more joint conjugal (greater partnership and sharing of roles). This would be more evident with the decline of the mutually supportive extended family system.

Whilst female employment and emancipation have gone a long way towards the democratization of the family unit, in practice many working women in Mauritius are subjected to a considerable degree of role strain in having to combine paid employment and domestic responsibilities. The greatest expansion in female labor has occurred in the EPZ sector where the hours of work are irregular (with mixed, alternating day and night shifts) and the work quite arduous. At present, no free nursery facilities exist and that would appear to be an urgent priority. Planned parenthood perforce becomes a preferred option as a means of maximizing material well-being and avoiding economic marginalization. Economic circumstances, therefore, clearly impose constraints on family building patterns.

Family Nuclearization

Small nuclear-type families constituting husband, wife and children in many configurations are becoming common in Mauritius. The scale of this trend needs to be studied. While it is not clear whether the explanation lies in the conventional but controversial, even often discredited theory suggesting a logical "fit" between the nuclear family and industrialization, it has already been observed that with the dissolution of the extended family system on a significant scale, there will follow a marked attenuation of long-standing networks of kinship support systems serving not only utilitarian functions but also as socialization and social control agencies. It is certainly a moot point to consider the association between family nuclearization fostered by secular values of rabid individualism and privatization (ultimately culminating in the anonymous and impersonal society) and the anomic-induced social pathologies preponderant in towns and cities universally.

Significantly with the proportion of the population below 15 declining (from 32.3% in 1983 to 28.9% in 1990) and the proportion of the population aged 65 and over increasing from 4.5% in 1983 to 5.3% in 1990 and predicted to increase later, the prospect of large numbers of elderly without traditional family support is disturbing. Unlike in the more mature and advanced societies, state provision for the elderly in Mauritius is not sufficiently developed and would warrant serious policy consideration.

6. ECONOMIC DEVELOPMENT AND SOCIAL PROBLEMS IN MAURITIUS

Economic development brings in its train both desirable and undesirable consequences. Conventional economic indices do not quite easily capture the scale of hidden costs and injuries entailed which consequently does not figure high on the policy agenda until it reaches crisis proportions. Statistics on social pathologies require careful interpretation in any society. Improvements in detection and reporting could account for increases. Nevertheless, lower social visibility in urban settings, for instance, the combination of a more liberated, self-assertive and expressive youth and the decline of traditional authority could quite conceivably encourage deviant behavior. Increasing rates have been noted in the following areas:

- Criminality and juvenile delinquency
- Drug abuse
- Divorce rates
- Suicides
- Stress-related illnesses
- Employment instability and high labor turnover
- Increase in population density
- Road accidents
- Environmental degradation
- Relative deprivation
- Concentration of property and land ownership.

Precise social indicators are needed to reliably and objectively gauge the adverse effects of various socio-economic variables on the "quality of life." The National Development Plan 1988-90 is currently committed to this end. Moreover, an internationally initiated study, with the collaboration of the University of Mauritius, has been proposed, to understand the impact of tourism on the Mauritian society. It is conceded, that for the sake of long-term sustainability, the social fabric cannot be allowed to degenerate further. Economic development is predicated upon social and economic stability.

7. SOCIAL STABILITY AND LONG TERM SUSTAINABILITY

Theoretical debates may rage interminably as to the degree to which strains and tensions in the social system are either functional or dysfunctional. In any event, the benefits of dialectics in the evolution of societies and, hence, social progress, cannot be denied. There is, nevertheless, a desired degree of social equilibrium - more so in an emergent, modernizing nation, anxious to avoid disruptions and discontinuities in its economic development.

With the exception of a brief but disturbing episode of intercommunal strife during the late 1960s, Mauritius has not known overt social conflict on a significant scale, arising from religious or racial differences. In a small, geographically self-contained, pluricultural and multi-ethnic society such as Mauritius, the premium placed on peaceful coexistence is understandably very high. The confluence of diverse traditions and cultures (Eastern and Western) has been a source of strength. And the welding of these disparate cultural elements in the forging of a national consciousness and identity without compromising on traditional purity and distinctness, is a perpetual challenge. But, however emblematic of a microcosmic instance of unity in diversity Mauritius may be, social stability based on intercommunal coexistence cannot be taken for granted.

In open, liberal democratic societies, the maintenance of social consensus depends on delicate political skills of balanced interest representation and allocation. This task becomes invidious and problematic when competition for scarce resources turns acute and the distribution of power patently and perversely unequal. An enlightened, informed and politically discriminating citizenry becomes increasingly intolerant of and cynical about state subterfuge. As the traditional values of a more community based society gives way to secular utilitarian values of an associational society, individualistic ethic gains ascendancy. While the individualistic ethic is not an entirely bad thing, in its most strident form, it produces the virulent social malcontent or misfit, placing individual self-interest above group and collective well-being.

In Mauritius, indeed as elsewhere, sustainable development depends on a new social value orientation displacing the cruder values of a free market economy, whilst avoiding simple-minded, facile and naive alternative systems. Indeed the tyranny of affluence, in a just and caring society, cannot be allowed to lead to blind indifference to destitution. It can be fairly reasonably asserted that the preservation of social stability, will be of critical concern in the Mauritian context, given the ostensible shift to a consumerist and self-seeking mentality and outlook on life. There is evidently a widespread recognition at the level of the policy, of the growing scale of relative deprivation in spite of the salutary redistributive measures on the part of the State. Contrary to the official commitment to create an economically successful but also a compassionate and egalitarian social system, deprivation and inequality do not appear to be receding.

Deprivation does not only consist of material exiguity but also the absence of a balanced lifestyle. An increasingly affluent society also becomes a leisure oriented society. Indeed, the stresses and strains of an industrial lifestyle render healthy diversion and recreation most imperative. The option to travel abroad for disportment and adventure is open to everyone but not within the means of all. And for the vast majority who have to seek leisure pursuits locally, there are limited outlets. Due to extensive coastal tourist development, seaside resorts for ordinary Mauritians have dwindled over the years. Besides, these resorts are not properly organized and managed for leisure purposes. A concerted national effort must go into creating attractive leisure complexes with all th associated amenities.

A great deal of deprivation can be alleviated by careful environmental management. Indeed, the vigorous promotion of a healthy lifestyle must be seriously entertained in order to reduce the alarming toll of morbidity and mortality associated with unhealthy diet and lack of exercise, no doubt exacerbated by lack of leisure pursuits and stressful living in a rapidly modernizing society. It is becoming increasingly apparent that Mauritians tend to manifest the typical disease patterns of Western nations. Much hope lies in the ability of the state to bridge the fulfillment-frustration gap (growing wider with the revolution of rising expectations), maintain social consensus and harmony, and avoid legitimation crises. The bedrock of the traditional values of compromise, mutuality and coexistence must be preserved and nurtured to enhance resilience and adjustment during crises and privations (which a vulnerable, albeit virile economy is prone to periodically).

8. CONCLUDING REMARKS

The sobering lesson that is to be learnt today is that in the societal development paradigm, nothing is ineluctable or inexorable. Late developers may benefit from selecting the mode and tempo of modernization and not have to replicate the original transition. At the same time, developmental leapfrogging has its own peculiar implications. Of all the constraining factors, economic growth undoubtedly figures most prominently - without it, social progress is a chimera. Nevertheless, economic growth per se does not presuppose social development and progress. Classical and neoclassical economic theorists have been wrong in reducing human well-being to monetary indices and blithely assuming that social betterment unfailingly glows from economic growth.

Mauritius may be illustrative both of the adverse social consequences of economic growth at any cost, albeit a realistic imperative at times and, more importantly, of the possibilities of tempering economic development with social justice and quality of life improvement efforts. In Mauritius, investment in human resource development and social infrastructure had paid off handsomely, enhancing the shock absorbing capacity and resilience of the people to better cope with the vicissitudes of economic fortunes. Recent economic history has shown that firstly, pure market forces neither really exist nor are practicable and, secondly, that unmitigated state dirigisme is self-defeating and implausible. Pluralistic political pragmatism, in combining elements of both, carries greater promise - as has been the case in Mauritius as well as in a number of other instances. While we may yet have to wait for Daniel Bell's post-industrial end of ideology (Bell, 1960), orthodoxy (political and economic, at any rate) has long been in decline - in the liberal, enlightened and dynamic world - to the chagrin of inveterate ideologists and dogmatists.

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Chapter 12

LABOR INTENSIVE VERSUS TECHNOLOGY INTENSIVE PRODUCTION IN NEWLY INDUSTRIALIZING COUNTRIES

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During the first half of the 1960s, a couple of Third World countries and some less developed European countries began to follow outward-looking growth policies by promoting exports manufactured by local companies as well as trying to attract foreign capital for export production, e.g. by establishing Export Processing Zones (EPZs). Their great advantage was cheap labor, but the labor force was largely unskilled due to the low level of economic development. Therefore exports were concentrated on products which required a relatively large number of unskilled workers, such as textiles and clothing, leather goods and footwear, wood and cork articles, electrical machinery including electronics, simple manufactures of metals, and miscellaneous finished products (e.g. toys and sporting goods). The production processes in these industries are fairly standardized and technologies are generally accessible.

1. EMERGENCE OF THE NEWLY INDUSTRIALIZING COUNTRIES

Between 1963 and 1974, the share in OECD imports of manufactured goods of the six export-oriented Third World countries (Hong Kong, Singapore, Korea, Taiwan, Brazil and Mexico) rose from 1.5% to 4.6%. If the four European low-income countries (Greece, Portugal, Spain and Yugoslavia) were included, this share would rise from 2.6% to 7.9%, respectively (see Table 1). The bulk of exports in both cases belong to one or the other of the aforementioned product groups.

Certainly, the high growth rates of private consumption and rising wage rates in industrialized countries, due to the long-lasting economic upswing, facilitated export expansion of the developing countries during this period. The situation changed when growth rates slowed down significantly after the first oil crisis of 1973, and rates of unemployment went up dramatically in the industrialized countries. Demand slackened and protective measures were introduced, in particular non-tariff barriers to trade, especially to reduce imports of labor intensive products from non-OECD countries. This was the first time when social scientists and researchers became particularly interested in the subject. They established the term "newly industrializing countries" (NICs) for countries which, differences apart, "are characterized by a fast growth of the level and distribution of industrial employment, an enlargement of export market shares in manufactures and a rapid relative reduction in the real per capita income gap separating them from the advanced industrial countries" (OECD, 1979, p. 6).[1] The theory of comparative advantage (applied to production factors) and the theory of the product cycle were used together to explain theoretically the observed process of industrialization in the NICs.

Table 1. Total OECD imports of manufactured products[1)] in selected years.

Percentage shares					
	1963	1970	1975	1980	1985
United States	17.1	16.4	14.5	13.0	13.0
Japan	4.2	7.1	7.2	8.8	13.1
France	7.8	7.3	8.3	8.2	6.5
Germany	20.8	18.8	18.1	17.1	14.8
Italy	5.5	6.3	6.5	6.8	5.8
United Kingdom	10.5	8.1	6.9	8.8	5.5
OECD NICs[2)]	0.8	1.1	1.8	2.5	2.2
Brazil, Mexico	0.3	0.5	0.9	1.1	2.0
Far Eastern NICs[3)]	1.2	2.5	3.7	5.4	7.5
NICs 6[4)]	1.5	3.0	4.6	6.5	9.5
Total NICs[5)]	2.6	4.4	7.9	9.0	12.1

1) SITC 5+6 - 68 + 7 + 8
2) Greece, Portugal, Spain, Yugoslavia
3) Hong Kong, Singapore, Korea, Taiwan
4) Far Eastern NICs + Brazil and Mexico
5) Far Eastern NICs + Brazil and Mexico and OECD NICs

SITC: Standard International Trade Classification
NICs: Newly Industrializing Countries
OECD: Organization for Economic Cooperation and Development

Source: After Urban, 1987, Table 2.

[1]A commonly used quantitative definition was given by Bela Balassa: a developing country was considered a NIC if the share of industry in GDP exceeded 25% and the share of manufactures in export was more than 50% (see Balassa et al., 1981).

In the mid-1970s, the NICs started to broaden their industrial base and diversify exports because of rising protectionism against their traditional exports as well as their higher level of industrialization. Korea, for example, shifted the emphasis to the development of heavy industries: steel, non-ferrous metals, chemicals, petrochemicals, machinery and shipbuilding as well as construction.[2] Efforts were also put into moving from consumer electronics to more sophisticated electronics production. At the end of the 1970s, car production also became important. Taiwan started major infrastructure projects in order to support her industry which was hard hit by the 1973-74 oil crisis. They ranged from the construction of transport networks to the establishment of public enterprises in basic industries (steel, cement, aluminum, petrochemicals, etc.). Moreover, the government promoted the development of capital goods industries: machinery and associated equipment soon became a new, important export industry.

A note has to be made with regard to the special role the electronics industry has been playing for the NICs. Because of rising labor costs at home, Japan had already started to transfer simple electric production and assembly of electronic equipment to the surrounding low-wage countries in the early 1970s. American and European companies followed suit, so that the NICs and, above all, the Asian countries already at an early stage of industrialization became acquainted with a field of production that turned out to be very dynamic, not only in terms of output, but also in technological development. In 1973, "telecommunications and sound recording apparatus" (SITC rev.2, 76) already made up 10% of OECD imports from the non-OECD NICs. It was the third largest group of products after clothing 26.9% (SITC rev.2, 84), and textiles 10.7% (SITC rev.2, 65), immediately followed by "electrical machinery, apparatus and appliances n.e.s." (SITC rev.2, 77) which had a share of 9.3% (see Table 2).

[2]Special emphasis was put on "upstream activities" and, in fact, the export of textile machinery soon successfully complemented the export of textile products (OECD 1988, p. 8).

Table 2. OECD imports of manufactures from NICs.

Product (SITC rev. 2)	Value (thousand US dollars) 1964	1973	1985	Percentage share 1964	1973	1985
SITC 51 Organic chemicals	17,045	66,539	1,215,918	1.86	0.60	1.54
SITC 52 Inorganic chemicals	10,480	36,892	292,067	1.14	0.33	0.37
SITC 53 Dyeing, tanning and coloring materials	463	4,782	68,517	0.05	0.04	0.09
SITC 54 Medicinal and pharmaceutical products	12,324	42,914	230,296	1.34	0.39	0.29
SITC 55 Essential oils and perfume materials; toilet-cleansing materials	12,434	42,139	127,095	1.36	0.38	0.16
SITC 56 Fertilizers, manufactured	222	7,643	13,039	0.02	0.07	0.02
SITC 57 Explosives and pyrotechnic products	542	6,664	19,502	0.06	0.06	0.02
SITC 58 Artificial resins, plastic materials, cellulose esters/ethers	1,786	26,142	574,788	0.19	0.24	0.73
SITC 59 Chemical materials and products, n.e.s.	7,004	21.063	208,604	0.76	0.19	0.26
SITC 61 Leather, leather manufactures, n.e.s. and dressed fur skins	5,061	66,430	412,826	0.55	0.60	0.52
SITC 62 Rubber manufactures, n.e.s.	2,817	31,307	795,508	0.31	0.28	1.01
SITC 63 Cork and wood manufactures (excluding furniture)	51,025	747,859	936,366	5.57	6.78	1.19
SITC 64 Paper, paperboard, articles of paper, paper-pulp/board	2,060	51,069	518,227	0.22	0.46	0.66
SITC 65 Textile yarn, fabrics, made-up art. related products	161,402	1,174,232	3,090,232	17.61	10.65	3.92
SITC 66 Non-metallic mineral manufactures, n.e.s.	35,003	259,259	1,618,883	3.82	2.35	2.06
SITC 67 Iron and steel	20,083	242,360	2,792,177	2.19	2.20	3.55
SITC 69 Manufactures of metal, n.e.s.	14,824	230,575	2,972,359	1.62	2.09	3.78
SITC 71 Power generating machinery and equipment	4,940	122,296	2,508,327	0.54	1.11	3.19
SITC 72 Machinery specialized for particular industries	1,959	47,728	652,268	0.21	0.43	0.83
SITC 73 Metalworking machinery	254	7,627	343,773	0.03	0.07	0.44
SITC 74 General industrial machinery and equipment, and parts	1,575	42,133	1,627,926	0.17	0.38	2.07
SITC 75 Office machines and automatic data processing equipment	279	233,354	4,640,338	0.03	2.12	5.89
SITC 76 Telecommunications and sound recording apparatus	20,034	1,148,421	7,724,778	2.19	10.41	9.81
SITC 77 Electrical machinery, apparatus and appliances, n.e.s.	11,605	1,022,002	8,445,037	1.27	9.27	10.73
SITC 78 Road vehicles (including air cushion vehicles)	1,107	143,163	2,725,251	0.12	1.30	3.46
SITC 79 Other transport equipment	7,306	66,564	681,135	0.80	0.60	0.87
SITC 81 Sanitary, plumbing, heating and lighting fixtures	11,146	49,760	400,968	1.22	0.45	0.51
SITC 82 Furniture and parts thereof	7,451	101,484	1,440,761	0.81	0.92	1.83
SITC 83 Travel goods, handbags, and similar containers	16,058	173,334	1,613,702	1.75	1.57	2.05
SITC 84 Articles of apparel and clothing accessories	296,053	2,967,226	14,606,897	32.30	26.90	18.55
SITC 85 Footwear	32,176	487,423	5,283,055	3.51	4.42	6.71
SITC 87 Professional, scientific, and controlling instruments	2,108	33,222	610,056	0.23	0.30	0.77
SITC 88 Photographic apparatus, optical goods, watches	5,472	134,540	1,704,414	0.60	1.22	2.16
SITC 89 Miscellaneous manufactured articles, n.e.s.	141,910	1,176,193	7,837,177	18.48	10.66	9.95
SITC 5 to 8 less 68 Total Manufactures	916,496	11,028,671	78,732,212	100.00	100.00	100.00

Source: OECD, 1988, Table 2.2.

2. CHANGING TRENDS IN THE 1980s

The beginning of the 1980s marked a new phase in economic policy and development for the NICs, characterized by the promotion of technology-intensive production. Before presenting the details, a few words have to be said about the NICs as a group. By 1984, three of the so-called OECD NICs (Greece, Portugal and Spain) had joined the OECD and were therefore no longer considered as NICs, but as part of the industrialized world. Yugoslavia, already heavily in debt, ran into an economic and political crisis by 1981, which set a limit to the efforts for further economic development. A fairly similar situation prevailed in the two debt stricken Latin American NICs: Brazil and Mexico. The remaining Asian NICs (Hong Kong, Singapore, Taiwan and Korea), nicknamed "the four little tigers," aggressively began to "leap" from standard to high technology intensive production. In the meantime, other developing countries, e.g. Malaysia, Indonesia, Taiwan, Sri Lanka, Mauritius and Pakistan,[3] had started to follow outward looking growth strategies and had become successful in producing labor intensive export products.

There are several reasons why the more advanced NICs were keen to move into more technology intensive production:

1. Rising per capita income and increasing wage levels reduced international competitiveness of the "old" NICs, especially compared to the "new" NICs.
2. Increasing protectionist barriers were set up in the developed countries, especially in the low product range (e.g. textiles, clothing, consumer electronics, steel).
3. New developments in the electronics industries, e.g. integrated circuits[4] and computer based programmable automation, helped to reduce the share of labor costs in many traditionally labor intensive industries,[5] and thus reduced the comparative advantage of the NICs. In some cases, relocation of production to the industrialized countries took place.
4. Capital intensive industries (such as steel, metal, shipbuilding, and construction) promoted by the NICs in the second half of the 1970s, suffered from world wide overcapacity because of the stagnation of the world economy.

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[3]Competition in low wage products came also from India and China which are usually not designated as NICs because of their huge domestic markets.

[4]For example, small electronic calculators which used to consist of several hundred parts, now consist of 60-70 parts only, due to integrated circuits, therefore less labor is needed for assembling.

[5]In the US, the share of "blue collar costs" in manufacturing industry sank from 23% to 18% within a few years. In the textile industry, the share is already below 10% (Wall Street Journal 18/19.3.1988).

The only answer to this situation was a strengthened focus on moving up the technology ladder, both as a means of modernizing and upgrading traditional industrial activities, and of becoming more competitive internationally in high technology products vis à vis the leading industrialized countries. (Micro-electronics, renewable energies, new materials and bio-technology are considered the "core technologies" for the future.) The final goal is to increase the value added per capita as a precondition for further increase in living standards.[6] There are several means to this end which have been used to a different degree by different countries:

1. Improved training of the work force, especially of scientific personnel.

2. Increase of indigenous research and development (R&D) by direct government action, e.g. publicly funded research laboratories; financing R&D projects; and/or promotion of R&D expenditures by private companies (fiscal incentives, provision of funds, especially for venture capital, etc.).

3. Technology transfer from abroad: acquisition of patents, licenses etc.; attraction of foreign direct investment, joint ventures and other so-called new forms of investment (special licensing agreements, management contracts, turn-key projects, etc.);[7] the establishment of "technology parks" which provide a suitable infrastructure and special fiscal incentives (e.g. tax holidays) to attract foreign as well as local high-tech companies.

4. Direct investment abroad by domestic companies, i.e. the taking over or participation in foreign firms in order to "internalize" know-how.

Moreover, proper technology policy will require coordination with trade policy and an adequate macroeconomic policy. As examples of successful establishment of high-tech industries in the NICs demonstrate (e.g. the computer industry in Korea), considerable protection was given to those industries during their first phase of development allowing them to gather experience and increase productivity until they were able to compete internationally.[8] Macroeconomic policy should prevent high rates of inflation in order to guarantee sufficiently high rates of savings and investment to provide for rapid technical progress in the economy. A proper mix of income policy and monetary policy including a sound exchange rate policy will thus be required.

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[6] "If a country fails to gain market shares in the dynamic growth industries while it loses market shares due to declining competitiveness in traditional industries, all hopes for latecomer industrialization are bound to be frustrated" (Ernst and O'Connor, 1989, p. 34).

[7] see Oman, 1989.

[8] The danger of protecting an "infant industry" too long has been demonstrated by the Brazilian computer industry.

A few words have to be said about the appropriate mix of government planning and market forces as well as the right size of companies. In Korea, where industrial development has always been characterized by a high degree of state intervention in the economy, the government is now relaxing its direct control, and is giving more emphasis to the establishment of a favorable economic climate, in which private industry can expand. In Hong Kong, where the regime has been extremely liberal so far, the government has recently taken a number of measures with a view to promoting the improvement of Hong Kong's technological potential. Besides providing information and training services, it is promoting techno-economic studies, e.g. in electronics, automation etc., and is financing R&D projects in more advanced areas of electronics (integrated circuit manufactures, automation, computer aided design and manufacture). In Taiwan, where government-owned enterprises have always played an important role (in the early 1950s over 50% of industrial production came from here), the role of the state as industrial entrepreneur was reduced in the mid-1980s to less than 15% of total industrial production. Instead, more emphasis was placed on the encouragement of private initiatives in the so-called strategic industries (information, electronics, machinery, and to a certain extent, bio-technology).[9]

With regard to company sizes, huge conglomerates typical of the Korean economy, certainly provide a better basis for long-term and costly R&D in new technologies. On the other hand, small and medium-sized enterprises which are typical of Taiwan industry are more flexible, will adapt faster to changes in market opportunities, and will find themselves lucrative market-niches more easily. Korea therefore started to promote the development of smaller firms, by facilitating the provision of loans such as venture capital, and setting aside certain activities as reserved branches for small and medium-sized enterprises. In Taiwan, as already mentioned, publicly funded research laboratories were founded to complement research in small and medium-sized firms.

The composition of NICs exports has indeed changed significantly during the 1980s. According to a study by OECD in 1980, only 21% of NICs[10] manufactured exports to OECD were high technology products and 60% low technology (OECD, 1988). By 1987 the share of high technology products increased to 31% and only 46% were low technology products (the rest were medium technology products) (see Table 3). Following another classification, about 40% of NICs exports to OECD were not labor intensive. A further indicator of the achieved level of technology is intra-industry trade which already made up one-third of total trade in manufactured goods between OECD countries and NICs in 1985.

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[9] "Among the products earmarked for encouragement in these areas have been precision instruments and machine tools, VCRs, telecommunications equipment, computers, automobiles and automobile parts" (OECD, 1988, p. 39).

[10] NICs = Singapore, Hong Kong, Taiwan, Korea, Brazil, Mexico.

Table 3. Changing composition of NIC exports to the OECD: Manufactures by technology level (per cent share).

Technology level	1964	1973	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
High	2.2	17.6	20.0	20.7	21.5	22.0	22.1	24.1	25.3	25.0	29.7	31.2
Medium	15.9	13.9	16.3	17.4	18.5	18.0	18.9	19.1	20.2	21.6	21.5	22.1
Low	81.6	68.4	63.5	61.7	59.8	59.9	58.9	56.7	54.4	53.2	48.7	46.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NICs: Hong Kong, Singapore, Taiwan, South Korea, Brazil, Mexico.
Sources: OECD, 1988, Table 2.4; Kurt, 1990.

Looking at the product structure of NICs exports to industrialized countries in more detail, the following can be observed. The shares in exports of most of the traditional labor intensive product groups such as clothing (SITC rev.2, 84), textiles (SITC rev.2, 65), cork and wood manufactures (SITC rev.2, 63) went down significantly between 1973 and 1985.[11] Among the products relatively important for NICs exports in the 1970s, some kept their share constant (Table 2): "telecommunications and sound recording apparatus" (SITC rev.2, 76) and "electrical machinery, apparatus and appliances n.e.s." (SITC rev.2, 77). Only a few of them increased their share: "iron and steel" (SITC rev.2, 67), "manufactures of metal" (SITC rev.2, 69) and "office machines and automatic data processing equipment" (SITC rev.2, 75). Most interesting, however, are those products which had a very small share in 1973 exports but which have increased their share significantly due to overproportionate growth rates. These were mainly machinery (SITC rev. 2, 71-74),[12] road vehicles (SITC rev.2, 78) and certain organic chemicals (SITC rev.2, 51 and 58). Although the share of these products in exports was still small in 1985, they will become important in the future, if their dynamic development continues.

Finally, one should bear in mind, that not only industry but also services may be more or less technology intensive. The fact is that, besides banking, the newly industrializing countries already went into advanced services such as software, data processing, printing, etc., which are, however, not reflected in their trade statistics.

One important item to be considered for the future is the further development of the international technology system. The pessimistic scenario is one, in which current trends towards a more restrictive system continue and can accelerate, and entry barriers to latecomers become more severe because of concentration of high-tech in a few countries/companies and politicization of technology transfer (high-tech neo-mercantilism).[13] The optimistic scenario is one where the international technology system becomes more open and accessible for latecomers because of a greater diffusion of technology, which could mean broader and increasingly complementary forms of technological cooperation between OECD

[11]One important exception being footwear.

[12]Power generating machinery and equipment (71), machinery specialized for particular industries (72), metalworking machinery (73), general industrial machinery and equipment, and parts (74).

[13]To give just one example: "US software firms, co-operating with the United States' government, apply tremendous pressure on South Korea to enforce more strictly its new software copyright protection legislation. Similar pressure is also applied to Brazil" (Ernst and O'Connor, 1989, p. 136).

countries and NICs, as well as increased south-south cooperation.[14] Regional economic co-operation might therefore gain importance.

3. CONCLUSIONS

Having reached a certain level of economic development and per capita income, the next phase will require the modernization and upgrading of the traditional export industries, as well as entering new, more technology intensive fields of production. In Mauritius, the main export industries so far have been sugar and clothing. Modernization of the former obviously means enhanced mechanization and an increase in output per hectare. Traditionally the equipment for the sugar industry has been manufactured locally; by putting more effort into this field of production, specialized machinery for the sugar industry itself could become an important export item for the future, analogous to the exportation of textile machinery complementing textile exports from Korea. Furthermore, it would offer a good opportunity to become familiar with industrial electronics, by buying and/or imitating technology first, and adapting and upgrading it for special purposes later on.

To cope with the rising wage level, the clothing industry in Mauritius will have to move upmarket, i.e. emphasizing product design and high-quality goods, and shifting operations to countries with low wages, as has been successfully demonstrated by the Hong Kong clothing industry some years ago.

In some NICs, upstream activities have been used to broaden the industrial base. For Mauritius, this would mean the production of textiles and textile fibers for the clothing industry, and fertilizers for the sugar industry - this will only be feasible if the market is considered big enough and/or production is expected to become internationally competitive quite soon.

Out of the four "core technologies" that would enhance technology intensive production in the future (micro-electronics, renewable energies, new materials and bio-technology), micro-electronics seems to be the most feasible for Mauritius, given its rather limited resources. In micro-electronics, respective information technology threshold costs have become rather low in some fields, e.g. software application, and many specialized areas of instrumentation and machinery, so that even small and medium-sized firms can be successful in this field. (As mentioned before, the production of specialized machinery for the sugar industry might be a good starting point.) Moreover, from its geographical location, Mauritius seems to have some comparative advantage in the field of renewable energies, especially solar energy and biomass.

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[14]In this connection, the technical co-operation accord between Argentina and Brazil that covers a range of industries and technologies should be mentioned, although it is still at an early stage of implementation (see Ernst and O'Connor, 1989, p. 131).

With regard to services, Mauritius has certainly gathered a lot of experience in the field of tourism. This could be utilized for the export of know-how in tourism services as well as hotel construction, in the same way as Korea has become an exporter of industrial turn-key projects.

Another comparative advantage of Mauritius seems to be the prevailing awareness of environmental problems which represents a good basis for the development of environmental production technology applicable to industry as well as tourism.

Given the rather good quality of basic education in Mauritius on the one hand, and the limited resources of a small country on the other, emphasis should be put on an intermediate level of education which is above the level of general secondary education, but below university level. One might think of technical or junior colleges. (It should be noted that even in a big country like South Korea, most core scientists have been trained abroad.)

The government should mainly provide a favorable economic climate in which individual companies can expand (including adequate infrastructure and training facilities), and give certain incentives or support to entrepreneurs to move up the technology ladder. In addition, publicly- funded research facilities might be necessary to complement research in small and medium-sized enterprises as well as basic research.

In the future, economic and technological cooperation will most probably increase, not only with the advanced industrialized countries, but also with the Asian NICs, as well as perhaps with countries in Southern Africa, depending on the economic and political developments there.

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Chapter 13

ENERGY DEMAND STRUCTURES IN MAURITIUS AND THEIR DEVELOPMENT OVER TIME

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1. INTRODUCTION

Energy is essential to all activities. No action will occur in a system without an enabling flow of energy. To support economic modernization drives, to expand food production and to halt environmental degradation, developing countries need larger quantities of fossil fuels and also need to change fundamentally the way their fuel wood is being depleted. It is therefore essential to get an insight into the country's energy flow to understand the system, and to make plans to meet the energy needs adequately. This paper reviews the energy profile of Mauritius. It analyses the past and present consumption patterns of commercial and non-commercial energy. It discusses energy consumption trends in the agricultural, industrial, residential and transportation sectors. It tries to assess what energy services are needed for a given set of physical and economic activities, and the allocation of resources that best meets Mauritius' demand. Finally, it analyses available energy supply alternatives.

2. ENERGY DATA AND SOURCES[2]

For the purpose of comparison, energy accounts routinely convert the quantity of energy from different sources, viz. fossil fuels (coals, crude oils, natural gases), electricity (generated in hydro-stations, fossil-fuelled, geothermal power plants), and biomass fuels (fuel wood, charcoal, bagasse) to common denominators (joules, tons of oil equivalent (TOE) and tons of coal equivalent (TCE), etc.). While this provides an equivalent measure of quantity, it tells nothing about the quality or form that is actually available or is needed for a given purpose. TOE and TCE have no internationally agreed basis of conversion. There is no standard coal or crude oil. These differences are significant especially when making comparisons between countries. Energy accounting is further complicated due to a very low conversion

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[1]In collaboration with Professor J. Baguant.

[2]All energy data for Mauritius were obtained from the 'Energy Use and Policy Planning in Mauritius' project (1987-1990), carried out by the University of Mauritius and funded by IDRC (International Development Research Center, Canada). See Baguant (1989), Baguant and Panray Beeharry (1989), and Baguant et al. (1989).

efficiency of most non-commercial energy sources. Statistics can also be based upon either net or gross calorific values. In the present exercise, energy values for Mauritius are from local sources and gross calorific values of fuels have been used. GDP and GNP figures are from World Tables (World Bank, 1989). International energy figures have been obtained from UN sources. Electricity conversion and distribution losses have been taken into consideration. The efficiency of electricity generation from hydro and oil have been taken as 40%, from bagasse 17.5% and from coal 17.0%, overall generation efficiency being 31% (Baguant, 1989). It is also necessary to define the terms used to describe energy at various stages. Primary energy as referred to here is an energy form which has not undergone any transformation within the boundary of Mauritius. Gasoline, diesel, kerosene, fuel oil, liquid petroleum gas (LPG) and coal are considered as imported primary energy. Bagasse, woody biomass and hydroelectricity are the local primary energy sources. (Bagasse is a by-product of the sugar industry; it is the fibrous residue left over when juice has been removed from the cane stalk.) Electricity produced from diesel, fuel oil, coal, bagasse and hydroelectricity is considered as secondary energy. The energy intensity as used here is the direct productive energy requirements to produce 1 value unit of goods by each sector. It has the units energy/currency. (TCE/1980 constant US$).

3. TOTAL ENERGY CONSUMPTION

To meet its energy needs, Mauritius has to import fuel and depends on this imported fuel for more than 80% of its needs (see Figure 1). Local energy sources cater for the remaining 20%. The energy flow in the Mauritian economy is shown in Figure 2. Figure 3 gives the quantity of local and imported energy consumed. The primary energy consumption has increased from 163 TCE in 1970 to 547 TCE in 1989, i.e. it has more than tripled since 1970. It increased at an average rate of 9% per annum from 1970 to 1978, stagnated and decreased slightly until 1982. This was partly due to the impact of the energy crisis. From 1983 until 1989 there has been an average increase of almost 10% per annum. Imported fuel consumption has increased from 126 TCE in 1970 to 454 TCE in 1989, increasing at a slightly higher rate than total energy consumed. Presently, total fuel imports account for 8% of the total Mauritian exports.

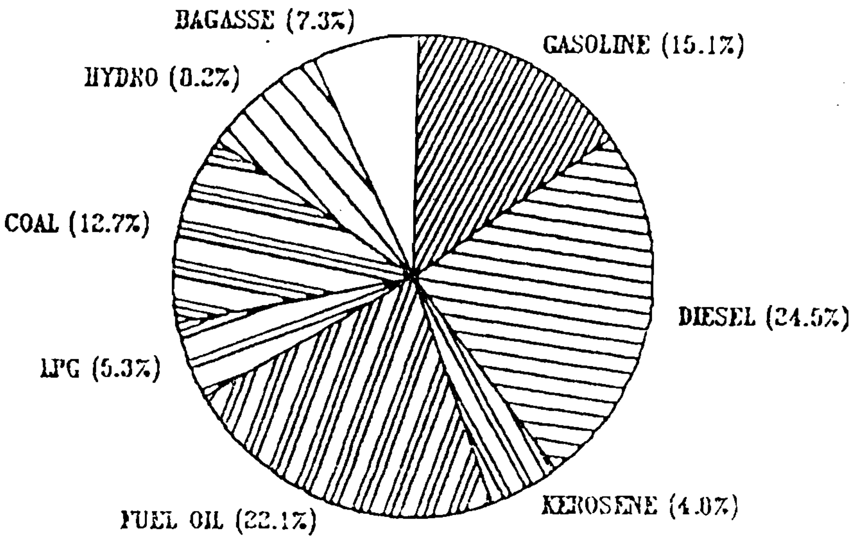

Figure 1. Primary energy consumption by fuel type, 1989. Note: LPG is Liquefied Petroleum Gas.

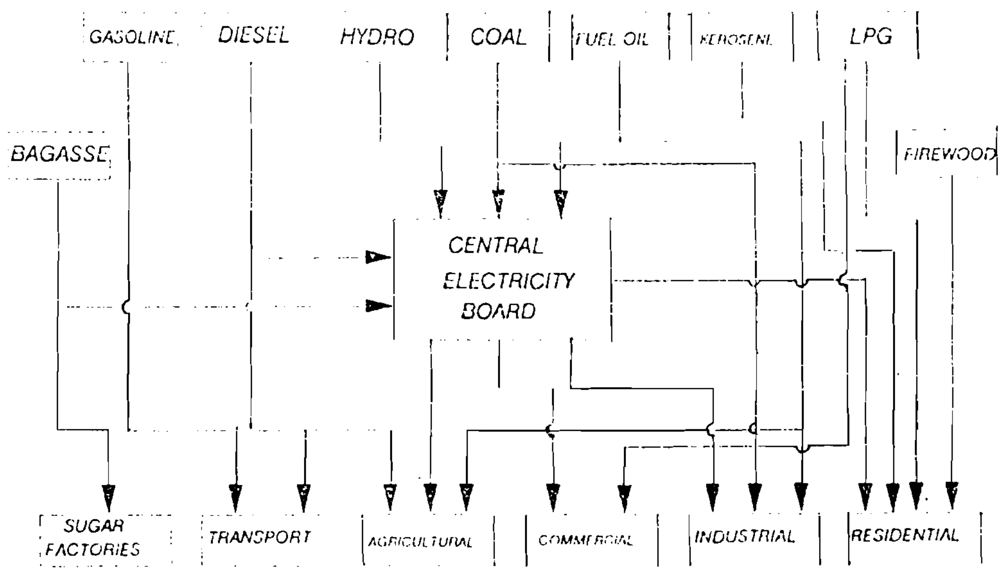

Figure 2. Energy flow in the Mauritian economic sectors.

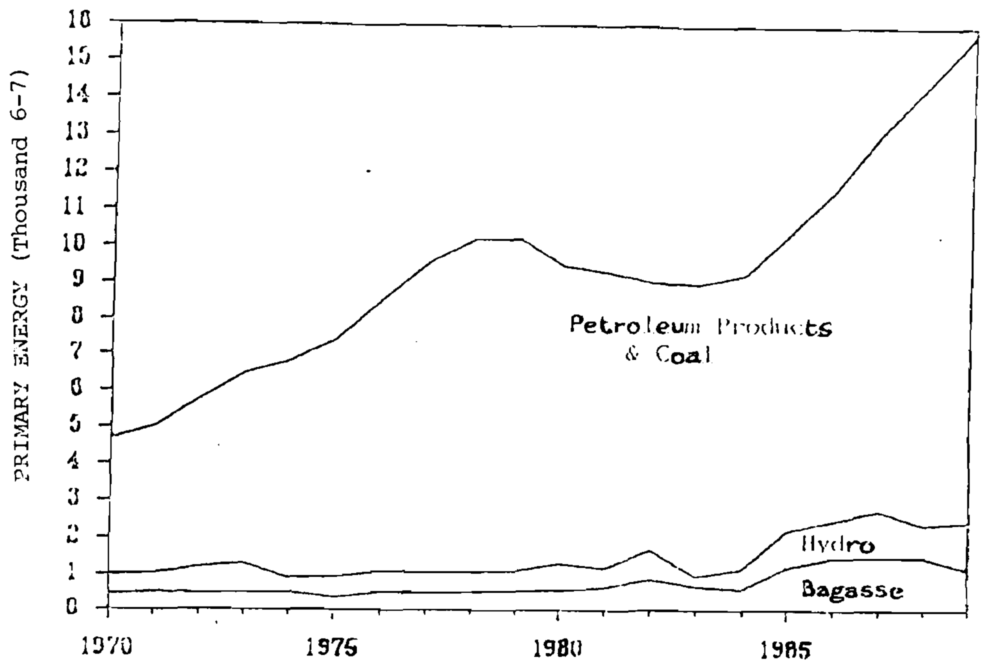

Figure 3. Primary energy consumption in Mauritius, 1970-1989. Note: Excluding energy for sugar manufacturing and wood.

The local primary energy sources which have been accounted for are the hydro and bagasse used for electricity production for the national grid. There are no reasonably accurate statistics of non-commercial energy (wood and charcoal) for the past years. It is therefore difficult to say how much of the observed growth in energy consumption has been due to the actual increase in energy use, and how much has been a substitution of non-commercial energy sources by commercial ones. Bagasse, which is used as fuel in the sugar industry, has also not been accounted for as it is within the boundary of this industry. It is interesting to note that if woody biomass is taken into consideration (assuming it is 60% of total residential energy consumption as estimated in a survey carried out by the University of Mauritius), the total local energy is more than 20% (see Table 1) of the total energy consumed, as compared to 15% when woody biomass is excluded. The share of domestic energy sources is 57% if non-commercial bagasse is included.

Table 1. Total energy consumption, 1989.

Energy sources	(a) %	(b) %	(c) %
Imported fuels	84.5	77.5	43.2
Bagasse (commercial)	7.3	6.7	3.7
Hydro	8.2	7.7	4.2
Woody Biomass		7.1	3.9
Bagasse (non-commercial)			45.0
Total	100.0	100.0	100.0

a) Energy consumption excluding non-commercial energy.
b) Energy consumption including woody biomass (assuming 60% of residential consumption).
c) Energy consumption including woody biomass and non-commercial bagasse.

4. ENERGY AND PRODUCTION

At any level of economic development, energy is an input to the production and consumption system. The mix of activities and the level of private income change as a country develops and it is also changed by deliberate planning. Changes in the energy use can be decomposed into a set of causal relationships or effects. Minor shifts in the mix of activities may therefore result in significant changes in total demand, and demand for specific fuels. To review the development of energy use by the Mauritian economy over time, a disaggregated microeconomic approach is adopted. Two main uses of energy are distinguished, one being for consumption purposes, i.e. directly consumed by households, and the other for production purposes in the agricultural, industrial, and services sector. Figure 4 shows the energy consumption by economic sectors.

Energy is essential to economic growth and development, but the linkages between energy and development are complex and still imperfectly understood. According to Proops (1984), a consensus seems to be emerging concerning the relationship between countries' energy use and their national product. Therefore if the energy use and output is plotted against time, many developed countries exhibit a humped shape (Figure 5), while developing countries display a rising trend. When an economy reaches the post-industrial stage, an increasing proportion of activities fall into the services sector which is less energy intensive. Therefore there is a general belief that continued economic growth of a country will entail less energy per unit of additional output. The per capita consumption of commercial energy is 0.5 TCE for the developing world, while it is around 6 TCE for the developed world.

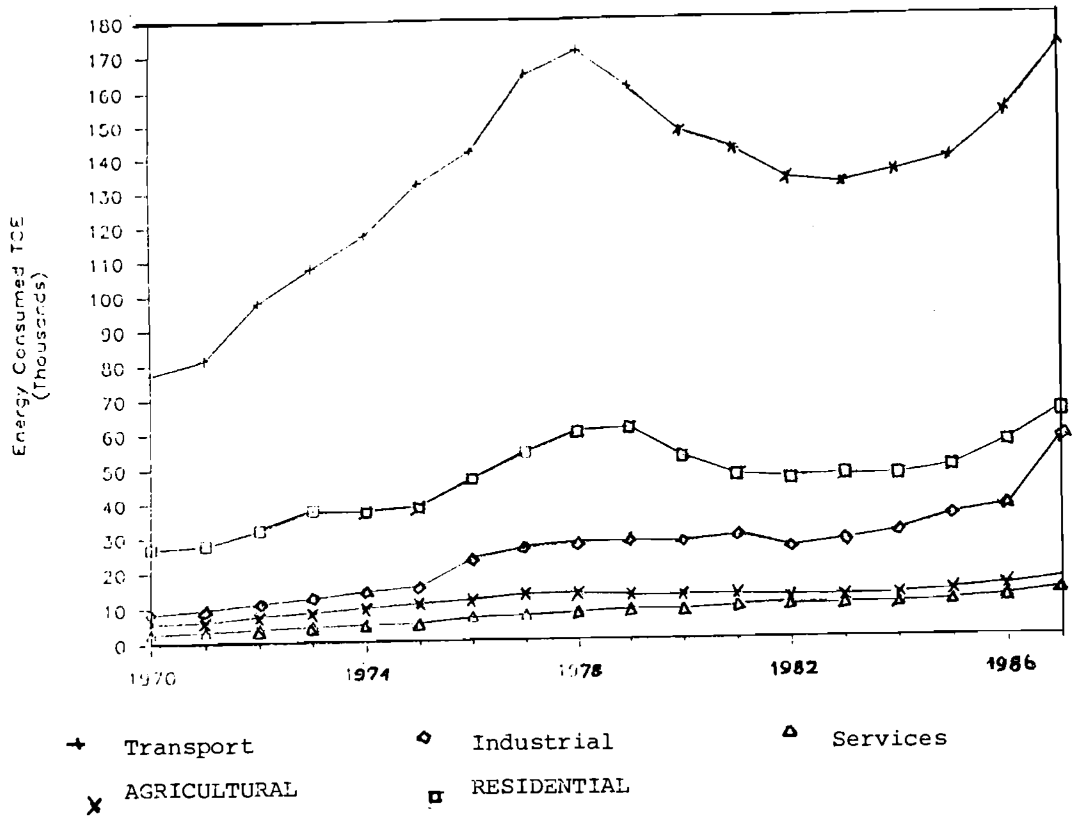

Figure 4. Energy consumption by economic sectors in Mauritius.

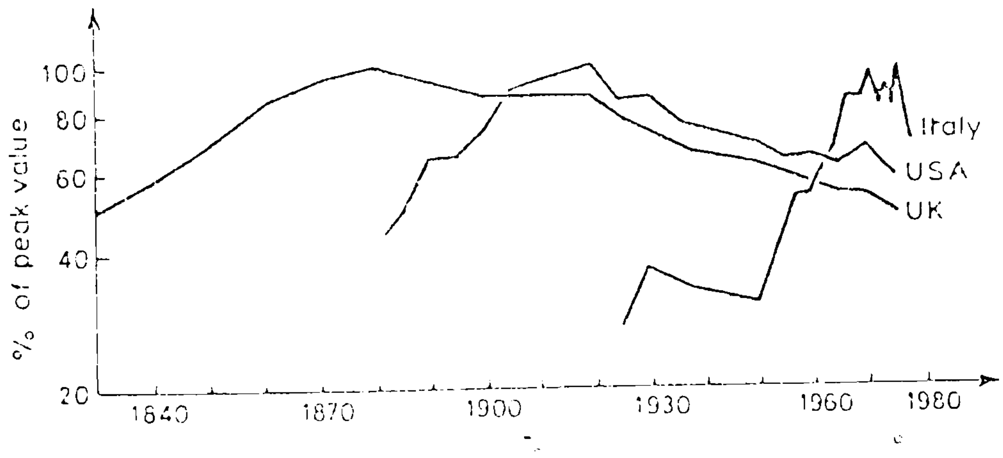

Figure 5. Energy output ratio.

Mauritius is a middle-income country with GDP per capita of over US$ 1400 in 1988. It is still developing and its actual energy consumption is 0.5 TCE per capita. The energy consumption per capita has increased 3 times since 1970 to 1989 (see Figure 6). The decline in energy/capita in the early 1980s is explained by the energy crisis (there is a time lag before it hit the country), and also because of the overall economic depression (low sugar prices). Due to the lack of data, we cannot assess the substitution of fossil fuels by non-commercial energy (woody biomass) during the energy crisis. But in the late 1980s, with no tax policy on kerosene and low tax on LPG, there has been a definite substitution of woody biomass by these fuels. The increase in energy consumption is also due to the mechanization of the agricultural sector and to the country's re-launching of its Export Processing Zone (EPZ).

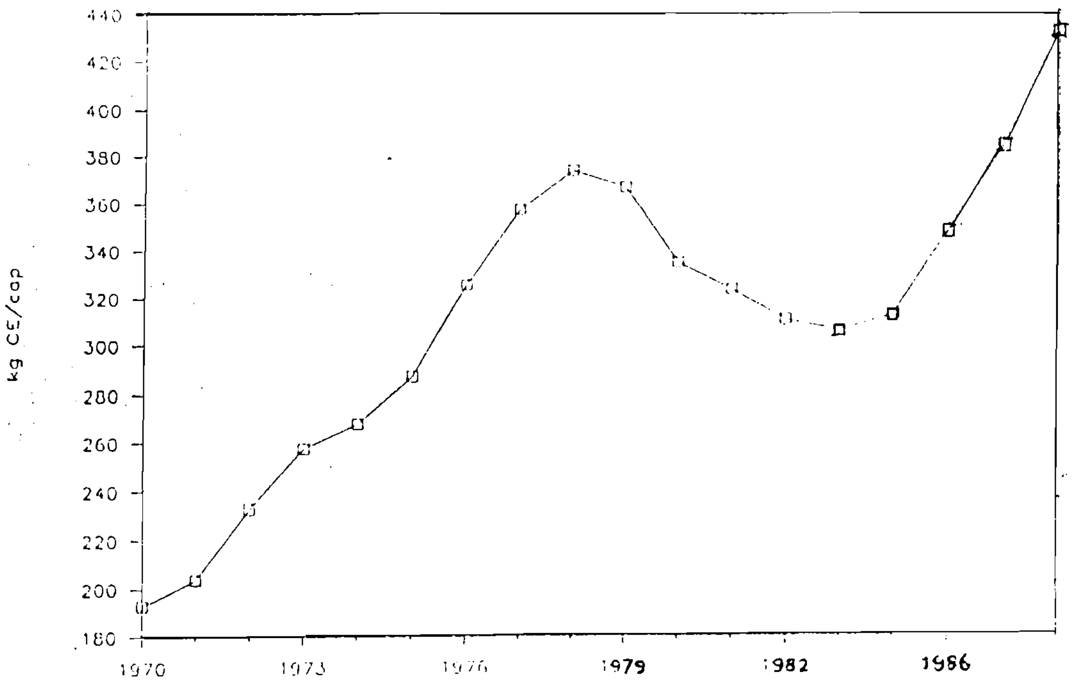

Figure 6. Energy consumption per capita in Mauritius, 1970-1987.

5. ENERGY INTENSITY (EI) OF ECONOMIC SECTORS

The Transportation Sector

The transportation sector has a special place in the energy demand. It is by far the largest consumer of gasoline and diesel, the mix being in the ratio 40:60. It accounted for 47% of primary energy consumption in 1970 and 35% in 1989. This is the most energy intensive sector of the Mauritian economy, its EI being around 4000 TCE/$ million. The energy intensity increased for a few years after 1970 and has been going down since the energy crisis (Figure 7). Similarly to other countries, personal travel and vehicle ownership has risen with GDP and household income. There is a growing demand for greater personal mobility and movement of goods. The shortage of vehicles, spare parts, fuel or roads is a severe constraint on productive development. As transport is totally dependent on oil and likely to remain so for some time to come, the sector's share in energy consumption is bound to continue growing in the future, together with the actual oil consumption growing at the rate of almost 10% annually. But the growth in transport energy can be met by more efficient vehicles and use of diesel instead of gasoline. There has been a great decrease in EI from 6417 TCE/$ million in 1970 to 3948 TCE/$ million in 1989. Three factors may be responsible for this decrease:

1) the replacement of old and inefficient vehicles by new efficient ones;
2) the substitution of regular gasoline to premium which is more efficient;
3) the total output representing, in fact, "transport and communications," and communications which is growing rapidly and is not that energy intensive.

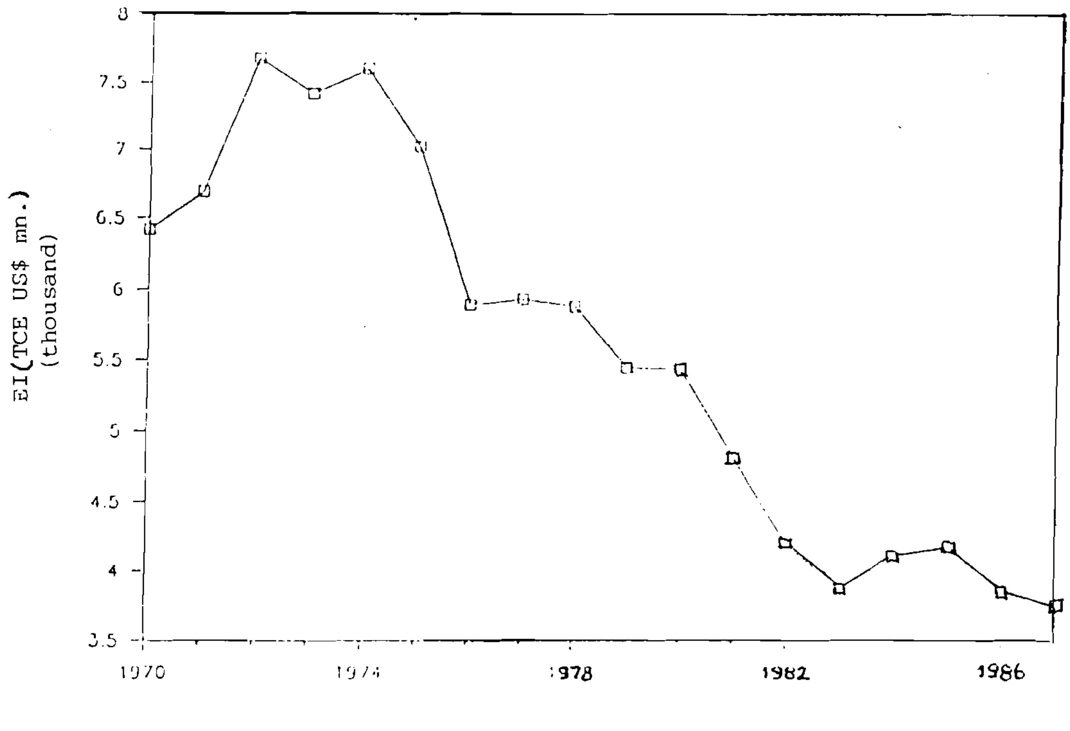

Figure 7. Energy intensity of the transportation sector, 1970-1987.

The Industrial Sector

The industrial sector referred to here includes all the manufacturing industries of the export processing zone, beverage industries, the textile industries, food processing, and construction, but it excludes the sugar factories that make use of the sugar by-product (bagasse) for their energy requirements. Industry is the second largest energy consumer of all sectors. It depends mainly on electricity (35%) and fuel oil (46%), to a smaller extent on LPG (1%), and, since 1987, on coal (18%). The EI in industry has increased by a factor of 1.5 since 1970, i.e. from 74 to 125 TCE/$ million. Figure 8 shows the EI for the past 20 years. With an expanding industrial sector, the EI has been increasing overall, even though the impact of the oil crises in the mid-1970s and early 1980s caused a decrease at those particular times. The stagnation and decrease of the EI in the mid-1980s was due to the increase in industrial output by mainly labor and not energy consuming machines. In that period, unemployment in the country reached alarming proportions and threatened its social and economic well-being, which led the Mauritian Government to promote the expansion and setting up of new industries to absorb the surplus labor. But since 1987, EI has been increasing because several new industries, such as those in the textile sector, have been equipped with coal-fired steam generation plants.

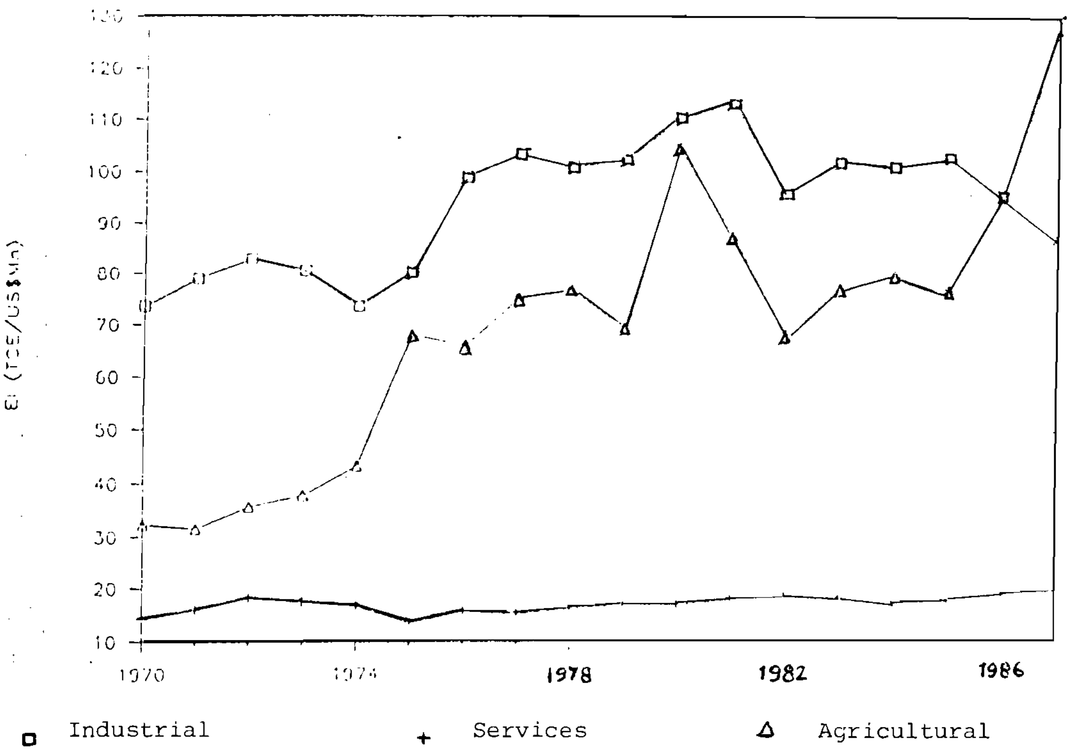

Figure 8. Energy intensity of economic sectors in Mauritius.

Given quasi-full employment and the scarcity of labor, industries in the future are likely to become more capital-intensive. Mechanization and a growing EPZ sector will lead to an increase in energy consumption. But the extent of the increase will depend largely on the energy intensity of the new industries. Most of the industries now belong to the textile or manufacturing sectors. Echiburu (1977) made a study of the labor/energy trade-off for U.K. industries for the period 1948-1975. Her results for the marginal energy requirements to substitute one man-hour were 1 kWh per man-hour for textile industries; 10 kWh for iron and steel industries; 2 kWh for food, drink, and tobacco industries; and 2 kWh for all manufacturing industries.

According to Bheenick and Hanoomanjee (1988), the industrial future of Mauritius lies in the direction of high-growth, high-technology industries such as information, communication, and electronics. The energy requirements of information processing are relatively low, the greatest need of such industries being skilled workers.

The Agricultural Sector

The agricultural sector is dominated by sugar cane plantations. The current policy of the government is to promote agricultural diversification by intensifying the growing of sugar cane and releasing land for other food crop cultivation. The fuels consumed in this sector are diesel, fuel oil, and electricity. There is a lack of data on the quantities of different types of fuels used in this sector, therefore estimates have been used. The sugar industry is very energy-intensive, but it is self-sufficient in its energy requirements. Bagasse, the by-product of sugar manufacturing, is used for electricity production for the sugar factories and for operating irrigation works during the crop season. Any excess electricity produced by the sugar industry is sold to the national grid. During the off-season, the national grid provides electricity for maintenance purposes and for irrigation. Diesel is also used for pumping the water for irrigation. Although agriculture is not a very energy intensive sector, the EI has tripled from around 30 to 90 TCE/$ million (Figure 8). This sector was not much affected by the energy crisis in the early 1970s, as it was labor intensive and not mechanized. The EI increased as a result of gradual mechanization, but there are fluctuations in the EI whenever the price and production of sugar changed. In the late 1970s, sugar production went down and EI increased due to cyclones and unfavorable climatic conditions. Sugar production was high in 1982, and there was some impact of the second energy crisis, causing a fall in EI. The energy consumption has been increasing with the introduction of mechanical loaders for the sugar cane, and further use of machines for irrigation, transportation, and land preparation. But there will be fluctuations in the EI due to changing prices and sugar production in the future. Intensive mechanization will be required as a result of the scarcity of labor and the policy to intensify sugar production per hectare in order to release land for other crops. This will cause a further increase in the EI in the years to come. Nevertheless, at present, there is much room for efficiency improvements in the use of equipment and vehicles in this sector.

Commercial and Services Sector

This sector is made up of private and public services, commercial stores, hotels, restaurants, government buildings and offices. Energy is difficult to allocate reliably in this as it comprises very different activities. It is the least energy-intensive, but there has been an increase in EI between 1970 and 1987 from 14 to 19 TCE/$ million. This is mainly due to the growth of the tourist industry, public infrastructure, and other services. The fuels used are electricity (90%) and LPG (10%), the latter being used for cooking in the hotels and restaurants. Although the energy intensity has been increasing steadily since 1970, there was a decrease after 1973 and in the early 1980s, most probably due to the oil crises (see Figure 8).

The Residential Sector

This sector is different from all the above sectors in that it uses energy for consumption purposes and not for production purposes. It is the main user of non-commercial energy, fuel wood and charcoal. Commercial energy consumption time series were readily available. The commercial fuel mix is electricity, kerosene, and LPG, in the ratio 57:41:2 in 1970 and 62:20:18 in 1989. The substitution of kerosene is likely to continue with the lowering of tax on LPG during 1986/87, improved electricity supply over the entire island, and improved standard of living of the Mauritian society. But a significant percentage of household fuel is purchased in informal markets or gathered, and energy consumption can only be assessed by household surveys. One such survey was carried out by the University of Mauritius in 1988. The survey results are reliable because traditional fuel consumption was measured, but it only captures a small sample at one point in time. Consistent time series of non-commercial data are practically inexistent.

In the survey carried out by the University of Mauritius, it was estimated that woody biomass made up to 60% of the total energy consumption. As shown in Table 2, the urban energy consumption per household is lower than the rural consumption, because the efficiency of the woody biomass is low compared to other fuels. The shortage of woody biomass and the government's policy to preserve forests and protect the environment will foster the shift towards commercial fuels.

Table 2. Average residential energy consumption by type of energy carrier units: MJ/month/household.

Energy carrier	Energy consumption Urban	%	Rural	%	Island	%
LPG	403.79	26.04	225.31	7.66	293.42	12.17
Kerosene	314.83	20.30	400.84	13.62	368.02	15.26
Wood	421.82	27.20	2113.95	71.85	1468.22	60.89
Charcoal	94.04	6.06	38.58	1.31	59.74	2.48
Eectricity	316.09	20.39	163.69	5.56	221.85	9.20
All sources	1550.58	100.00	2942.36	100.00	2411.25	100.00

6. ENERGY CARRIERS

This section analyzes some of the major energy carriers in the Mauritian context.

Oil

Oil plays a major role as it is an energy source suitable for a variety of purposes and equipment. It is mainly used in the transport, commercial, and industrial sectors; for cooking in the residential sectors; and for operating irrigation pumps. Because of its relatively low cost, it has kept other small-scale biogas plants out of market. The oil consumption in developing countries is about 173 kgCE per person, while in the developed countries, it is around 5255 kgCE (Parikh, 1980). In Mauritius, the oil consumption is 350 kgCE per capita and for further development an increase in oil consumption is evident. For a developing country like Mauritius, the availability of foreign exchange is a major factor determining its capacity to import goods and to support investments that can generate economic growth. If oil prices continue to increase, the result will be a reduction in the availability of foreign exchange.

Electricity

Electricity can be generated from a variety of fuels. Electricity produced in Mauritius is, to a major extent, of thermal origin (Figure 9), hydroelectricity being limited by the small catchment areas. The growth rate for the period 1970 to 1989 has been 7.5% annually. The rapid growth in electricity consumption is proportional to population and economic growth, and increased rural electrification. The production of electricity is only 176 kWh/cap in developing countries as against 4811 kWh/cap in developed countries (Proops, 1984). As expected from a country like Mauritius, the per capita production of electricity (600 kWh) is higher than that of developing countries in general. The extent of electrification is high - 97% of households are connected to the national grid and use electricity for lighting purposes.

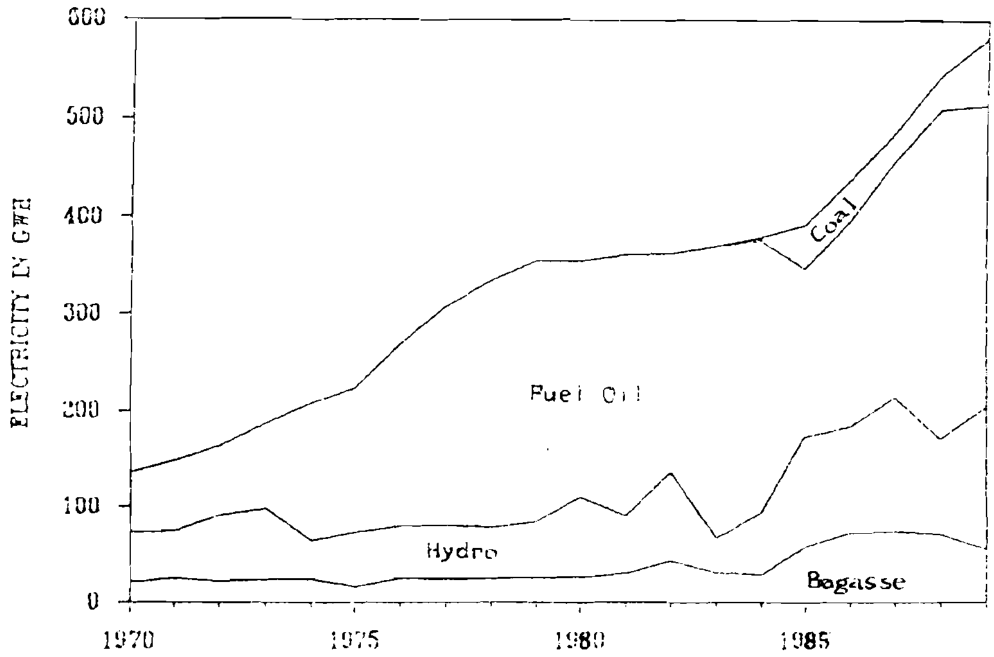

Figure 9. Electricity generation by source in Mauritius.

Biomass

Biomass plays an important role in low to middle income countries. But data on fuel wood and charcoal are difficult to collect, and the only available data are from the survey mentioned earlier. The rural population, which accounts for 60% of the total island population, consumes 12% less commercial energy than the urban population. This is explained by the fact that non-commercial energy, i.e. fuel wood and agricultural waste (bagasse), meet a large proportion of rural energy requirements (more than 60%). In view of the fact that the supply of this energy is not the result of planned activity, continued supply from these sources cannot be taken for granted and may not be sustainable over the long-term. Serious ecological consequences may result from a continued gathering of firewood. It diminishes vegetation cover and causes deforestation. This leads to soil erosion and also climatic changes.

7. SUBSISTENCE, DEVELOPMENT, AND SUSTAINABILITY

If the level of commercial energy consumption and commercial energy production is examined along the lines of Parikh (1980), Mauritius is in the phase of development just above the subsistence threshold. But as mentioned previously, the bulk of the domestic sector consumption comes from non-commercial energy sources, hence the commercial energy is used essentially to contribute to economically productive activities. These activities have to be sustainable for the further development and progress of the country. But there are constraints to sustainability. The main ones are:

1) the limited availability of oil, gas and coal,
2) the population pressure, and
3) the pressure of the developing economic and technological infrastructure.

The options which can be adopted to overcome these are:

1) employment of available renewable resources, and
2) use of the most appropriate energy carrier for a particular end use.

The locally available energy resources which could substitute imported fuels are bagasse, solar radiation, alcohol from molasses and cane leaves.

Bagasse and cane top leaves can be utilized for electricity generation. Actually 70×10^6 kWh generated from bagasse by the sugar industry are sold to the national grid annually, and according to Baguant (1989), there is potential to increase this contribution up to 530×10^6 kWh. This can be achieved by renewing and replacing the inefficient equipment for energy production.

Existing hydro power plants can be improved and new ones developed (Harel, 1989). Ethanol can be produced from molasses, another by-product of the sugar industry. This can be used for cooking, as a substitute for firewood and kerosene. As LPG is more efficient, the tax on it can be further lowered or at least kept low to encourage a shift from traditional fuels.

In the transport sector, the use of diesel must be encouraged instead of gasoline. To alleviate the acute transport problem in Mauritius, to decrease environmental problems, and at the same time save energy, one alternative could be the use of bicycles by workers. In most cases, the EPZ workers live within a few kilometers from their place of work and commute by bus.

Solar energy is now used for heating purposes to a very limited extent, but its use could be encouraged by alleviating the tax on solar heaters. Installation of small biogas plants can also be envisaged.

There has not been much emphasis on the environmental issues associated with present energy usage except the dangers of deforestation. Pollution due to emissions from fuel combustion is not yet a problem. Nevertheless, sugar factories must control the emissions from their furnaces as the flue gas contains ash and carbon particles which are deposited in the neighboring residential areas. Monetary incentives have been provided by the government to install scrubbers and to renew energy equipment. The use of coal for raising process steam in the industrial sector is viewed with concern. The use of bagasse for this purpose might be considered. It is crucial to plan ahead to avoid the dangers of pollution, which impedes sustainability.

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Chapter 14

ESTIMATION OF ENERGY DEMAND ELASTICITIES FOR MAURITIUS

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1. INTRODUCTION

The main objective of this paper is to get a better understanding of the structure of energy demand in Mauritius. This is needed to help us work with the possible development of future energy demand. We have conducted this study by using the historical development of energy demand as a tool to place Mauritius in an international context. We can thereby compare Mauritius to other countries. If we also have some knowledge about the level of development in these other countries, it could prove to be useful for us when we try to form a picture of a possible future path for energy demand in Mauritius.

The first problem with the demand models based on market prices and cost-minimizing decisions is that there may be operating constraints or management objectives other than profit maximization. This, in turn, implies that energy consumption decisions may be based on matters other than solely on cost-minimization or utility-maximization.

The second problem is that the structure of the economy may be changing in a way that makes the structure of energy demand itself change rapidly. Mauritius will be compared
to other countries in Section 2, in order to address this problem.

We estimate log-linear models with a Koyck lag to explain the dynamic adjustment of demand to changes in income or price. The equation is the following:

$$\log Q_{it} = \alpha_i + \beta_i \log Y_{it} + \gamma_i \log P_{it} + \lambda_i \log Q_{it-1} + \epsilon_{it}$$

Here Q_{it} is the consumption of energy carrier i at time t, Y_{it} is gross domestic product (GDP), and P_{it} is the price of energy carrier i. By this equation, the short-run income and price elasticities are given directly by the estimated coefficients β_i and γ_i, respectively. The long-run income and price elasticities are $\beta_i/1\text{-}\lambda_i$ and $\gamma_i/1\text{-}\lambda_i$. The data we have used are from 1970 to 1987.

2. RESULTS

One expected result from this type of study is that income or GDP elasticities are higher in a country with a relatively low level of economic development, than in a more developed and industrialized country. One reason for this is that in such countries a large proportion of total energy consumption comes from non-commercial sources, for example woody biomass. The fuelmix then changes as income rises; the proportions of oil and electricity grow, mostly at the expense of the non-commercial energy sources. This implies that for any given growth rate of total energy use, there will be a higher growth rate of commercial energy demand (oil, electricity and coal).

It is also likely that price elasticities of energy demand will be lower in developing than in more developed countries. This applies especially to the residential sector, the reason being that at low levels of income, most energy is consumed as a necessity. Another reason for small price elasticities might be legislative restrictions on how the prices are allowed to change over time.

Demand Elasticities by Sectors in Mauritius

The estimated results are, in most cases, in the expected range according to our earlier discussion. We concentrate our discussion on the long-run elasticities since we consider them to be most interesting for future work on energy demand. The income or GDP measure used in this section consists of the income or GDP for each sector respectively.

Price elasticities were expected to be small. In the estimated models we found them to be insignificant in all sectors except in transport. However, the elasticities were small even in this sector: -0.35 for gasoline and -0.87 for diesel. The conclusion is that the energy demand is rather unsensitive to price changes. Therefore, we only discuss the income or GDP elasticities in the rest of the paper. The estimated elasticities are presented in Table 1.

Residential sector: The estimated income elasticity for electricity is 2.75. This is a rather high figure, but it fits well with the assumptions that households tend to switch from other energy carriers to electricity when income rises. The income elasticity for kerosene was estimated to be 1.72. Compared to other studies, this is a rather large figure. It could be explained by the fact that it has been a policy in Mauritius to promote kerosene use in order to make the residential sector move away from the non-commercial woody biomass. In other studies, (e.g. Pindyck, 1980), this elasticity was found to be very small or even negative. This is due to the fact that kerosene is an energy carrier from which households tend to move away as income rises. The estimated elasticities for LPG turned out to be insignificant.

Table 1. Estimated income and price elasticities in Mauritius.

		ELASTICITIES			
		Income		Price	
		Short run	Long run	Short run	Long run
Residential sector					
	Electricity	0.32	2.75	Insignificant	
	Kerosene	0.87	1.72	Insignificant	
	LPG	Insignificant		Insignificant	
Industrial sector					
	Electricity	0.74	1.51	Insignificant	
	Oil	0.71	1.20	Insignificant	
Transport sector					
	Gasoline	0.62	1.49	-0.15	-0.35
	Diesel	0.69	0.71	-0.84	-0.87
Service sector					
	Electricity	0.48	0.83	Insignificant	
	LPG	0.75	2.58	Insignificant	
Agricultural sector					
	Electricity	Insignificant		Insignificant	
	Diesel	Insignificant		Insignificant	
	Oil	Insignificant		Insignificant	

Industrial sector: The demand elasticity was estimated at 1.51 for electricity, and 1.20 for oil. These results are within the expected range. Both estimates are somewhat higher than typical values of more industrialized countries, and they indicate that energy intensity per industrial GDP will grow as GDP increases.

Transport sector: The estimated demand elasticity for gasoline is 1.49. This is well within the expected range. The estimated elasticity for diesel turned out to be 0.71, which is somewhat low but still reasonable.

Service sector: The estimated elasticity for electricity is 0.83. For LPG we estimated the elasticity at 2.58. The result for LPG is high for the service sector, and we cannot see a good and reasonable explanation for such a high elasticity figure.

Agricultural sector: The energy use appears to follow a trend in this sector. We could not estimate any significant elasticities. A reason for this might be that, regardless of whether it is a good or bad year in terms of agricultural production, the energy consumption is approximately the same. Therefore, it is almost impossible to explain the level of energy demand with the help of only GDP and prices.

One energy carrier that we have not mentioned yet is coal. The reason is that it is a new energy source to the economy of Mauritius and we could not get time-series that were long enough to enable us to estimate demand elasticities for coal.

Demand Elasticities for Mauritius Compared to Other Countries

In order to put the results we have generated for Mauritius into perspective, we compare them to results from similar studies made in other countries or regions. It is difficult to find comparable studies that use the same kind of models, data, and time-periods. Therefore, we have restricted our analysis to three energy carriers: oil, gasoline, and electricity. The results are taken from Donnelly (1987), Pindyck (1980), Bohi (1981), and Bohi and Zimmerman (1984). The results are displayed in graphs for gasoline (Figure 1), oil (Figure 2), and electricity (Figure 3).

It is clear from the graphs that the results from the comparison are consistent with earlier expectations. Mauritius, as a less developed country with lower GDP/capita than Europe and USA, has higher estimated elasticities.

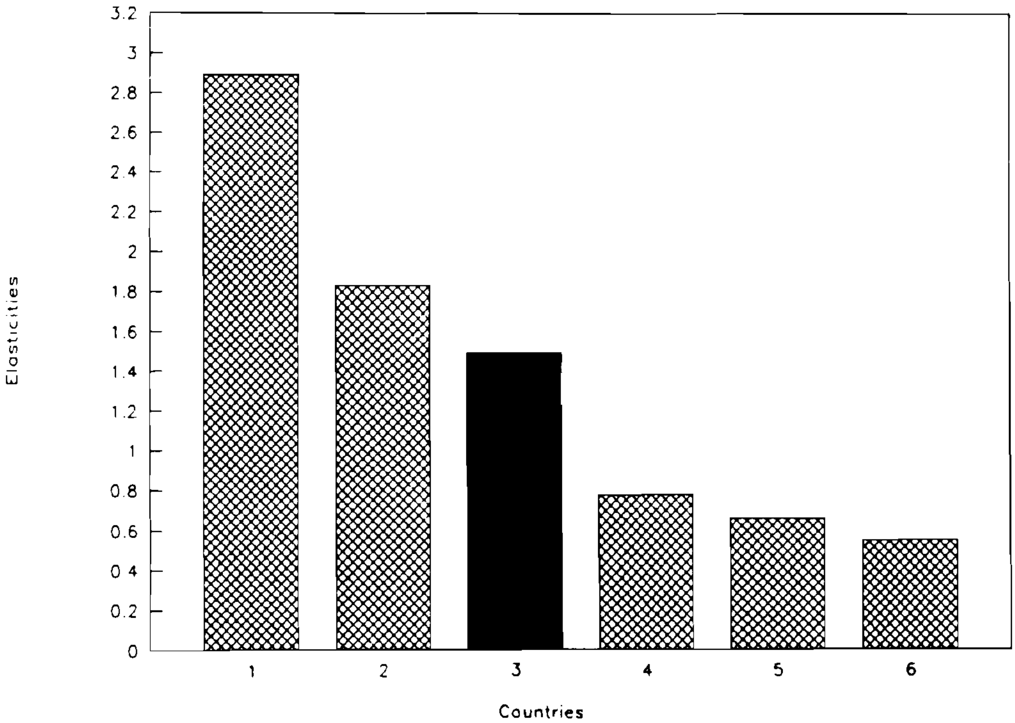

Figure 1. Demand elasticities for gasoline.
1. Brazil 2. Turkey 3. Mauritius 4. USA 5. Europe 6. Australia

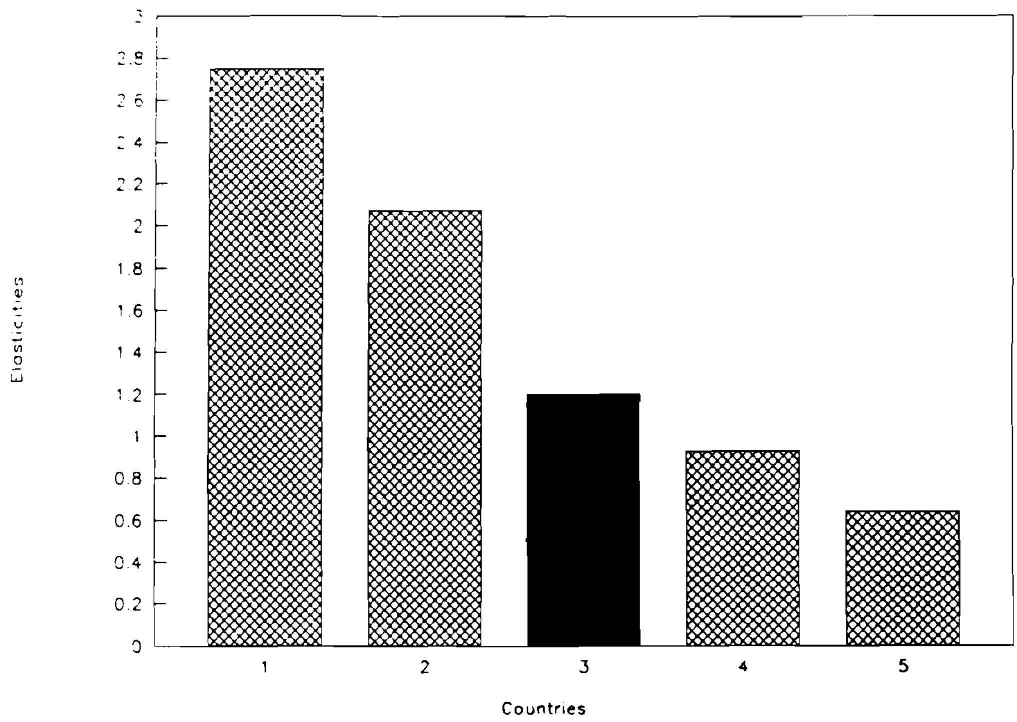

Figure 2. Demand elasticities for oil.
1. Brazil 2. Turkey 3.Mauritius 4. USA 5. Europe

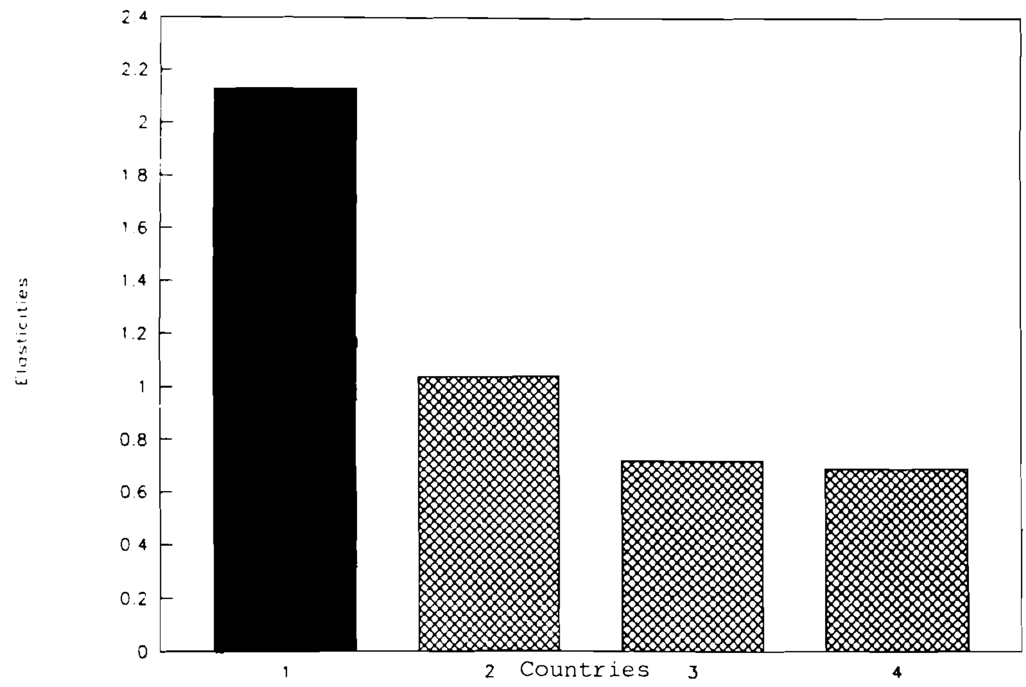

Figure 3. Demand elasticities for electricity.
1. Mauritius 2. Europe 3. USA 4.Australia

3. CONCLUSIONS

Can these comparisons help us to understand the future elasticities of energy demand in Mauritius? It is always very difficult to predict the future. We have problems when we try to make definite conclusions about future energy demand elasticities, but these graphs show that it is correct to assume that the income/GDP elasticities will be decreasing with a rising level of development and thereby also with a rising GDP/capita.

We could for example study gasoline and introduce the different levels of GDP/Capita for the countries concerned. If we study the relationships in Figure 4 the following curve can be drawn.

Here it is rather clear how a possible path for the demand elasticity may look. From the steep trend in the beginning when GDP/Capita is low, to the flat trend when GDP/Capita has risen. The conclusion is that as GDP/Capita will rise in the future, energy demand elasticities will decrease. The decrease will happen faster in the beginning of the increase of GDP/Capita, but its rate will slow down as the income level approaches that of the more industrialized and developed countries.

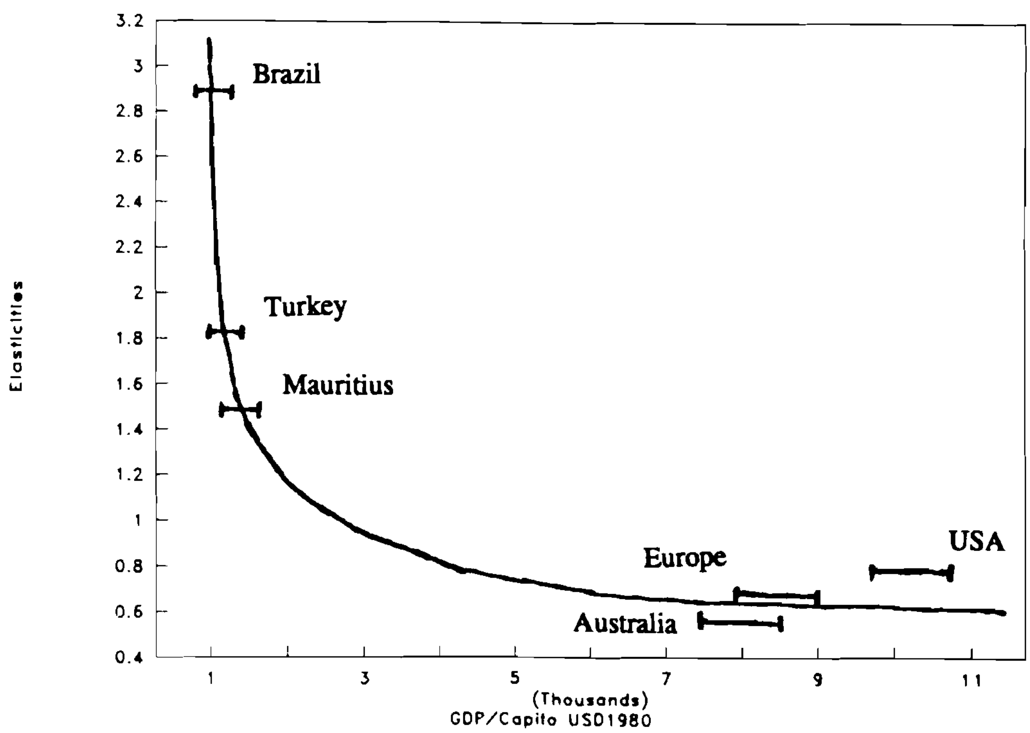

Figure 4. Income elasticities for gasoline in selected countries.

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Chapter 15

THE AGRICULTURAL SYSTEM OF MAURITIUS

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In the past two decades, the concept of sustainable development as opposed to consideration of development based solely on an economic evaluation, has been arousing much interest and controversy, particularly since the study of the Club of Rome on the "Limits to Growth" in the early 1970s (Meadows et al., 1972), and later the U.S. Presidential Report on "Global 2000" (Council on Environmental Quality, 1980). Although there are definitional problems related to the concept itself due to the complexity of the development process, it essentially relates to the judicial use of some resources by man, in ways that would maximize the chances of posterity to continue to benefit from them. The focus has been on environmental costs of certain economic development paths and lifestyles, and on the strategic implications for the future.

This paper provides a succinct evaluation of the Mauritian agricultural system at the national level, in the context of the widest possible interpretation of sustainable development, taking into account the specificities of the politico-socio-economic, agro-ecological and other environmental characteristics of the island. This is attempted by an identification of the goals that could be attributable to the Mauritian agricultural sector, and its performance appraisal in the achievement of these goals and whether these are being attained in a sustainable way. Finally the vulnerability and weaknesses of the system are identified, and the choice of future options is briefly analyzed while retaining the overall objective of sustainable development.

1. PRESUMED GOALS OF THE MAURITIAN AGRICULTURAL SECTOR

Mauritian agriculture can be imputed with two major goals, listed below in their existing order of priority, although history has witnessed shifts in their relative importance. The first objective is to contribute to the national socio-economic development and well-being of the population. The second is to sustain the food and nutritional requirements of the population. The structure and recent performance of the Mauritian agriculture is presented in Tables 1 and 2, and Figure 1.

[1]The contents of this paper do not necessarily reflect the official stand of the University of Mauritius.

Table 1. Agricultural crops: area harvested, production and yields (1987).

Crop	Area harvested (ha)	Production (metric tons)	Yield (kg/ha)
Sugar (manuf.)	77,348	691,134	8,935
Tea (manuf.)	(82,752)*	-	-
Tobacco (leaves)	3,757	7,147	1,902
Foodcrops	634	903	1,424
(potato Irish)	5,017	53,130	-
(tomato)	(788)	(15,535)	19,703
(maize)	(647)	(6,825)	10,548
(rice)	(1.089)	(3,865)	3,551
(onion)	(14)	(40)	2,872
(others)	(202)	(2,145)	10,610
Fruits: bananas	(1,843)	(15,785)	-
pineapples	(371)	(7,920)	21,347
	(63)	(1,015)	16,139
Livestock			
Cattle[1]	-	1,423	-
-local Rodriguez	-	(1,194)	-
-imported	-	(229)	-
-goat & sheep[2]	-	173	-
-pigs	-	732	-
-poultry	-	7,500 (2)	-
-milk	-	11,000 (2)	-

[1] Abattoir slaughters only [2] Estimates * Effective area under cultivation
Source: Central Statistical Office (CSO), 1987a.

Table 2. Livestock numbers (1983 Census).

Type / Species	Cattle	Goats	Sheep	Pigs
Small breeders	15,920	72,278	589	7,054
Large breeders	8,255	76	1,359	1,031
government livestock stations	1,310	342	89	513
Total	25,485	72,696	2,037	8,598

Note: Small and large breeders: Exact definition is unspecified except for cattle where the small breeder is considered to be one holding less than ten heads. Generally small breeders are those small-scale units being run on a part-time basis, the production system being of an extensive type. Source: CSO, 1984.

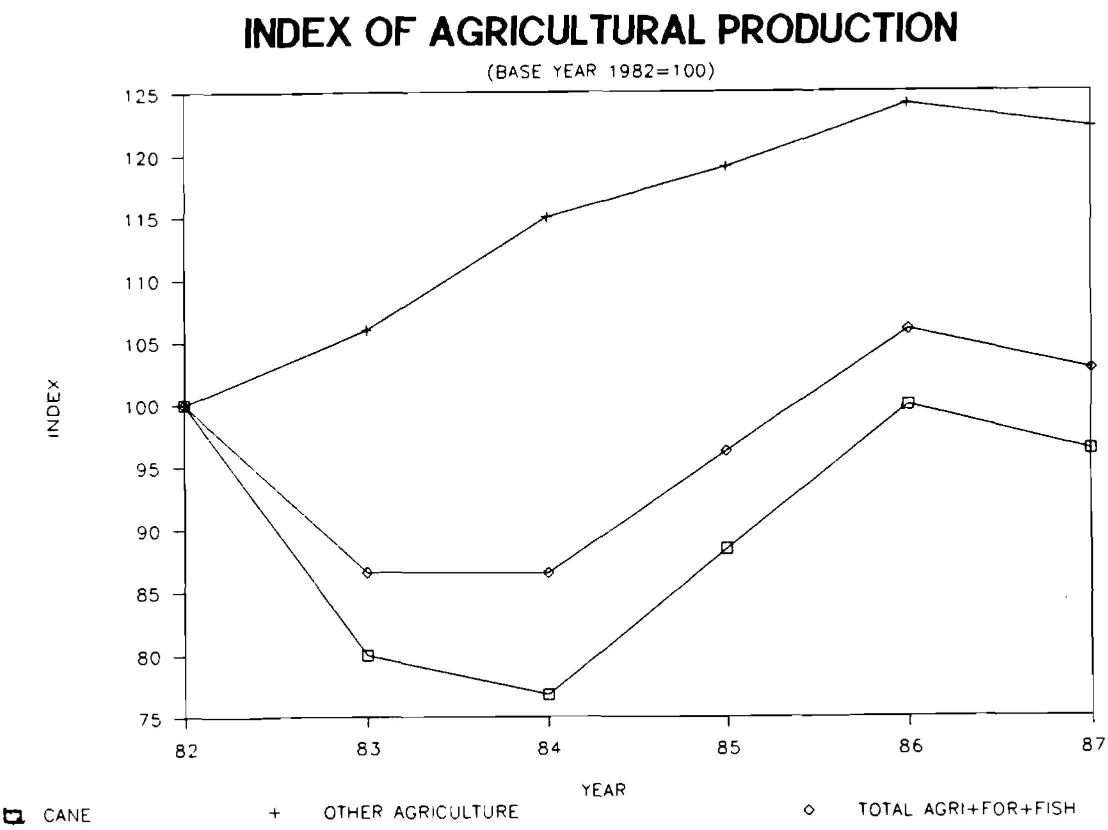

Figure 1. Index of agricultural production. Source: CSO, 1988a.

2. NATIONAL SOCIO-ECONOMIC DEVELOPMENT

The share of agriculture in GDP has been declining from 22% in 1976 to 15% in the period 1984/87, to an estimated low of 8% in 1989. A real decline in more recent years (1982-87) is also apparent in terms of agricultural production indices (Figure 1). Export duty levied by government on sugar is, however, a significant contributor to treasury earnings. It represented 11% of government current revenue in 1987, although this may tend to decrease since the promulgation of the Sugar Industry Efficiency Act of 1989.

Table 3 presents the significance of the agricultural sector in the national economy, and emphasizes the economic role of the sugar sector which accounted for 76% of agricultural GDP in 1985 (excluding sugar milling).

Table 3. Significance of the agricultural sector in the national economy in 1985 (Rupees million).

Economic activity	Gross output at producers' prices	Intermediate Consumption	GDP at market prices	Indirect taxes less subsidies	GDP at factor cost	Compensation of Employees	Gross operating surplus
Agriculture, Hunting, Forestry & fishing	3,098.0	990.0	2,108.0	-15.0	2,123.0	1,043.0	1,080.0
-sugarcane	2,184.0	646.0	1,538.0	-	1,538.0	883.0	655.0
-foodcrops, fruits & flowers	244.1	39.3	204.8	-12.4	217.2	30.0	187.2
-livestock	284.1	147.7	136.6	-2.6	139.2	18.0	121.2
-fishing	131.7	44.6	87.1	-	87.1	13.3	73.8
National Economy	31,211.5	14,594.3	16,617.2	2,737.6	13,879.6	6,570.4	7,309.2

Source: Compiled from CSO, 1987b.

The Mauritian agriculture is primarily export-oriented. It is still a significant generator of foreign exchange, and an important component in the balance of payments status. This is illustrated in Figure 2 in terms of 3 parameters:

AES = Agricultural Export Share

$$= \frac{\text{Total Agricultural Export Earnings}}{\text{Total Export Earnings}} \%$$

AEC (1) = Agricultural Export Coverage of Total Imports

$$= \frac{\text{Total Agricultural Export Earnings}}{\text{Total Import Bill}} \%$$

AEC (2) = Agricultural Export Coverage net of the Export Processing Zone (EPZ) imports

$$= \frac{\text{Total Agricultural Export Earnings}}{\text{(Total Import Bill-EPZ Import Bill)}} \%$$

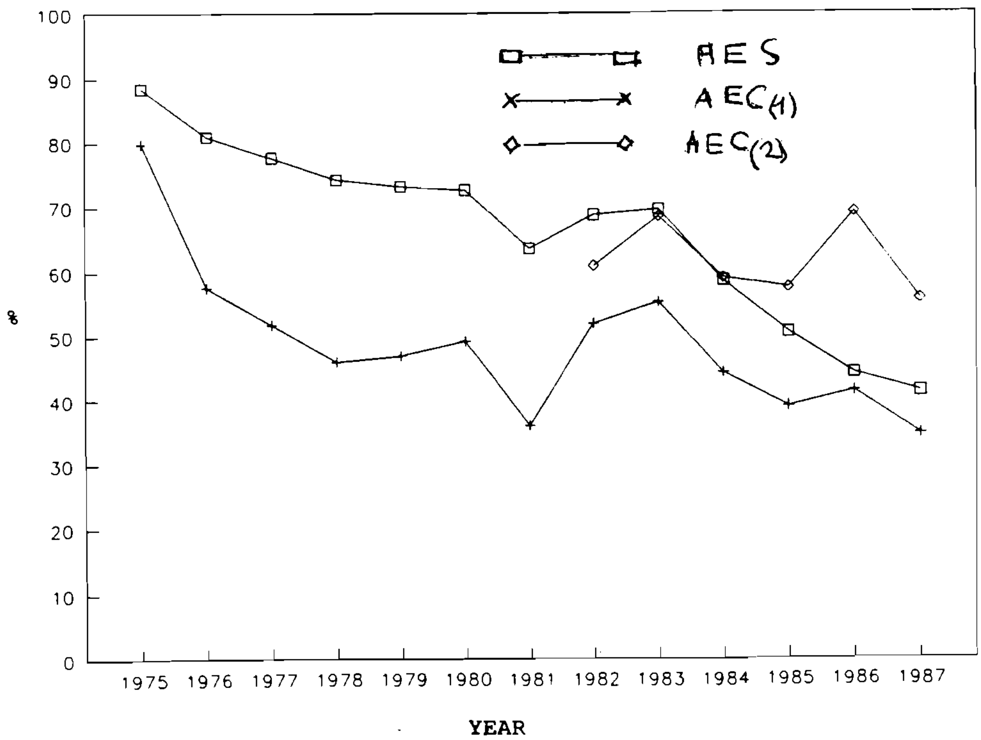

Figure 2. The relative importance of agricultural exports (at current value). Sources: Compiled from CSO, 1984, 1985, 1986, 1987a, 1988a.

The share of agriculture in total export earnings (AES) shows a significant decline from 88% in the mid-1970s to about 40% in the late 1980s. The ability of the agricultural sector to cover for our imports (AEC(1)) thus also shows a similar trend, essentially deriving from the increasing dominance of the Export Processing Zone (EPZ) sector in terms of gross export earnings and its effects on national income, and hence the standard of living. However, the EPZ sector is also a high consumer of imported raw materials,[2] and if this is taken into account, it is clear that agriculture (essentially the sugar industry) still remains the major net foreign exchange earner. Correcting for such EPZ imports (which are increasing) thus improves the coverage of the import bill by the agricultural sector (AEC(2)).

3. EMPLOYMENT GENERATION

The increasing problem of unemployment in the 1940s led to the creation of agricultural land settlement schemes and later, to an extensive expansion of the tea program, both on state-owned lands. However, it was realized from the early 1970s that the absorptive capacity of agriculture was limited and could not cope with the rapidly increasing population in the post-war period. Saturation point was not too far away. Eventually, that was the main factor that led to the setup of the EPZ in the early 1970s. Figure 3 shows a more recent trend of decline in employment status in large agricultural establishments (20% of total employed in 1987), particularly since 1983 when the EPZ sector started its second phase of development with a remarkable upshoot in its labor intake.

A sectional breakdown of the employment situation in the agricultural sector is presented in Table 4. The relative importance of small establishments is only approximative, but will be clearer when results of the recent 1990 Population Census are published.

The employment level in agriculture appears to have levelled off to around 75,000 for a few years now. Paradoxically, a different problem has surfaced recently. The increasing competition from the non-agricultural sector has created a seasonal lack of labor which is acutely felt during the sugarcane harvest season (Figure 3).

4. FOOD AND NUTRITION FUNCTION

On the global scale, agriculture obviously performs this primary - and its primeval-function quite satisfactorily. Food problems and crises, except for occasional periods of natural and man-induced calamities, appear to be more related to distributional and income factors. The picture can be quite different at country levels.

[2]The ratio Net Earnings/Gross Earnings are: EPZ - 23%; Tourism - 15%; Sugar industry - 80%.

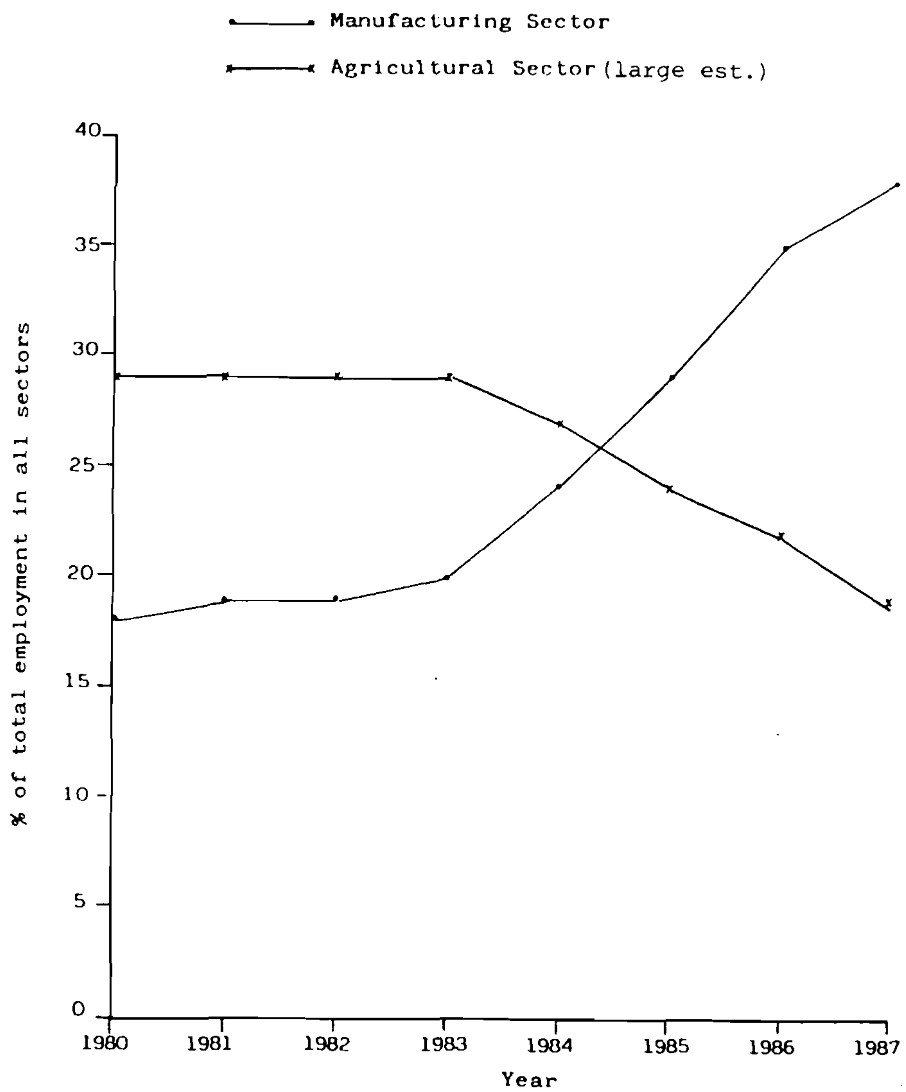

Figure 3. Comparison of the share of employment in the agricultural and manufacturing sectors. Source: CSO, 1988b.

The Mauritian agricultural system may be considered to satisfy national food requirements. But it does so in an indirect manner, in terms of generating enough foreign exchange earnings to import consumed food items.

Table 4. Employment in the agricultural and fishing sector (large and small establishments), June 1988.

Sector	Large establishments			Small establishments			Total agricultural and fishing employment		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Sugar	31,148	10,562	41,710	4,000	3,000	7,000	35,148	13,562	48,710
Tea	2,141	809	2,950	4,000	4,000	8,000	6,141	4,809	10,950
Fishing	464	27	491	3,000	-	3,000	3,464	27	3,491
Other	1,307	838	2,145	9,000	8,000	17,000	10,307	8,838	19,145
Total	35,060	12,236	47,296	20,000	15,000	35,000	55,060	27,236	82,296

Notes: Agricultural (large) establishments comprise:

(i) Sugar cane plantations where 25 arpents or more were harvested, and the sugar factories.
(ii) Tea plantations of 5 arpents or more, tea factories and the Tea Development Authority.
(iii) All "flue-cured" tobacco establishments irrespective of acreage.
(iv) Other agricultural establishments employing at least ten persons on the day of the survey.

1 arpent = 0.4221 hectare.

Source: CSO, 1988a.

The concept of Agricultural Export Coverage is used again in Figure 4 to show the extent of coverage of our food import bill by agricultural exports.

AEC = Agricultural Export Coverage of Food and Beverages Import Bill

(3) = $\frac{\text{Total Agricultural Export Earnings}}{\text{Food and Beverages Import Bill}}$

AEC = Agricultural Export Coverage of Food, Beverages, and Agricultural Inputs Import Bill

(4) = $\frac{\text{Total Agricultural Export Earnings}}{\text{Food, Beverages, and Agricultural Inputs Import Bill}}$

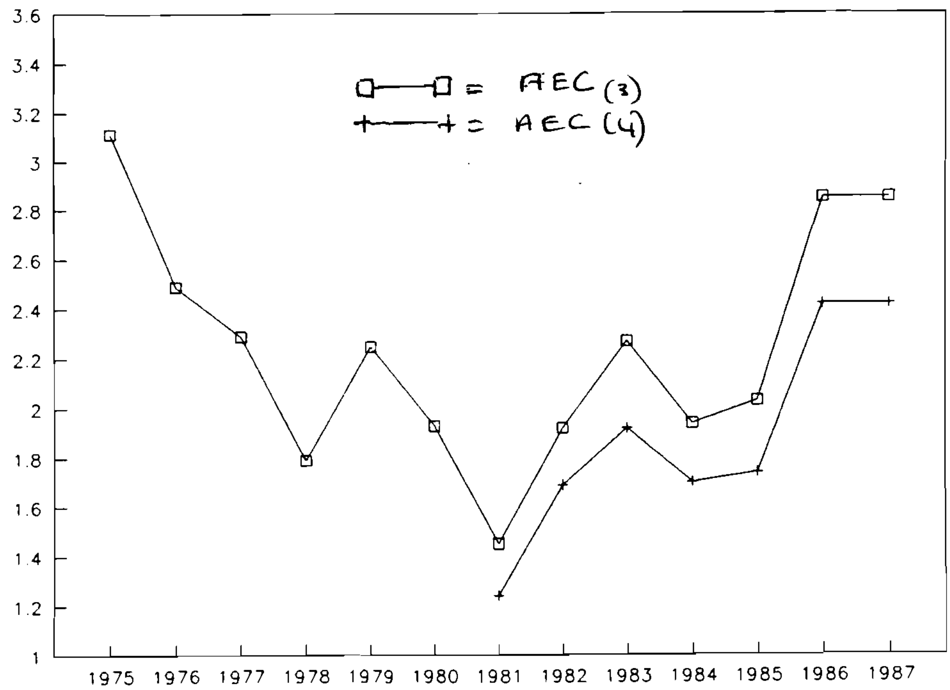

Figure 4. Agricultural trade related to food imports (estimates at current value). Sources: CSO, 1984, 1985, 1986, 1987a, 1988a.

AEC(3) shows a steady decrease from a ratio of 3.11 in 1975 to a serious slump in 1981. It picks up later, agricultural export earnings being 2.85 times the total food import cost in 1987. AEC(4) follows a similar trend, clearly at a lower level as it accounts also for imported agricultural inputs.

The favorable coverage of food imports by agricultural exports is accompanied by improving the sustainability of food intake levels in quantitative terms. Figures 5 and 6 indicate these trends.

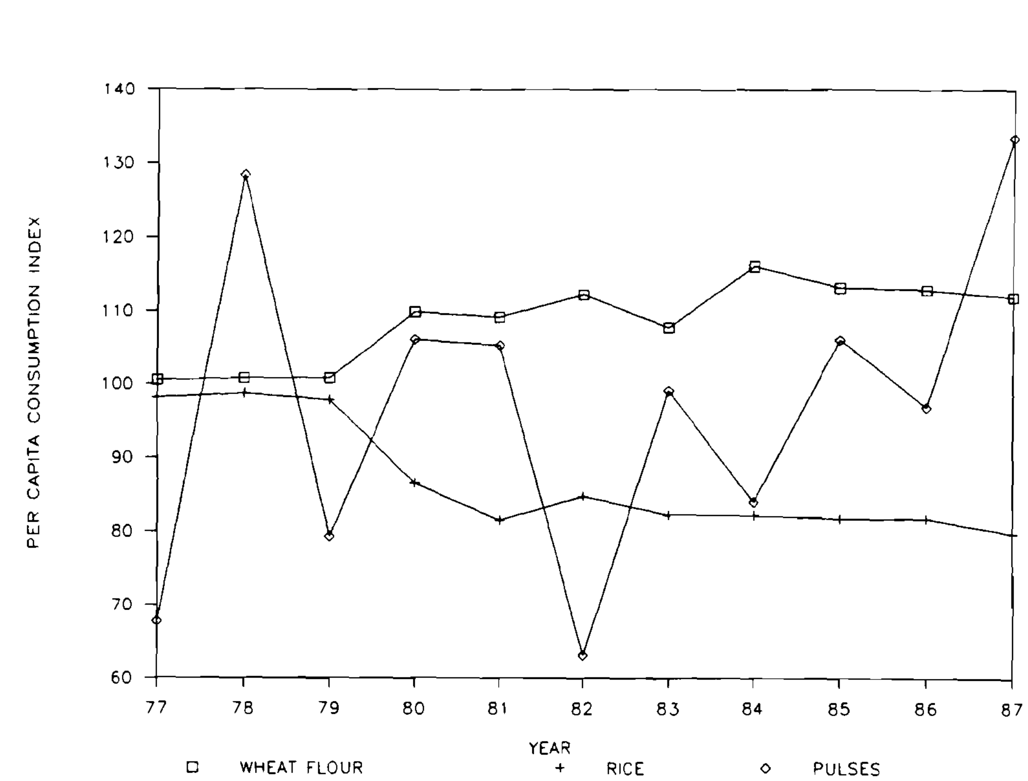

Figure 5. Per capita food consumption indices, (base year 1976 = 100%). Sources: CSO, 1984, 1985, 1986, 1987a, 1988a.

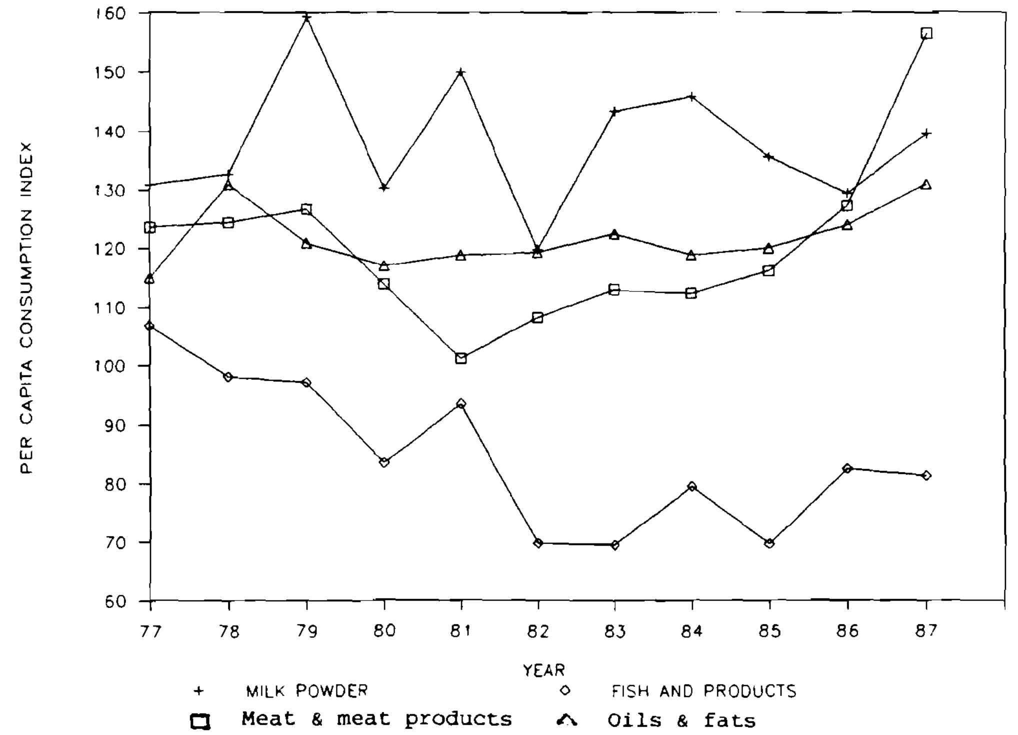

Figure 6. Per capita food consumption indices, (base year 1976 = 100%). Sources: CSO, 1984, 1985, 1986, 1987a, 1988a.

The per capita consumption of the major imported foods with relatively high income elasticity of demand are on the increase during the period concerned. Rice intake shows a downward trend, probably in favor of wheatflour, while the apparent diminishing consumption of fish may be reflective more of decreases in fish catches, although official estimates of these appear to be underreported.

Assessed in monetary terms, the Mauritian agricultural system clearly satisfies the food requirements of the population. However, when judged as a direct contributor, in kind, to national food supply and food security (a normal expectation from agriculture to safeguard the effective or physiological food and nutritional demand), its performance is poor.

The concept of Food Self-Sufficiency Ratio (FSSR) can be used here. This parameter can be expressed in various ways: monetary, quantitative, nutritional, aggregate or on an individual food basis. All of these have their limitations, and only the monetary evaluation is presented here, in relation to two broad groups of food, foodcrops and livestock:

(i) National FSSR (Foodcrops)

$$= \frac{\text{Gross Output at factor cost (foodcrop)}}{\text{(Gross Output at factor cost (foodcrop) + Net trade in foodcrop related production)}}$$

(ii) Domestic FSSR (Livestock and Poultry)

$$= \frac{\text{Gross Output at factor cost (livestock and poultry)-Imports of Inputs}}{\text{(Gross Output at factor cost (livestock and poultry)+Net trade in livestock production)}}$$

Self-sufficiency ratios thus defined are relatively low, although an improvement is noticed in recent years: 26% to 35% for livestock and 15% to 24% for foodcrops between 1977 and 1986 (Table 5). Progress has in fact been mostly achieved in poultry and potato production.

Table 5. Food self-sufficiency ratios for foodcrops and livestock products (per cent).

Year/ Sector	1977	78	79	80	81	82	83	84	85	86
Foodcrops*	0.20	0.20	0.18	0.16	0.15	0.17	0.19	0.21	0.23	0.24
Livestock & poultry**	0.32	0.29	0.27	0.26	0.26	0.26	0.27	0.27	0.32	0.35

* Foodcrops:

(i) Include vegetables, fruits and rootcrops normally produced in Mauritius.

(ii) Net trade includes imports of cereals, vegetable, fruits and spices and export of vegetables and fruits.

(iii) Sugar and tea are excluded as they do not constitute the normal components of the diet, both on habitual and nutritional considerations.

(iv) This is a national parameter, the imported inputs not being considered. Such data are presently unavailable on a separate basis for the foodcrops concerned.

**Livestock:

(i) Ratio referred to as "domestic" because it accounts for imported inputs in the livestock sector (feed and live animals).

(ii) Net trade equals imports, in the virtual absence of any livestock exports.

Note: Exports are FOB and Imports CIF. Sources: CSO, 1987a, 1987b.

5. RESILIENCE OF THE AGRICULTURAL SYSTEM

The Mauritian agricultural system is still highly dependent on sugar and on preferential international trade arrangements, while being entangled within an internal web of a socio-politico/agro-ecological complexity. An assessment of its resilience can be made by an account of its evolution in the recent past, when it was subjected to shocks of different kinds.

The windfall gains following the boom years of 1973 and 1974 improved the national economy and enhanced its capacity to support import payments. It is significant to note that the then government took a bold and judicious decision to secure the European Community (EC) sugar market on a long-term basis as from 1975. At a time when the world market price was rocketing high, a guaranteed quota was contracted for an EC price, which was about two-fifths of the prevailing free market price.

Sugar prices slumped in 1976, followed by a second oil crisis in 1979. The buffering effect of the EC sugar protocol could already be felt. But the capacity of agriculture to sustain a positive balance of payments and trade position, and the enhanced standard of living itself resulting from the 1973/74 boom years was to regress. The foreign indebtedness of the country increased, and the government had to devalue the Mauritian currency in October 1979.

The price of sugar on the world market improved in 1980/81. However, the EC quota commitments with the droughts and cyclones of 1980 and 1981 nullified any benefit for Mauritius. No sugar was exported to the U.S. in 1981, and most economic indicators were at critical levels. The standard of living itself might have been affected. Consumption of some imported food items slightly depressed in 1981/82 (Figures 5 and 6).

The economic readjustment program initiated in 1979 led to a second devaluation in 1981. The government lost the June 1982 general elections in a dramatic way. The immediate problem of the newly-elected government was the budget preparation. Public expenditure cuts and the improvement of the balance of payments were considered pressing strategies. Two sore areas were noted:

1. Subsidies on rice and flour, which drained Rs 296 million in 1980/81, i.e. 9.6% of current government expenditures.

2. The food import bill which in 1981 amounted to Rs 1,197.2 million, i.e. 24% of the total import bill, and 74% of the sugar export revenue.

The state of economic recession which led to increased access to the World Bank and IMF support demanded a major policy re-orientation, according to the government. As far as agriculture and food were concerned, the "cash-crop, cheap food" agro-food policy bias had to be readjusted to be compatible with the economic realities of the day, and the economic imperatives of the future. The strategy was to gradually phase out food subsidies on imported rice and flour, while initiating a more aggressive agricultural diversification/food import substitution program. It was proposed to reallocate marginal sugarcane lands to food production as from 1987 (at the rate of 1% p.a.), and to set up an Agricultural Diversification Corporation, a parastatal agency to implement the program. A sustained campaign followed. Two White Papers were published: one on Rice and Flour (Ministry of Finance, 1982), and another on Agricultural Diversification (Ministry of Finance, 1983). The recommendations of a workshop on "Food Habits" of the nation were approved and publicized (Government of Mauritius, 1982).

The government split up in March 1983; another one was elected in August 1983. The post-1983 strategy was the rehabilitation and consolidation of the EPZ and Tourism sectors which had remained quite lethargic for many years. Substantial progress was achieved in the industrial and service sectors.

The agricultural and food trade balance improved significantly, with falling rice and flour prices, while sugar prices were maintained relatively high by the sugar protocol, and tea experienced a boom in 1984. The weather also was rather favorable for most of the second half of the 1980s.

The food subsidy bill became lighter, even in absolute terms, and it is still maintained. Although a study was carried out on the practical aspects of re-allocation of sugarcane lands, no enforcement measures have been taken and the Agricultural Diversification Corporation has not been set up. The current strategy also aims at the development of export-oriented, high-value horticultural production, while maintaining the objectives of improving food self-sufficiency in selected foods.

The social commitments are now fairly shared by the EPZ and other sectors of the economy, and the rough winds have subsided. The agro-food system with sugar at the helm is able to sail along, as it has been doing for a century and a half now.

6. FUTURE PROSPECTS

The International Dimension

Around 80% of sugar exports (about 500,000 metric tons p.a.) are presently guaranteed by the EC within the terms of the sugar protocol of the Lomé Convention. The protocol is renewable on a 5-year basis, for an "indefinite" period.

The prospects for sugar exports already appear shaky. There is a controversy about the meaning of "indefinite" duration. The EC sugar price, which was about three times the world market price in the past five years, has been frozen for a few years now. The existing arrangement is due for renewal in 1991, on the eve of European unification; the full implications are still unclear. The EC has recently declared a policy of cutting down on its farm subsidy and other support programs by 30% between 1986 and 1996. The political motivation in favor of the African, Caribbean, and Pacific (ACP) countries may thus suffer a serious setback in the near future, especially as the EC is no longer in a deficiency position regarding sugar production.

The U.S. market has been seriously dwindling in the past decade. It represented 19.55% of total sugar exports in 1979, and only 1.58% in 1988. This trend reflects the drastic change in sugar consumption patterns in the U.S. in favor of other non-caloric sweeteners.

The tea sector is even more vulnerable. It has no trade arrangements similar to those of sugar, and the revenue is totally dependent on the vagaries of the world free market, of which Mauritian exports represent less than 1%. It is presently going through a crisis period following the boom of 1984.

The Internal Dimension

The small-scale sector in agriculture is too fragmented and marginal with low profitability. It is afflicted by labor scarcity due to increasing competition with the EPZ and services sectors; marketing problems for some types of produce (milk, vegetables); scarcity and costs of agricultural inputs; and the inadequacy of infrastructural and institutional/credit support measures. The larger-scale sector is also hit by the labor shortage and marketing problems for some types of commodities (e.g. beef production).

A more insidious problem has been seeping in through the years, that of increasing encroachment of agricultural lands by other sectors of the economy. Table 6 summarizes the evolution of land use between 1965 and 1986. The expansion of physical infrastructural development (by 215% in the 1965/86 period) has had the effect of reducing agricultural, mainly sugarcane lands by 15%, i.e. by 16,163 ha. The sugar industry has so far been readjusting through improved productivity and thus partially absorbed such diminution of its resource base. Agro-ecological factors are also constraining. Cyclones and droughts have been mentioned. Soil conditions are satisfactory for large estate plantations, as a result of mechanical land preparation through the past 40 years or so, but they are still limiting for most other agricultural producers in terms of rockiness and topography.

Table 6. Land use in Mauritius (1965 and 1986).

Sector	1965 Area (ha) / % of total	1986 Area (ha) / % of total
<u>Agriculture</u>	<u>106,228</u> (56.95%)	<u>90,065</u> (48.29%)
Sugar cane	97,973 (52.53%)	83,289 (44.65%)
Tea	6,232 (3.34%)	3,776 (2.02%)
Foodcrops, tobacco & others	2.023 (1.08%)	3,000 (1.60%)
<u>Forests, scrubs, grasslands & grazing lands</u>	<u>64,465</u> (34.57%)	<u>65,330</u> (35.02%)
Forest plantations	6,775 (3.63%)	6,774 (3.63%)
Natural forests (nature reserves)	2,387 (1.28%)	2,388 (1.27%)
Savannahs, grasslands, meadows, etc.	7,446 (4.05%)	7,446 (4.0%)
Scrub & other forest lands	47,857 (25.66%)	48,772 (26.15%)
Built-up infrastructure/areas	11,857 (6.36%)	25,500 (13.67%)
Others (reservoirs, roads, rocks)	3,925 (2.12%)	5,605 (3.02%)
Total	186,500 (100%)	186,500 (100%)

Source: Ministry of Housing, Lands and the Environment, 1990.

7. AGRICULTURE AND THE ENVIRONMENT

The significance of agriculture-environment interactions, topical in the context of sustainable development, is still a grey area. There is a need to identify and quantify such interactions and their implied environmental benefits/costs.

Some Positive Interactions:

1. Agriculture generally keeps the environment green.
2. Soil fertility overall has been maintained in Mauritius. Cultural practices, particularly in the sugarcane sector, may be deemed satisfactory. Sugarcane yields have in fact been increasing: 8.08 mt/ha in the 1950s; 8.88 mt/ha in the 1970s; and 9.9 mt/ha in the 1980s.
3. Agriculture has a significant role in limiting indiscriminate use of lands in the non-agricultural sector.

4. Crop-livestock interactions are favorable and minimize waste problems (e.g. use of livestock wastes and sugarcane scums as manures; feeding of canetops and other sugar by-products to livestock).

Some Negative Interactions:

1. The extensive development of the tea program since the mid-1950s led to a decrease in forested areas and affected to some degree the water catchment zones. The program, however, was subsequently scaled down, and one of the factors considered was precisely its potential environmental hazard.
2. Some reports exist about excessive use of fertilizers and pesticides, although controversy prevails regarding actual application rates.
3. Cultural practices on sugarcane interlines do pose a potential hazard in terms of erosion and loss of soil fertility.
4. Goat browsing and its negative impacts on forests and scrublands, particularly on hillsides.
5. Animal husbandry in/around residential areas, e.g. pig production.
6. Tobacco cultivation/health interactions.

8. CONCLUDING OBSERVATIONS

The Mauritian agricultural system still constitutes the backbone of the national economy, although it is increasingly superseded by the EPZ sector. It constituted the base for industrial development. It also partially relieves the energy sector through the use of bagasse. It has contributed to the development of water resources in terms of irrigation infrastructure development. Finally, it compensates for its limited role in food production by generating more than enough revenue to import food.

However, there exists a dichotomy arising from a strong, deep-rooted sugar conservatism in the internal socio-economic fabric (called the "sugar mentality" in Mauritius), that derives from a long history of sugar-based agriculture and the superior bio-adaptability of sugarcane, in contrast to the fragility of sugar itself to exogenous factors. Reconciliation is so far being achieved through:

1. International marketing arrangements and strategies, which appear to maintain, even strengthen, the indigenous conservatism and complacency.
2. A structural adjustment program of the national economy.
3. Maintenance and consolidation of the sugar industry.
4. Agricultural diversification.

Political diplomacy is extensively used to preserve and improve the sugar protocol arrangement. Efforts are geared at improving the quality of tea to fetch higher prices. An export-oriented strategy for high-value agricultural products is pursued. The national economy has been going through a restructuring phase, particularly in the 1980s, through the expansion and consolidation of the EPZ and tourism sectors.

Encroachment of agricultural (mainly sugarcane lands) is now strictly controlled. Thus far the sugar industry has been buffering this drain through increasing productivity. The upper limit of this capacity will be determined by the agro-ecological potential of the remaining agricultural land resources and technological development, but it may still be significantly high even if existing yield variations are considered. To harness such potential would need massive capital and technological investment plus a package of socio-economic measures and incentives needed to offset the relatively disadvantaged position of the agricultural sector in comparison to the industrial and services sectors.

The sugar sector was already provided with the necessary incentives to modernize and improve its efficiency, through the Sugar Industry Efficiency Act of 1989. Other measures to improve productivity are at various stages of implementation. They include the Prime Minister Land Derocking scheme, irrigation extension and development (e.g. drip system), product diversification (special sugars), breeding of better sugarcane varieties, consolidation of the small-scale sugarcane sector (land area management units with its benefits of economies of scale), extension and a package deal of other services and incentives (Farmers' Service Centers).

These measures are also expected to benefit agricultural diversification also. In fact, one of the trade-offs for partial relief on the export duty on sugar (that particularly hits the large-scale sugar estates/millers) is agricultural diversification, particularly for food production.

Agricultural diversification has had limited success so far except for poultry and potato production, and small-scale vegetable production. Diversification has been essentially restricted within the boundary of the sugar system while having to be necessarily compatible with and subservient to sugar production. Nonetheless, it has been an efficient use of the sugar industry resources, i.e. land, labor and infrastructure.

The agricultural diversification debate is a long-standing one. History indicates that it had always gained importance in periods of low sugar prices, and wars when food security imperatives obviously predominated. The current debate revolves around agricultural land re-allocation and a food import substitution/food security strategy versus production of special export-oriented products.

While both import substitution and export promotion are supported, the current approach regarding land use may be summarized as follows: An annual production target for sugar has been set at 640,000 metric tons to safely meet all commitments, while improvement of productivity in the longer-term would allow release of land that would be diverted to agricultural diversification. Concomitantly, the use of land resources should be increased to the optimum level by multiple production systems, e.g. by maximizing the use of available interlines and rotation lands in the sugar sector, and by agro-forestry systems.

The actual removal of sugarcane lands for agricultural diversification still seems heretic (but less so in regard to tea lands), although such shifts directed to non-agricultural development have been occurring at a fast pace. Such re-allocation of land resources have to be faced in the long-term, not only within the agricultural sector but also between agriculture and the rest of the economy. The current exercise of the National Physical Development Plan is extremely important in terms of sustainable development.

There are more specific social implications also in terms of agricultural and food policy. Who in the Mauritian society is actually going to produce the food that could and should be produced? And who in the population is actually going to adapt their consumption patterns to the production potential of the agricultural system and the natural resource endowments of the country? Could the "cash-crop/cheap food" policy be indefinitely sustained with the likely substantial increases in food imports and the heavier burden of food subsidies? And could nutritional-health interactions be convincing enough towards a gradual change in diets?

Little success has been achieved so far in these areas. The eternal producer-consumer conflict can only partially explain the lack of achievement. In fact, it derives more from the socio-cultural complexity of the Mauritian society which makes the whole issue a sensitive one with high political overtones.

There are other factors to be considered in relation to the resilience of the agricultural system. They may be long-term (climate effects, technological development), or sudden-crisis situations. These could be very serious indeed and could arise from:

1. An international energy/food crisis with rocketing prices of imported strategic/basic goods;
2. natural calamities (cyclones, droughts);
3. war conditions, and/or
4. the collapse of existing marketing arrangements, e.g. the sugar protocol.

Their impacts may be disastrous. It would then be imperative to have some sort of contingency planning to mange such occurrences. What would be the cost implications? Clearly the issues are complex. The interconnectedness of the agricultural system with the rest of the economy and the environmental implications increase the complexity, and call for a holistic study. The IIASA project, as a complement to the Enhancing Carrying Capacity Options (ECCO) project of the University of Mauritius, may offer the ideal framework for such study.

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Chapter 16

MAURITIAN AGRICULTURE FROM AN INTERNATIONAL PERSPECTIVE

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IIASA

1. HOW DOES MAURITIUS COMPARE

With less than 0.01 percent of the world's arable land and about 0.02 percent of the world population, Mauritius plays a very modest role in the international agricultural scene.

In the UN/FAO (Food and Agriculture Organization) nomenclature, Mauritius belongs to the group of middle-income sub-Saharan African countries including countries like, for example, Cameroon, Côte d'Ivoire and Zimbabwe.

The Mauritian level of development, economic performance, and agricultural productivity compares favorably to the average performance within the group of middle-income sub-Saharan countries, as illustrated by several indicators shown in Table 1. This has mainly been achieved by the steady economic growth (with ups and downs, of course) during the last two decades, a development mainly led by rapid increases in textile export processing introduced in 1970 shortly after independence.

2. HOW DOES MAURITIUS INTERACT WITH THE GLOBAL FOOD SYSTEM

About half of the total area of Mauritius, practically all suitable land, is occupied by agriculture of which more than 90 percent is under one single crop, sugar cane. It comes as no surprise that this very high degree of specialization implies an equally high level of interaction with the international markets, regarding both agricultural exports and imports.

Agricultural Exports

Around three quarters of Mauritian agricultural production are exported, with sugar accounting for close to 95 percent of agricultural exports and tea for some 5 percent in the mid-1980s. Although establishing the export processing zone (EPZ) after 1970 has decreased the share of agriculture in total export earnings from more than 90 percent in 1969/71 to about 50 percent in 1984/86 and close to 40 percent in recent years, agriculture still is an important source of foreign exchange earnings.

Table 1. Performance of Mauritian economy - selected indicators.

	Mauritius	Mid-income African economies	Sub-Saharan Africa
GNP per capita 1987 (dollars)	1490	870	330
growth 73-80 (% p.a.)	3.9	-1.2	0.1
growth 80-87 (% p.a.)	4.4	0.3	-2.8
Life expectancy at birth 1987 (years)	67	53	51
Population growth 80-87 (% p.a.)	0.9	3.3	3.1
Urban as % of total population	42	37	27
Labor force 1980, % in			
Agriculture	28	71	71
Industry	24	9	8
Services	48	20	15
ODA per capita 1987 (dollars)	65	39	25
Debt as % of 1987			
GNP	4.3	5.3	4.1
Exports	6.1	14.6	14.7
Share of Agriculture in GNP 1987	15	27	34
Fertilizer/ha of arable land 1986 (kg)	236	12	9
Food prod/cap in 1985/87 (79/81 = 100)	103	97	100
Energy cons/cap 1986 (kg oil equiv.)	378	265	105

Note: ODA: Official Development Assistance. Source: World Bank data.

Figure 1 shows levels of production and exports of sugar from 1961 to 1987. In the order of 700 thousand tons of sugar are produced annually of which some 600 thousand tons are exported. Some 80 percent of sugar exports are guaranteed by the European Community (EC) in the context of the sugar protocol of the Lome Convention. This preferential treatment has been of great importance to Mauritius in securing foreign exchange earnings from agriculture.

Figure 2 indicates the role of Mauritius in the world sugar market. Despite production increases, the importance of Mauritius in terms of the share in world production and trade of sugar has decreased over time. In the early 1960s, Mauritius contributed close to 1 percent of global sugar production. Over the last 25 years this share has been reduced by half to less than 0.5 percent. Over the same period, the share of Mauritian exports in world sugar trade has experienced a decline from more than 3 percent in 1962/64 to about 2 percent in the late 1980s. Nevertheless, it is the third largest sugar producer in Africa, South Africa and Egypt topping sugar production in that region, and ranks around position thirty on the global scale. Tea exports, although of some importance for the agricultural economy in Mauritius, have no international significance.

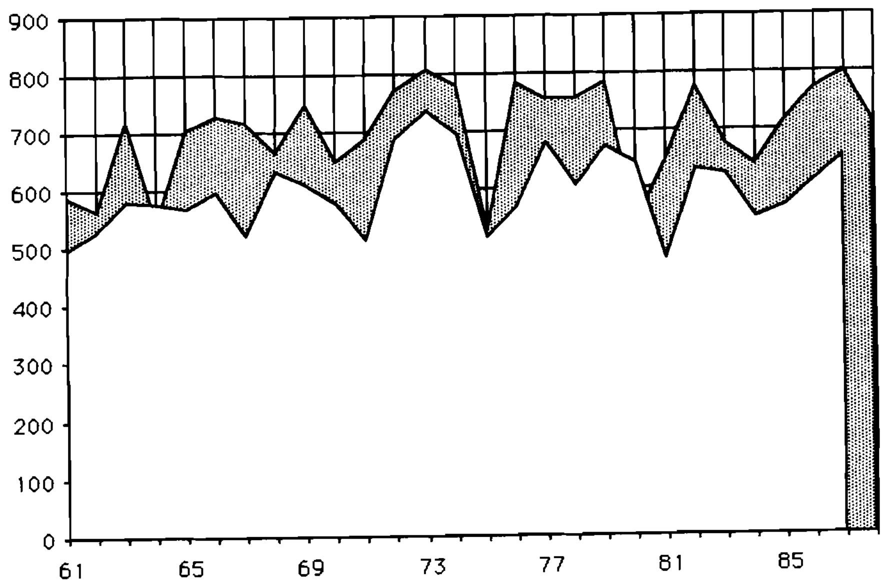

Figure 1. Production and export of sugar (thousand metric tons). Source: FAO/AGROSTAT data tapes.

Figure 2. The role of Mauritius in the world sugar market.
Source: FAO/AGROSTAT data tapes.

Agricultural Imports

Although varying somewhat, the share of agricultural imports in domestic food consumption amounts to some 70 percent. Except for root commodities - Mauritius falls into the humid zone ideally suited to production of tropical root crops - self-sufficiency in most commodity groups has stagnated or even deteriorated. These imports, however, are more than covered by sugar export receipts.

Figure 3 shows historical trends in self-sufficiency of cereals, pulses, and vegetable oils. Insignificant amounts, well under 5 percent of domestic consumption, of cereals are produced domestically. The domestic maize crop is complemented by imports mostly in terms of wheat and rice.

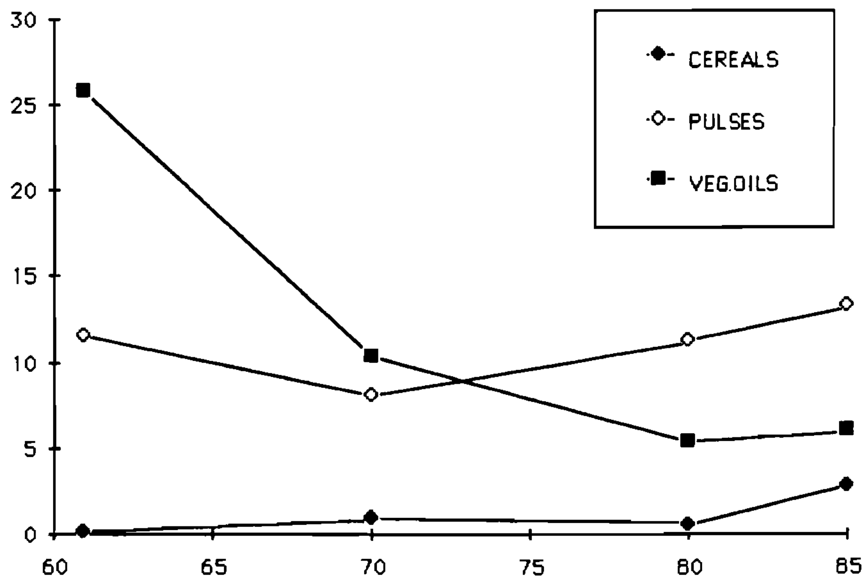

Figure 3. Self-sufficiency in cereals, pulses, and vegetable oils. Source: FAO/AGROSTAT data tapes.

Figure 4 shows self-sufficiency ratios (SSR) of root crops, meats, and milk. In the last 25 years the contribution of domestic roots production to national demand has increased from 50 percent to about 80 percent. SSR of meats has remained at around 50 percent. Self-reliance in dairy products has gradually eroded to reach a level of about one-quarter of domestic consumption.

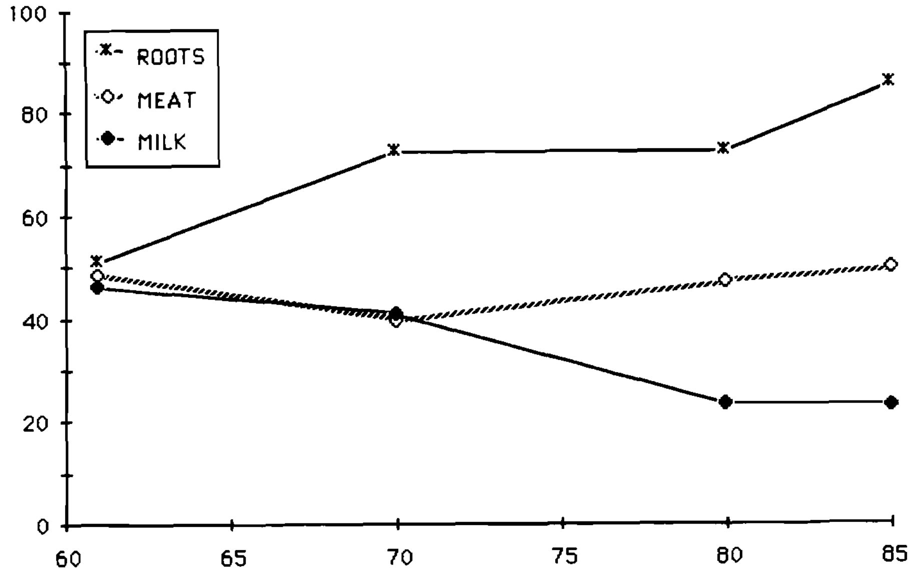

Figure 4. Self-sufficiency in roots and livestock products.
Source: FAO/AGROSTAT data tapes.

The structure of agricultural imports, in value terms, in the middle of the 1980s is presented in Figure 5. Import requirements of cereals account for around 40 percent of agricultural imports, meat and dairy products account for one quarter, and vegetable oils for 15 percent. All other agricultural products constitute the remaining 20 percent of the agricultural import bill.

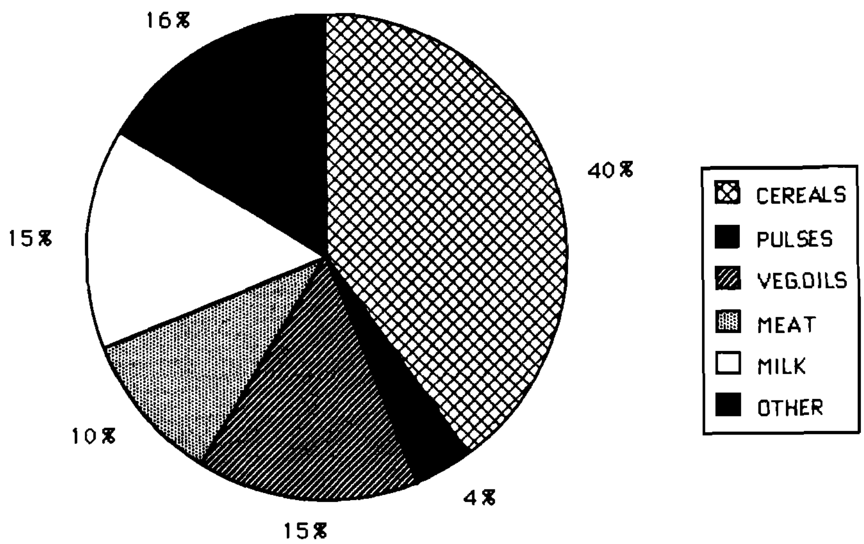

Figure 5. Structure of agricultural imports in the mid-1980s.
Source: FAO/AGROSTAT data tapes.

For countries with high integration in international markets, such as Mauritius, it is of importance to the trade balance, inflation, and employment that prices of exported goods and imports remain balanced. Figure 6, for example, shows historical prices of wheat and sugar. It clearly indicates that the variability of international sugar prices exceeds that of wheat. This underlines the importance of the preferential treatment of Mauritian sugar exports by the EC, thus largely stabilizing foreign export receipts from agriculture.

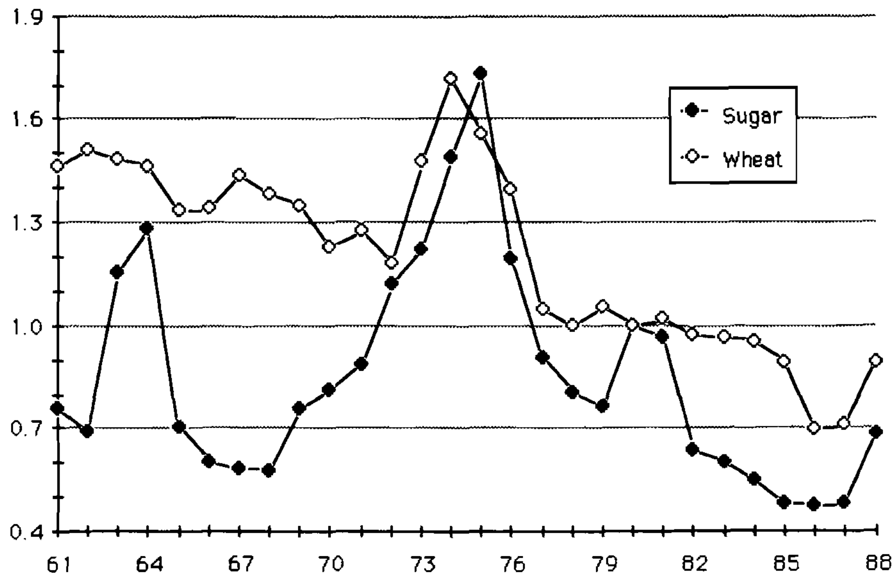

Figure 6. Index of world market prices, wheat and sugar. Source: FAO/AGROSTAT data tapes.

3. FUTURE PROSPECTS

According to an agro-ecological assessment (FAO/IIASA/UNFPA, 1983), one-third to one-half of the arable land in Mauritius has good suitability for maize, rice, and root crops. This land, at the expense of sugar production, could be used to satisfy most of the domestic cereal demand (except, of course, for wheat). Two-thirds or more of the arable land is well suited for sugar, banana, and oil palm. Economic reasons and frequently occurring hurricanes, however, do not favor the latter two crops.

All of the potentially arable land in Mauritius is already in use. Infrastructure and land requirements of the non-agricultural sector encroach on the arable land base. Yield increases, therefore, are the only means to promote growth of agriculture production.

Diversification in agriculture has been a political issue in the past. Although, as indicated above, Mauritius could theoretically produce most of its staple food requirements, a shift towards increased self-reliance is not likely to occur, both for cultural and economic reasons. After more than a century of cultivation, sugar is deeply rooted in the Mauritian society. More important though, a simple "back of the envelope" calculation reveals that sugar production is by far the most profitable use of arable land, yielding certainly twice as much per hectare compared to what could be expected from cereal production even under good management. Under current circumstances, economic reasons are therefore not likely to promote diversion of land from sugar to cereal production.

This is true even if sugar may somewhat lose in the medium term on international markets relative to cereal prices, as projected by a simulation of the IIASA/FAP agricultural world model (Fischer et al., 1988). Figure 7 shows an index of cereal prices and "other food" crops (the aggregate into which sugar falls in the IIASA/FAP commodity classification) obtained from the model for the years 1990 to 2025. Under the assumptions of the reference scenario, "other food" crops lose about 10 percent relative to cereal crops over this 35 year period. Other simulations with the IIASA/FAP model system, assessing the potential effects of climate change on world food supply, demand and trade, indicate even somewhat stronger negative impacts on agricultural terms of trade for Mauritius. Figure 8 shows the index (1990 = 1) of "other food" world market prices relative to cereals under different climatic assumptions.

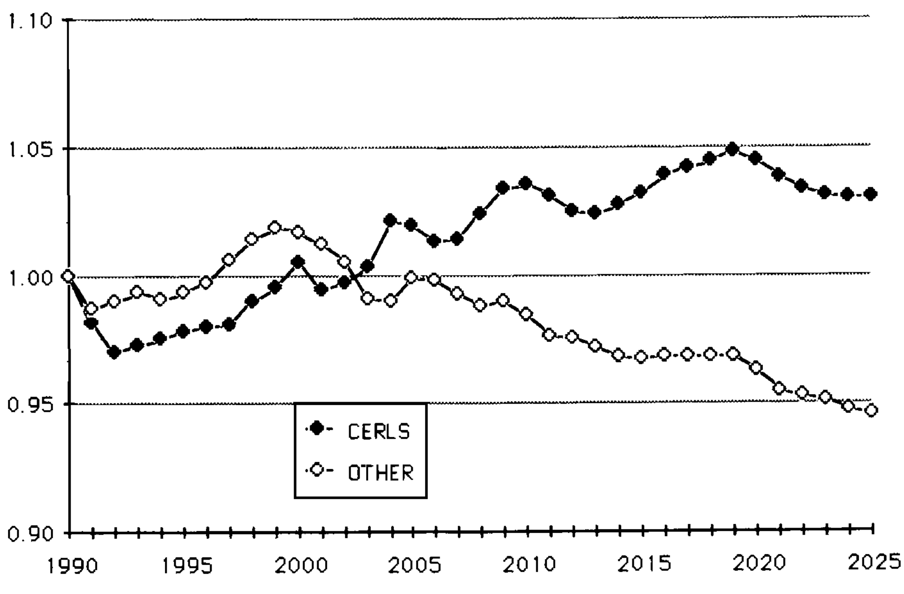

Figure 7. Projection of international agricultural prices, 1990-2025. IIASA/FAP reference scenario. Source: IIASA/FAP basic linked system.

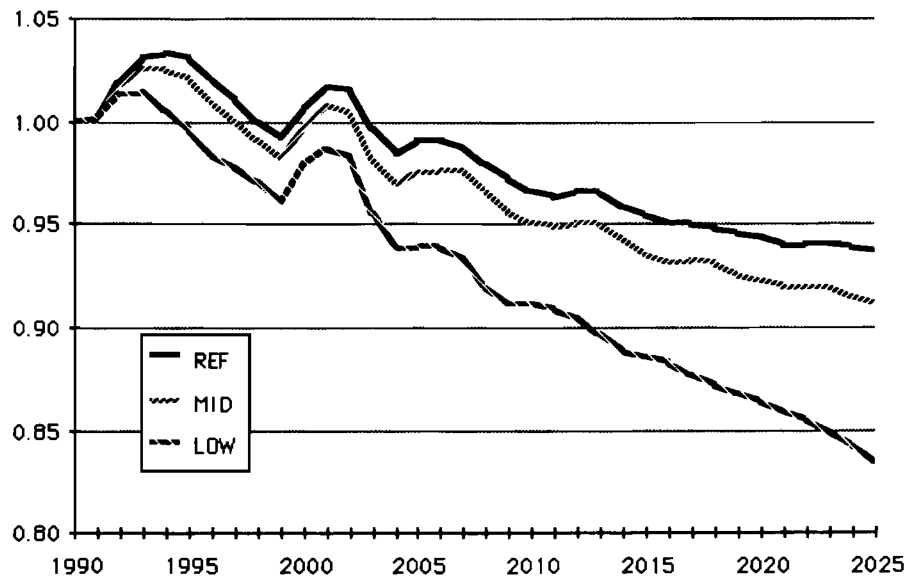

Figure 8. Index of international agricultural prices under alternative climate change scenarios. Source: IIASA/FAP basic linked system "Impact of Climate Change on World Food Supply, Demand and Trade."

Notes: REF: Reference Scenario, assuming no climate change yield impact.
MID: Middle Estimate Scenario, a likely assessment of climate impact yield changes.
LOW: Low Estimate Scenario, a pessimistic assessment of climate impact.

The analysis suggests however that Mauritian agriculture might want to reappraise the situation if the EC preferential sugar treatment were to be discontinued.

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Chapter 17

TOURIST DESTINATION CYCLES AND SUSTAINABLE DEVELOPMENT: A COMPARATIVE ANALYSIS OF THE BAHAMAS AND MAURITIUS

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1. INTRODUCTION

Recent works by Butler (1980) and others (Hovinen, 1981, 1982; Meyer-Arendt, 1985; Stough, 1985; Richardson, 1986; Keller, 1987; Strapp, 1988; Cooper and Jackson, 1989; and Debbage, 1990) suggest that resort areas can be characterized by different stages of destination development (Figure 1). These studies have indicated that resorts tend to experience a predictable cycle of evolution passing through six identifiable stages: exploration, involvement, development, consolidation, stagnation, and either decline or rejuvenation. The general thesis is that resorts are initially "discovered" by a small number of adventurous and innovative tourists, and then experience a period of rapid growth as a more structured form of mass tourism is introduced. Over time, the rapid growth rate in visitor arrivals eventually peaks and slows down, and a period of stagnation occurs. The resort area may then decline in popularity, or rejuvenation may occur through the addition of some man-made attraction (e.g., gambling), or previously underutilized natural resource.

Butler's resort cycle traditionally has been examined in the context of type of visitors, the number of arrivals, and capacity levels. It is argued in this paper that an appreciation for changes in industrial organization, especially the role of imperfect oligopolistic competition, and the overall economic context can compliment the already established resort cycle research agenda. In analyzing how industrial organization and oligopoly can influence the resort cycle, this paper utilizes Markusen's (1985) notion of the profit cycle. The profit cycle has emerged as a prominent paradigm in understanding how profitability and market structure (oligopoly) can influence the life-cycle of different industries, and is used here as a theoretical guide-post for discussion purposes. This paper also makes particular reference to the latter stage of the resort cycle because "the model raises the disturbing conclusion that without very cohesive and progressive planning, all tourist centers are destined for some form of decline" (Strapp, 1988, p. 506). Williams and Shaw (1988, p. 239) elaborate on this point by suggesting that:

> The greatest challenge for decisionmakers in the future concerns the renewal of the mass tourist resorts of the post-war period. As the

product cycle reaches maturity and their facilities age, potentially they will present enormous redevelopment problems. If they do not attract new rounds of investment in tourist facilities, how is the built environment to be maintained and what will be the impact on local labour markets.

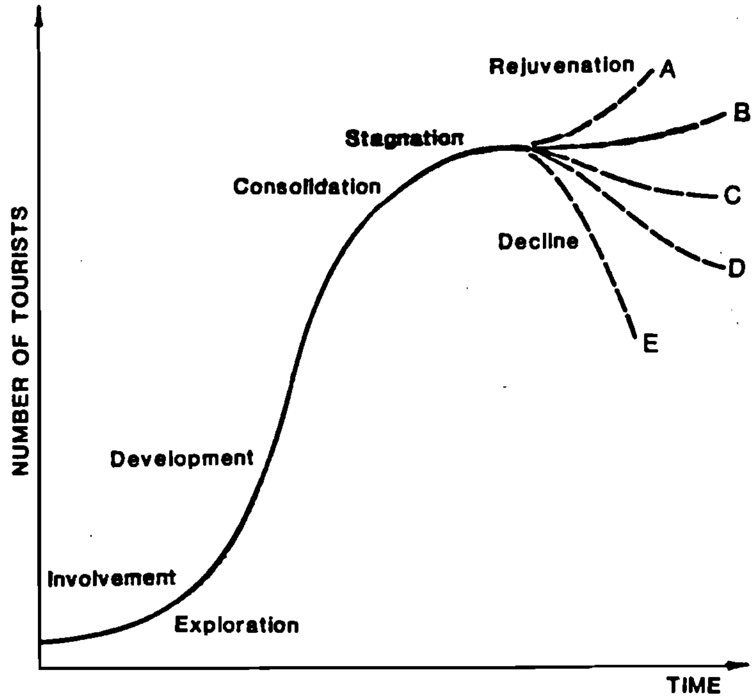

Figure 1. Theoretical stages of the resort cycle. Source: After Butler (1980).

As tourist destinations evolve from small-scale, integrated, and predominately indigenous forms of tourist development towards a larger-scale, foreign-owned form of mass tourism, it is possible that many resort areas may contain the seeds of their own destruction. Handling larger volumes of tourists at lower profit margins can bring down prices and further encourage the development of a mass market. However, it can also lead to declining average expenditures per visit and excess capacity. Consequently, as tourist destinations mature, they can lose the appeal of being new and the "in" place to visit. Overdeveloped destinations are ultimately unable to compete with newer attractions as capacity levels are exceeded and potentially serious environmental, social, and economic problems begin to emerge. These issues can be particularly critical in the island microstates of the Caribbean, Indian Ocean, and South Pacific that are seldom well-endowed with resources, and are therefore vulnerable to over-exploitation. The smallness and insularity of many island economies, and the limited economic alternatives can exaggerate these problems because many island microstates view international tourist development as a key growth industry. The rapid growth in tourist revenues is often part of a broader strategy for obtaining much needed foreign exchange earnings. However, rapid growth is often achieved without any long-term planning or integration of the tourist industry with the local system.

This paper argues that the stagnation and potential decline associated with the latter stages of the resort/profit cycle thesis suggest that international tourism may not be sustainable over the long-term in many island economies. It is also argued that to encourage sustainable cycles of tourist development, national governments must formulate tourism policies that emphasize overall development goals and priorities for which the physical, social, and economic costs and benefits have been clearly demonstrated. Otherwise the end result may be a form of development that is unsustainable and a national economy that is dominated by multinational companies, low levels of local involvement, high leakage rates, environmental degradation, and residential resentment.

The remainder of this paper will:

1) describe the increasingly oligopolistic structure of the international tourist industry;
2) indicate the intrinsic value of the profit cycle in explaining how oligopoly can shape the product life-cycle of a resort area; and
3) analyze the evolution of the tourist life-cycle and the industrial structure of tourism for two island microstates at very different stages of tourist development: the Bahamas and Mauritius.

Tourism is the most important economic sector in the Bahamas, affecting two out of every three jobs, and generating about 75 % of household income and nearly 60 % of government revenues (Bahamas Ministry of Tourism, 1981). On the other hand, in Mauritius, the tourist industry is only the third most important source of foreign exchange, and tourist receipts account for only 9.3% of gross national product (compared to 50% of GNP in the Bahamas). Consequently, these two countries provide an excellent opportunity for analyzing tourist destinations at the opposite ends of the resort cycle spectrum: the well-developed mass market appeal of the Bahamas vis-à-vis the newly emerging resort destination of Mauritius.

2. OLIGOPOLY AND INTERNATIONAL TOURISM

In its simplest form, oligopoly is the control of a commodity or service in a given market by a small number of companies or suppliers. As a consequence of this market situation, where sellers are few, the supply offered by any single company can directly influence the overall market price. The effect of any one supplier's pricing and production strategy upon similar decisions by the competitors can be fairly accurately measured. In tourism, the concentration of market power or share into the hands of a few suppliers, can clearly be seen by the market distortion and imperfect competition associated with two of the most readily identifiable activities of the industry: the airline and hotel industries.

(a) The Airline Industry

The airline industry is a reasonable example of an essentially oligopolistic market, especially so in the United States market. Although there is much more to the international tourism scene than just US airlines, an analysis of the American market can be justified because it provides some insight into the potential impact of deregulation on the airline industry. Since airline deregulation in 1978, a number of significant changes in the structure of the United States airline industry have taken place. Largely through a process of mergers and acquisitions, passenger market shares have become more concentrated in a few airlines. In 1987, the five largest airlines accounted for 71.5 % of the industry total passenger miles flown, compared with 54.5 % in 1985 (Table 1). The oligopolistic structure of the US airline industry can provide the major airlines with considerable leverage when negotiating routes, schedules, and fares for the large number of relatively undifferentiated resort destinations in the Caribbean and the Bahamas. For many resort areas, the situation is one of increasing vulnerability to the corporate strategies of a small number of very large airline carriers.

The current debate over the deregulation of the European airline industry may have similar implications for Mauritius which depends heavily on Air France, British Airways, and Lufthansa for the transportation of European visitors to the island. In 1986, European visitors accounted for over 40 % of the total tourist arrivals in Mauritius. The potential significance of any radical post-deregulation restructuring of the European airline industry could adversely affect the Mauritius tourist economy and the relative role of the national airline (Air Mauritius) in the marketplace.

Table 1. The ten largest U.S. airlines, 1985-1987.

1987 rank	Company	1987 market share[1]	1985 rank	Company	1985 market share[1]
1.	Texas Air System	19.0%	1.	American	13.3%
2.	United	16.7%	2.	United	12.5%
3.	American	14.1%	3.	Eastern	10.0%
4.	Delta	11.7%	4.	TWA	9.6%
5.	Northwest	10.0%	5.	Delta	9.0%
6.	TWA	8.3%	6.	Pan Am	8.1%
7.	US Air	7.3%	7.	Northwest	6.7%
8.	Pan Am	6.6%	8.	Continental	4.9%
9.	Southwest	1.7%	9.	People Express	3.3%
10.	America West	1.5%	10.	Republic	3.2%
	Others	3.1%		Others	19.4%

[1] Passenger miles flown. Source: Standard and Poor, 1989.

(b) The Hotel Industry

The concentration of ownership in hotel accommodation has been almost as dramatic. According to Britton (1978), the top twenty hotel companies in the world accounted for 67 % of the rooms listed in the Service World International magazine's top 100 largest chains in 1976. The economies of scale afforded by pooled marketing efforts and shared computer reservation systems has allowed the leading hotel chains, such as Holiday Inn and Sheraton Corporation, to effectively dominate the marketplace (Table 2). The consumer appeal of standardized lodging has allowed the major companies to squeeze out the smaller entrepreneurs by dominating the supply of technological, financial, and human resources. The effect of this practice is particularly pronounced in the developing world, where the absence of an entrepreneurial class, foreign exchange, and skilled labor has led to the rapid intrusion of large-scale foreign capital in the lodging industry. According to the World Bank (1986), over 80 % of all tourist accommodation in the Bahamas is foreign-owned. The more popular destinations in the Bahamas are commonly dominated by a small number of large foreign hotel chains that control a substantial proportion of the total number of hotel rooms. Unlike the Bahamas, Mauritius is not yet completely dominated by the large foreign-owned multinational hotel chains. However, Sun International, Pullman International, Méridien, and Club Méditeranée have an established market presence in Mauritius, and collectively account for 41 % of the total number of hotel rooms available (Official Hotel and Resort Guide, 1989). Many of the hotels in both the Bahamas and Mauritius are owned and operated through a management contract which provides the parent company with the flexibility to transfer investments to more modern, dynamic resorts in other parts of the world, should these countries experience political instability or the down-side of the resort cycle.

(c) Vertical Integration

Along with the horizontal integration and takeover of similar businesses, the tourist industry has also experienced a considerable amount of vertical expansion. One of the most frequently cited examples of this trend has been the active participation of airlines in the hotel business. Through a process of direct ownership, management contracts, and a variety of investment agreements, airlines such as Air France, British Airways, Japan Airlines, Pan-Am, SAS Airlines, Swiss Air, and United Airlines have established formal economic links with various hotel chains, tour operators, travel agents, and rental companies. For example, the Méridien Paradis Hotel on the southwest coast of Mauritius is formally affiliated with Air France.

Table 2. The world's largest hotel chains.

Rank	Company	Nationality	Number of hotels	Number of rooms
1.	Holiday Corp.	US	1,867	361,539
2.	Sheraton Corp.	US	464	134,800
3.	Ramada Inns, Inc.	US	756	127,900
4.	Marriott Corp.	US	451	117,789
5.	Quality Inns Int'l	US	979	112,839
6.	Days Inn	US	775	105,000
7.	Hilton Hotels	US	271	95,146
8.	Prime Motor Inns	US	192	82,500
9.	Trusthouse Forte	UK	826	76,000
10.	Hyatt	US	144	67,000
11.	Imperial Group	UK	494	61,323
12.	Balkan-tourist	Bulgaria	460	61,299
13.	Accor	France	536	59,438
14.	Motel 6	US	501	57,434
15.	Howard Johnson	US	448	54,707
16.	Hilton International	US	143	50,000
17.	Club Méditerranée	France	176	49,253
18.	Radisson Hotels	US	197	47,599
19.	Econolodge	US	478	40,000
20.	Intercontinental	US	100	38,000

Sources: Standard and Poor, 1989; Gee et al., 1989.

One consequence of the trend towards oligopoly and vertical expansion is that the economic performance of any one resort area cannot be fully understood without an appreciation of the context and structure of the regional economy. For developing countries like the Bahamas and Mauritius, the end result is an economy very vulnerable to the corporate strategies of the major suppliers. These dominant suppliers tend to be headquartered in the major tourist-generating countries, such as the USA and Europe. In the case of the Bahamas, the well-established mass tourist industry is "very positively correlated with economic performance in the USA" (World Bank, 1986, p. 2), while the Mauritius tourist industry is increasingly dependent on the European market and economy for tourist arrivals and revenues.

3. THE PROFIT CYCLE

Some of the more innovative research in the field of oligopoly and cyclical development patterns has been carried out by Markusen (1985), who attempted to relate the role of corporate strategy, and the theories of oligopolistic behavior, to the profit cycle scenario. Markusen argued that in the early stages of the profit cycle, the emphasis is on innovation with new companies garnering substantial profits from the relative novelty of their product, and the absence of immediate competition. The microstates of the Commonwealth Antilles (e.g., Anguilla, British Virgin Islands, Cayman Islands, and Turks and Caicos), and Mauritius would fall into this category. The low proportion of hotel rooms in large hotels, the distinctive market appeal, and the high repeat visitor rates have led to consistent, rather than rapid growth since 1979. The major airline and hotel chains have yet to invest in the tourist product on a large-scale. Annual visitor arrivals have only recently begun to "take-off" as the more adventurous tourists, seeking a unique experience, begin to arrive in large numbers. Until the early 1960s, the evolution of the tourist industry in the Bahamas seemed to follow a similar development cycle (Figure 2). The Bahamas was perceived as a luxury playground for a small number of highly affluent visitors.

At some point, Markusen then suggests that the number of competitors will decline as economic pressures encourage companies to cut costs and rationalize production. "The strategy of the firm turns from product design and market outreach to more efficient management" (Markusen, 1985, p. 32). The emphasis is on scale economies, mass production, and both vertical and horizontal integration, in an effort to cut costs and increase productivity. In the Caribbean tourist system, the large, more resourceful tourist destinations like the Bahamas, Jamaica, and Puerto Rico are examples of resort areas with a well-established mass-market appeal and substantial promotion budgets that essentially strive to maintain market share.

In the latter stages of the profit cycle, the competition may become excessive and the market saturated. Faced with the prospects of gradual or no growth in market share, Markusen suggests that the key firms may respond by oligopolizing. "Domination of the market by a few sellers will permit these corporations to reinstate greater-than-normal profits by the classical maneuver of restricting output and raising prices." (Markusen, 1985, p. 33). The response of the US airline industry to deregulation is an example of an essentially oligopolistic corporate strategy at work. The end result is that the market is dominated by a few large firms more concerned with increasing and protecting market share, than with innovation and the introduction of new products.

Markusen contends that previously healthy industries can atrophy when subject to long-term oligopoly, particularly when faced with competition from young and more inventive competition from other parts of the world. Although the Bahamas has yet to experience an actual decline in the annual number of tourist arrivals, it is faced with a highly competitive marketplace. The international scope of the tourist industry means that the Bahamas can be vulnerable to the development of new resorts in faraway places like the Indian Ocean. According to the Bahamas Ministry of Tourism (1981, pp. 2-29), the Bahamas is in a highly competitive situation in the European long-haul market where "travellers are comparing the Bahamas, with for example, the Seychelles and Mauritius in the Indian Ocean." It is possible that the future growth of the tourist industry in Mauritius may be at the expense of a corresponding decline in the number of European visitors to the Bahamas. The end result could be job losses and plant closings as corporations take absolute profit losses on production.

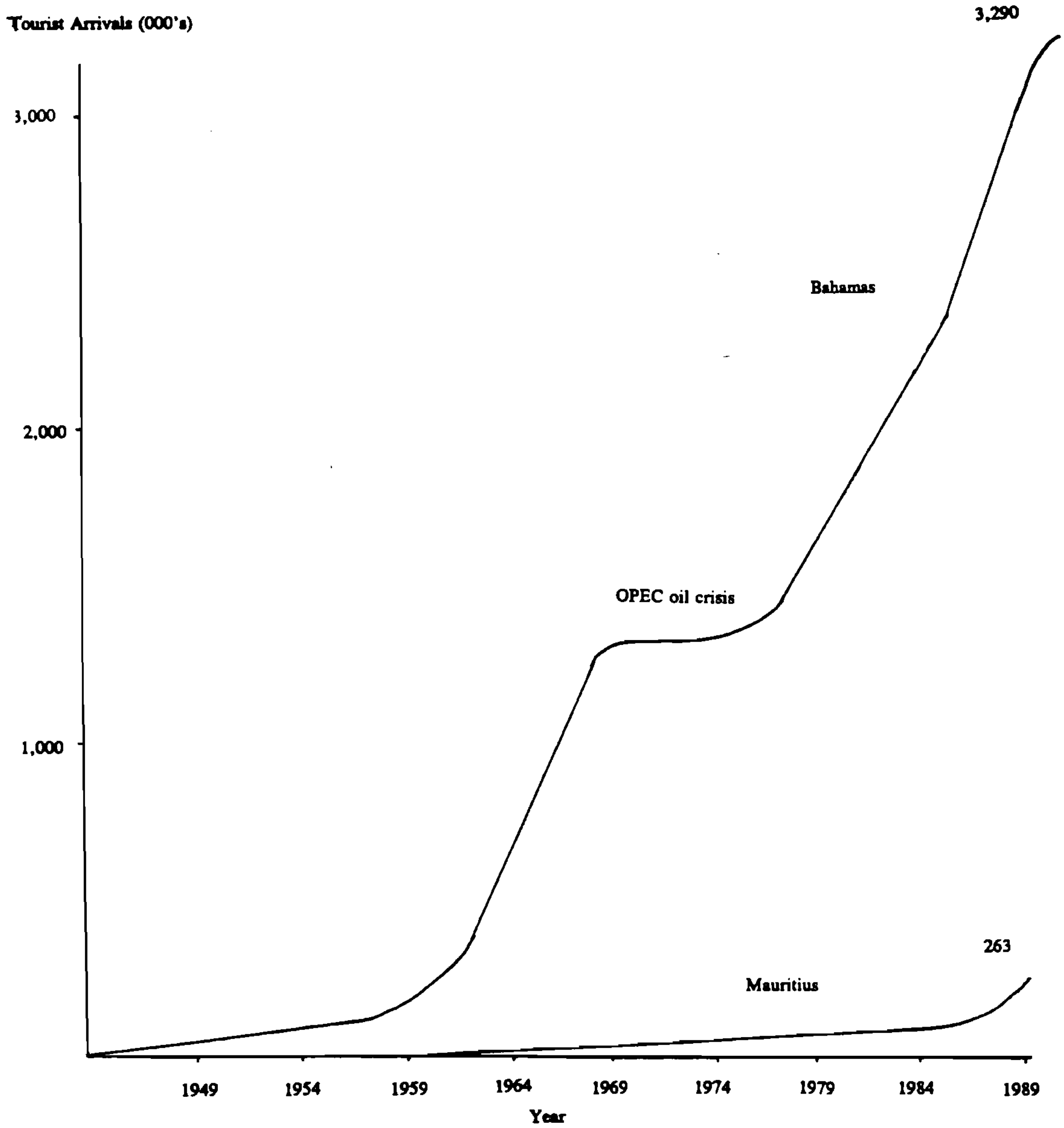

Figure 2. Evolution of tourist arrivals to the Bahamas and Mauritius.

4. OLIGOPOLY AND THE RESORT CYCLE IN THE BAHAMAS AND MAURITIUS.

(a) Bahamas

The Bahamas is an archipelago of more than 700 islands situated 50 miles off the US Florida coast, and extending to the southeast for about 1,000 miles into the Atlantic Ocean (Figure 3). Tourism has become the most important sector of the economy with the most developed resort areas located on Paradise Island and New Providence Island. In 1988, visitor arrivals totalled 3.15 million and total visitor expenditure was $1,149 million, making it one of the largest tourist industries in the region (Bahamas Ministry of Tourism, 1989). Since the 1960s, the growth in visitor arrivals has been continuous (with the exception of the early 1970s during the OPEC oil crisis), and the national tourist economy seems to have evolved through the various stages of Butler's resort cycle (Figure 2). In the late 1980s, annual growth rates began to slow down as the tourist industry seemed to be approaching the consolidation and stagnation phases of Butler's curve.

As resorts begin to "take-off," Butler suggested "local involvement and control of development will decline rapidly" (1980, p. 8). Markusen also implied that an increase in growth rates and large profit margins would be gradually pre-empted by an increasingly oligopolistic industrial structure, concerned more with market share. Before 1966, tourist development in the Bahamas was small-scale, with a minimal socio-economic impact on the national economy (Albury, 1984). After 1966, tourist development on Paradise Island in particular, was rapid and large-scale, and by 1985, this relatively small island had over 25 % of the 13,166 hotel rooms available in the Bahamas (Bahamas Ministry of Tourism, 1989). The rapid development of the tourist product on Paradise Island and elsewhere has allowed the Bahamas to emerge as a major tourist destination in a very short period of time. The level of foreign ownership has also increased rapidly as larger and more sophisticated corporations provided the necessary scale of operation to accommodate the rapid increase in the influx of visitors.

Furthermore, large companies like Resorts International and Holiday Inn Corporation have been able to organize, co-ordinate, create, and market the diverse inputs that constitute the various tourist products, and establish key links with the major oligopolistic suppliers, largely based in the USA. An exit survey conducted by the Bahamas Ministry of Tourism (1984), showed that three-quarters of all Paradise Island visitors used a travel agent to co-ordinate hotel and airline arrangements; and almost 50 % arrived on a chartered flight. Of those on a commercially scheduled flight, over half flew one of three airlines: Eastern, Delta, or Pan-Am. More than two-thirds participated in a packaged vacation with foreign-owned tour operators like Piedmont Vacations, Go-Go Tours and Delta Dream Vacations. The end result was an increased dependence on a small number of large foreign-owned suppliers that provided the necessary scale of operation to accommodate and stimulate the rapid increase in the number of tourist arrivals during the 1980s.

However, the rate of increase has already begun to decline as the country approaches the upper limits to growth.

Some of the emerging problems include: water supply shortages, escalating investment costs, regional income inequalities, traffic congestion, the destruction of traditional landscapes, and excess hotel capacity at other destinations (Bahamas Ministry of Tourism, 1981). As a consequence, the Bahamian government is moving towards a policy of decentralization by emphasizing tourism development in the outer islands. However, a governmental policy of dispersal may be difficult to implement because, as Markusen suggests, the spatial consequences of a mature oligopoly at a broad regional development level can be severe. Potentially likely outcomes are to: "overconcentrate production in original sites, retard the rate of dispersion of production, underdevelop capacity in outlying areas; monopsonize the resources of its host regions, and restructure ruthlessly when market control erodes" (Markusen, 1985, p. 2).

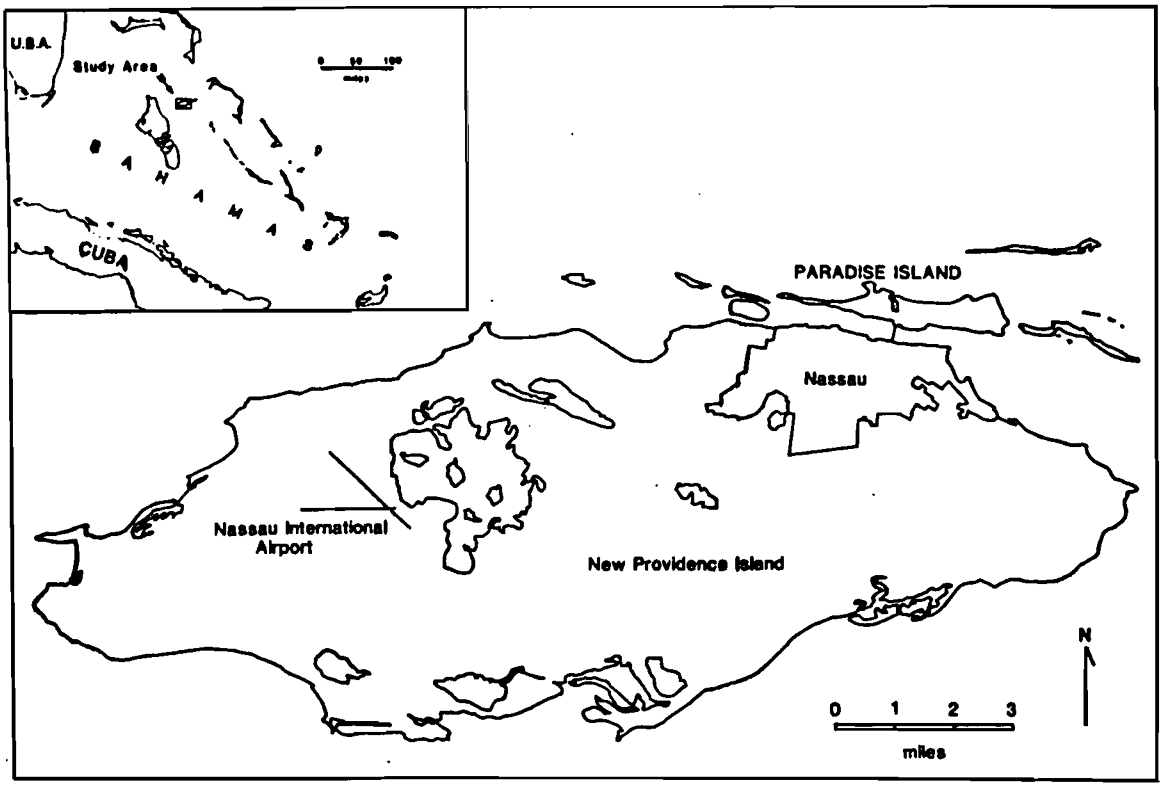

Figure 3. Relative location of Paradise Island, New Providence Island, and the Bahamas.

(b) Mauritius

Mauritius is a small, densely populated island nation situated in the Indian Ocean about 1,000 miles off the east coast of Africa (Figure 4). Mauritius is an advanced developing country with an economy based on export-oriented manufacturing (mainly textiles), sugar, and tourism. In recent years, the tourist industry in Mauritius has witnessed a period of gradual growth, both in terms of gross foreign exchange earnings and tourist arrivals. In 1989, gross tourist earnings rose to $208 million while tourist arrivals peaked at 263,440, compared to only 36,398 arrivals in 1971 (Mauritius Government Tourist Office, 1990). The growth of the tourist industry in Mauritius has been gradual and consistent, rather than rapid, although the industry seems to be approaching the "take-off" point in Butler's resort cycle (Figure 2).

To accommodate the projected rapid growth in future tourist arrivals, hotel room capacity on Mauritius increased rapidly in the late 1980s. According to the US Department of Commerce (1989), six additional hotels were expected to be operational by 1989 bringing an additional 1,000 rooms (a 30 % increase in hotel capacity from 1988). In 1989, there were 67 hotels with 3,605 rooms as against 54 hotels and 2,488 rooms in 1984 (Mauritius Government Tourist Office, 1990). Most of this growth has been concentrated along the north shore of the island (Figure 4). However, the rapid development of the hotel sector is unlikely to continue apace due to a lack of space in preferred locations. The potential for overdevelopment has resulted in the Mauritius government setting a ceiling of 350,000 tourist arrivals by the year 2000 in an attempt to maintain a proper balance between the local population and the tourists (Bhuckory, 1989). The Mauritius National Development Plan also acknowledges the need to decentralize tourism activities away from the island of Mauritius (Mauritius Ministry of Economic Planning and Development, 1988). To this effect, airport facilities on the outer islands of Rodrigues and Agalega are being improved in order to enhance their tourist potential.

As the hotel industry rapidly developed in the late 1980s, the national airline (Air Mauritius) expanded its fleet. In 1989, Air Mauritius acquired two Boeing 767s to add to its current fleet of two Boeing 707s, one 737, and two 747s. The expansion of the Air Mauritius fleet has allowed the airline to capture a greater part of the international air passenger market to Mauritius, and therefore retain a greater proportion of the tourist dollar within the country. The national carrier currently serves nearly all major destinations which are important to the tourist industry, namely London, Bombay, South Africa, Malaysia, Singapore, Reunion, Munich, and Geneva. To accommodate the increase in passenger load stemming partly from the rapid increase in tourist arrivals, the international airport passenger terminal was expanded in 1987. However, the airline has faced stiff competition from Air France, British Airways, and Lufthansa as the European tourist market has grown. Consequently, Air Mauritius has negotiated cooperative arrangements with the more established airlines, in part, to access the extensive computer reservation systems that allow the larger airlines to be accessible to a wider audience.

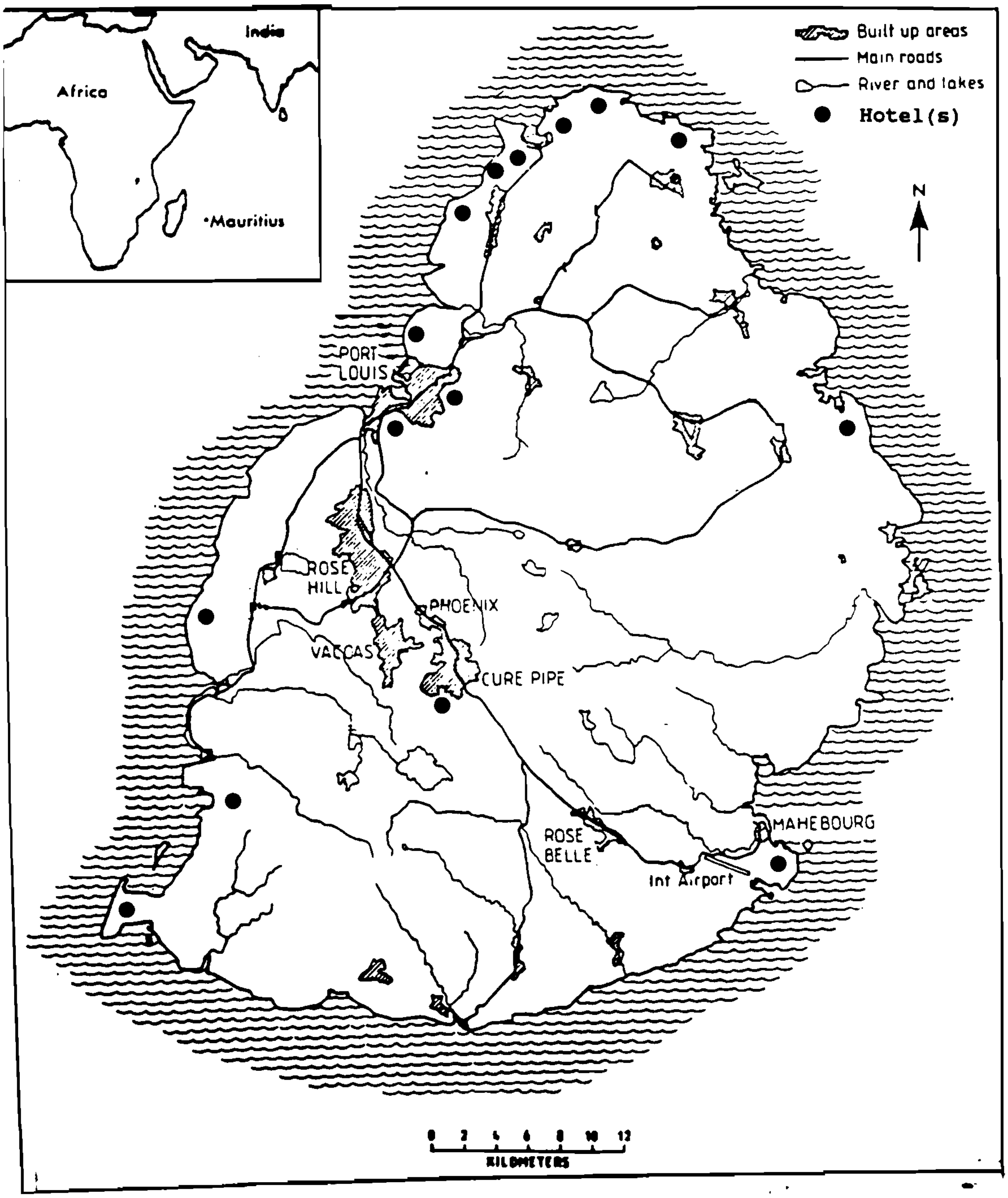

Figure 4. Relative location of Mauritius.

The move towards large-scale airline operations and the increase in the size of the companies involved has contributed to the emergence of large-scale tour operators providing packaged vacations to Mauritius. For example, tour operators like Travel Corporation of America (Travcoa) offer comprehensive "Islands of the Indian Ocean" packaged vacations that include Mauritius on a circuit tour of the Seychelles, Reunion Island, Madagascar, and Mauritius. By bulk purchasing airline seats and hotel rooms, these companies are able to reduce fixed costs per capita and offer competitive prices to increasingly larger markets. However, according to Turner and Ash (1975, p. 116), "destinations like the Indian Ocean's Mauritius will only hold onto 10 % of the total cost of an incoming package holiday." The high leakage rate assocciated with package holidays is explained by the heavy dependence on international airlines, hotels, and tour operators in providing the tourist product. For example, the Travcoa packaged tour uses Air France to transport its customers through the islands, and during the stopover on Mauritius tourists stay at the foreign-owned Sun International hotel on the east coast of the island.

The evolution of tourism in Mauritius is at a critical juncture as the industry appears to approach the "take-off" point on Butler's curve. The expanded development of tourism as a form of diversification may reduce the country's dependence on the traditional sugar cane industry, but it may also introduce a new regime of foreign developers. The emphasis on international air travel and packaged vacations increases the likelihood that the Mauritius tourist industry will eventually be controlled by a small number of large foreign-owned companies emphasizing external economies of scale. As a result, the tourist industry may become over-commercialized and lose the qualities which originally attracted tourists. Environmental degradation is already a problem on the island with limited sewage treatment capacity, an increasingly scarce water supply, unclean beaches, and polluted lagoons. If Mauritius is not careful, it is possible that the oligopolistic industrial structure that is partly responsible for the evolution of the mass market in the Bahamas, may be repeated in Mauritius. To borrow from Finney and Watson (1977), tourism may become a new kind of sugar.

5. SUMMARY AND POLICY IMPLICATIONS

It is clear that the well-being of a resort area can be partly explained by the inherently protective, risk-minimizing corporate strategy of the oligopolistic firm. For resort destinations dominated by a small number of large companies, the innovative edge that initially generated a distinctive and popular product can also result in an organizational structure that is incapable of dynamically responding to consumer tastes. For destinations like the Bahamas that are in the later stages of the resort cycle, and are well-integrated with the corporate structure of the international tourist industry, the potential future outcome may be stagnation and decline. For the handful of firms that control the bulk of the tourist product in the Bahamas, corporate strategies are frequently based on competitive stability and market share, at the expense of innovation and diversification. The end result may be an acute vulnerability to external economic conditions, competition, and innovation at other resorts.

Mauritius can avoid many of the problems that beset the Bahamas because the tourist industry in Mauritius has yet to experience the rapid growth rates in visitor arrivals associated with the development stage of Butler's resort cycle. Furthermore, Mauritius has a more diversified economic base based on textiles, sugar-cane, and tourism; a larger domestic market; and a national development plan that is centered on integrating tourism with all other sectors of the economy. A coherent development strategy is imperative since, when all the alternatives have been explored, it is likely that international tourism in some form will be almost inevitable.

Possible tourist policies that could be implemented in the future include the development of a regional tourist association representing the island states of the Indian Ocean to assist in determining: the desirable levels of tourist taxes; the extent of concessions offered to multinationals; the basic terms on which the island governments could approve franchise agreements; and policies for training local staff. By establishing supra-national associations, the small microstates of the Indian Ocean may be better placed to negotiate with the large multinational, and more successful in advancing issues of national interest. The Mauritius government has already proposed multi-destination tours combining other neighboring destinations, especially the Indian Ocean Commission members, Kenya, and Tanzania in an effort to further promote regional tourism while minimizing promotional costs for each of the participating countries (Mauritius Ministry of Economic Planning and Development, 1988). Furthermore, the University of Mauritius began to offer a diploma in hotel management in 1987 in an attempt to upgrade the skill levels of the indigenous labor-force. Other options include moratoriums on the development of new hotels, and restrictions on the number of cruise ships in port in order to regulate the expansion of large-scale tourism.

Although the end result may be slower growth rates, the final product may be a tourist industry that is sustainable and stable over the long-term and well-integrated with the indigenous economic system. To further minimize the transfer of earnings abroad, other policy alternatives include: designing hotels that use local materials and reflect indigenous architecture; encouraging hotels to purchase local foodstuffs; and developing a national airline. Both the Bahamas and Mauritius have established national airlines (Bahamasair and Air Mauritius), in part, to minimize economic leakage rates. For example, although Air France is the principal carrier for the Travcoa "Islands of the Indian Ocean" package tour, the air transportation for the Mauritius leg is provided by Air Mauritius which successfully negotiated the route schedule. Other examples of sustainable development policy initiatives by the Mauritius government relate to hotel development. According to Bhuckory (1989), hotel architecture higher than the surrounding trees along the adjacent coastline is not allowed in an effort to blend hotels with the natural environment. Furthermore, hotel-owners must provide public access to the beaches at their own cost so as to diffuse resident resentment when public access is denied.

All these policy issues are of critical importance because a fundamental implication of the resort cycle agenda is that the continued growth of a resort area is by no means assured. A better understanding of the broader economic processes that shape the life-path of a resort should help tourism planners better manage the sustained success of resorts entering the consolidation and stagnation stages of Butler's evolutionary curve.

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Chapter 18

WATER SYSTEMS AND WATER MANAGEMENT ON THE ISLAND OF MAURITIUS

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1. INTRODUCTION

The provision of water services is one of the most fundamental environmental issues. Water is an extremely complex resource, deeply involved in many ways in socioeconomic development and subjected to different competing uses. Two main perspectives may be distinguished:

- Water is closely involved in a number of the basic natural constraints to societal development (soil productivity, industry production factor, energy resources, health promotion).

- Water is active in generating side effects of human intervention in natural systems by its mobility, erosiveness and chemical properties.

In a thirsty, rapidly developing country like Mauritius with limited land resources, water supply development tends to become an extremely complicated proposition. The development of the country and the resulting rapid growth of industry and agriculture, as well as the improvement of living conditions have led to a substantial increase in water consumption. Water resources management presents a challenge to authorities charged with satisfying constantly increasing demands to develop supplies, allocate them in sufficient quantities to all users, and give top priority to the provision of high quality drinking water. It is now widely accepted that water can no longer be considered a free commodity and should be viewed as a partly substitutable input to various economic and social activities.

This paper synthesizes the most important aspects of the water management situation in the island. The facts and conclusions contained in the Master Plan Study For Water Resources by the Central Water Authority (1990a, 1990b) forms an indispensable reference in connection with the writing of this paper. The paper also analyzes the complexity of water in the island in relation to sustainable development and the different processes that threaten the sustainability.

2. WATER AND SUSTAINABILITY

Many of our activities are water-dependent (see Figure 1). A basic criterion for sustainable development is the satisfaction of present needs without compromising future needs. Sustainable development must therefore also be a question of a sustainable interaction between the society and the water cycle, including all the ecosystems fed by that cycle. Water has five important functions: (1) supplying the human body, (2) contributing to the necessary hygiene and breaking disease transmission pathways, (3) acting as a carrier of nutrients and a cooling agent for plants, (4) providing the necessary physical and chemical environment for aquatic life, and (5) serving as a production factor for industries. Sustainable development seen from a water perspective would mean that the following needs must be met today as well as tomorrow:

- Drinking water has to be available.
- It must be sufficient to allow satisfactory hygiene.
- Soil characteristics (permeability, retention capacity, etc.) must be secured in order to allow both rainfall to infiltrate, and a water supply to facilitate biomass production on a large enough scale for self-sufficiency.
- Water quality has to be ensured to secure the productivity of our rivers, lakes and coastal lagoons, and to preserve biological diversity.

3. BASIC DATA

General Outline

Mauritius has a surface area of 1852 km^2, and except for the beaches and the coral formation of the reefs, it is entirely of volcanic origin with altitudes varying from sea level to a central plateau with a maximum level of 600 m. The coastline is some 200 km long, and the lagoon area is estimated at 243 km^2. Owing to its various dependencies, its Exclusive Economic Zone (EEZ) spreads over a surface area of about 1.7 million km^2.

The population was estimated at 1,020,166 in 1987 with an annual growth rate which has dropped from 3.12% between 1952 and 1962 to 1.44% between 1962 and 1983. There is a marked tendency towards a reduction in growth rate and an aging of the population. The GDP (1988) is of the order of Rs 22,500 million. The economy of the country rests on three monoactivities:

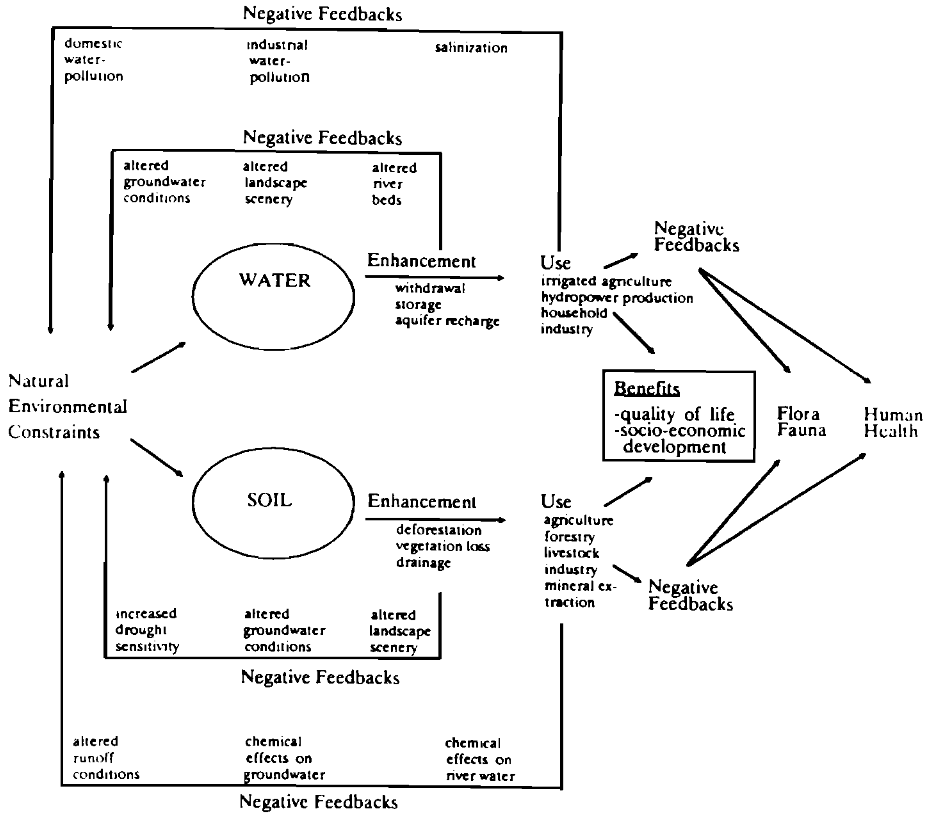

Figure 1. Linkages between land use and water. Source: Stockholm Studies in Natural Resource Management, 1988.

1. Agriculture.
It has stabilized at about 15% of the GDP. The sugar sector is the agricultural key sector with sugar cane crops occupying about 87% of the agricultural land. 692,000 tons of sugar were produced in 1988. Other crops produced are tea (6-7,000 tons/year) and tobacco (900 tons/year); the last decade has also been characterized by an agricultural diversification to vegetable cultivation which now occupies 5-6,000 ha. Fishing in the lagoon provides a living to 2,000 fishermen for a total annual production of 1,000 tons. Aquacultural activity has also increased during the last decade and has reached a production figure of 50 tons of the big freshwater prawn *Macrobrachium Rosenbergii*. Further development of this activity will depend on the guarantee of quantity and quality of water resources.

2. Industry.
The industrial sector accounted for 43% of total employment in 1987 and in terms of value added, the industrial sector accounted for 33% of the national cake in 1987 compared to 26% in 1976. From 1970 to 1987, the

manufacturing industry has increased from 8 to 24% of the GDP, and from 6 to 43% of jobs. The annual rate of growth of 30% between 1984 and 1986 is expected to stabilize at around 10% in the coming years. 53% of the GDP contributed by industry in 1987 came from the free zone, which is based essentially on the textile industry.

3. Tourism.
The tourists visiting Mauritius have increased from 140,000 in 1986 to 208,000 in 1987. This figure may reach 270,000 in 1990 and a long term target of 400,000 is presently proposed. In 1988 the number of beds was estimated at 6,600 and should reach 8,500 in 1990.

Climatology

Climatic conditions prevailing in Mauritius not only determine the water resources of the island but also land use and irrigation needs. Mauritius enjoys a moderate tropical climate, mainly because of its relief and being an island. Two seasons are observed:

- Summer from November to April. This is the warmer and rainier season, during which tropical cyclones may occur. February and March are the wettest months.

- Winter from May to October. This is the cooler and drier season. October is the driest month, and severe droughts usually occur during November and December, before the start of the rainy season.

The most significant climatic feature for development in Mauritius is rainfall. The rainfall generated by the east-southeastern trade winds rises from a mean of 1,300 mm/year on the windward eastern coast to 4,000 mm/year on the central plateau and the highgrounds, dropping to 900 mm/year on the western leeward coast. As opposed to rainfall, the potential evapotranspiration drops from 2,000 mm/year on the coastal plains to 1,400 mm/year on the central plateau. The global balance is positive since the yearly rainfall is equivalent to a 2,100 mm thick water layer over the whole island, whilst the mean potential evapotranspiration reaches 1,700 mm/year (Sigma-Sogreah, 1981). Figure 2 gives the isohyets for the period 1951-1980 and shows that there is a regional distribution with the north and west much drier than the east, south and center.

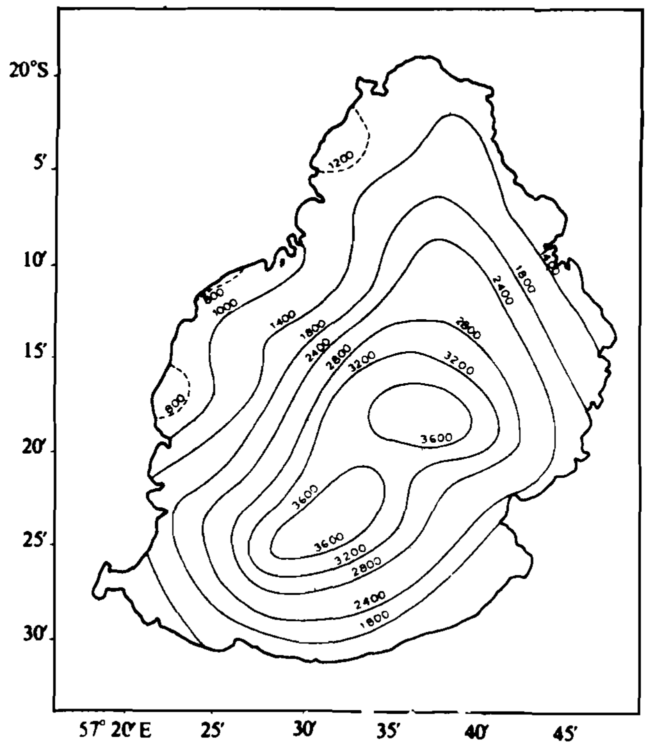

Figure 2. Normal annual rainfall in mm, 1951-1980. Source: Padya, 1989.

Geology

Mauritius has been formed by successive volcanic eruptions and the formations are the result of four major activity periods which are, from the oldest to the latest:

a) Emerging period of the island (between 10 and 6.7 million years).

b) The old series. During this period of activity (6.2 to 5 million years) the island acquired its circular shield shape. The basaltic masses make up the island's skeleton and cover nearly 20% of its area as high mountain masses and a few hills scattered on the center of the island.

c) The intermediate series. After a relatively calm period (1.5 million years) during which heavy erosion took place, depressions were filled by volcanic flows between 3.5 and 1.7 million years. This was followed by a calm period of about 1.2 million years.

d) The late volcanic series. During this period (700,000-25,000 years) flow sprang from volcanoes situated in the core of the original volcano and spilled through gaps towards the sea.

Only the late volcanic series gave rise to good aquifers in view of their thickness and permeabilities.

4. WATER RESOURCES

Surface Water Resources

The highgrounds and the central plateau act as a water tower from which the water runs off through a complex hydrographical network. The substantial rainfall over the island results in a dense and heterogeneous network. Most of the rivers are perennial and spring from the central plateau, and flow radially to the sea. Forty-seven catchment areas exist which vary in size from 3 to 164 km^2. The location of the various basins are illustrated in Figure 3. There are nine storage reservoirs for precipitation catch (total capacity of 70 Mm^3) and 300 abstraction points from surface streams.

Underground Water Resources

The aquifers of Mauritius contribute substantially to domestic, industrial and agricultural purposes. Over the whole island, the late lava flows have given rise to four main aquifers: those of Curepipe, the northern plains, the eastern plains and the southeast. These aquifers have a high recharge in the central plateau regions and the flow gradients towards the coast are very steep, up to 2 or 3%. About 120 wells and boreholes are exploited as shown in Table 1.

Ninety percent of the exploited groundwater goes for domestic supply. The maximum capacities of the aquifers are estimated at 350,000 m^3/day (130,000 m^3/day for Curepipe, 50,000 m^3/day for the north, 110,000 m^3/day for the east and 55,000 m^3/day for the south) (Central Water Authority, 1990a). However, further hydrogeological studies must be carried out to find the true potential of the aquifers.

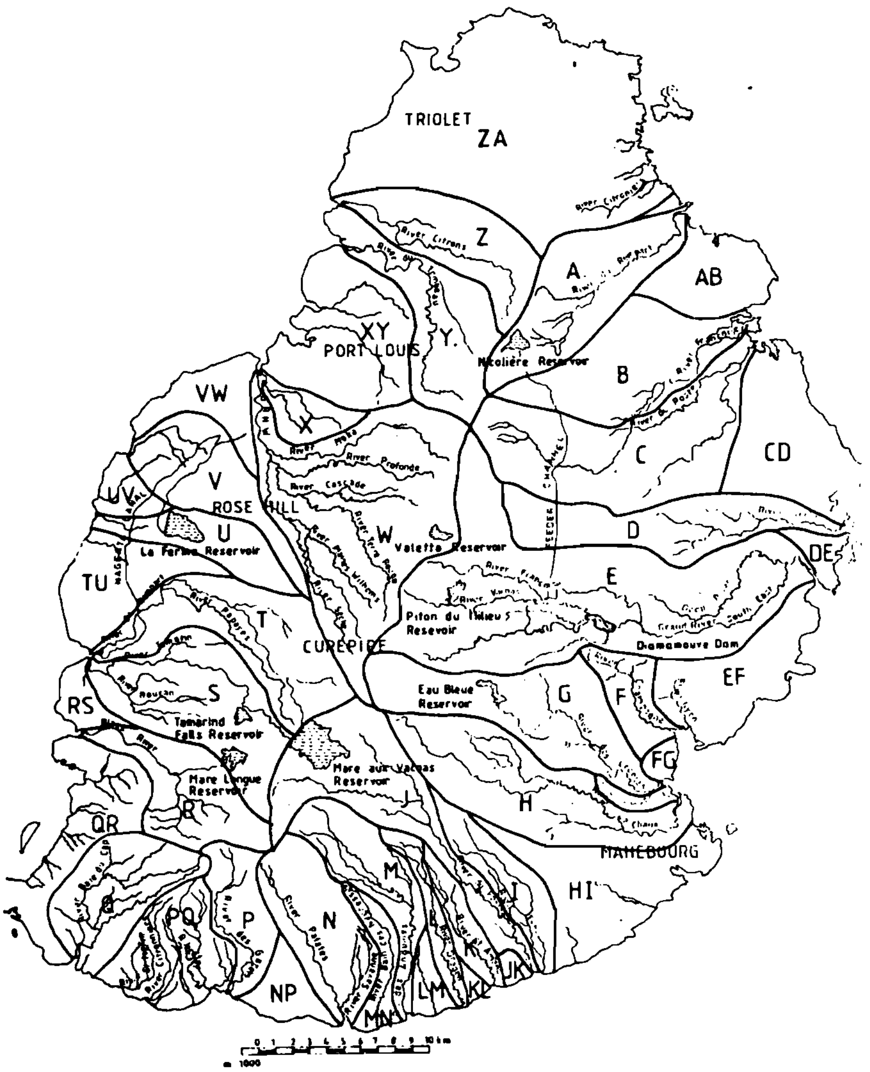

Figure 3. Surface water basins. Source: Central Water Authority, 1990a.

Table 1. Exploited groundwater stations (1989).

Aquifer	Domestic	Irrigation	Industrial
Curepipe	23	4	20
Port-Louis	0	0	3
North	17	17	9
East	6	1	1
South	3	7	2
Total	49	29	35
Estimated Production (m^3/day)	136,000	10,000	6,000

Source: Central Water Authority, 1990a.

Water Rights

The island has inherited an ancient judicial tradition regarding water rights and uses; the present legislation is still based on the "Rivers and Canals Act" of 1863. River water rights are allocated to a "normal flow" of a river which is, at first approximation, a mean flow as of 30 September, *i.e.* a dry period flow. The rules for allocating water rights are framed generally in the following manner:

- riparian (irrigation) - up to 9/10 of normal flow;
- reserved flow - 1/10 of normal flow for environmental conservation;
- above the normal flow - for domestic or industrial requirements or for transfers towards other river basins.

Water rights are associated very often with land ownership and generally for irrigation purposes. Time limits are not often allocated. Water rights correspond to a very substantial volume (1 Mm^3/day) and are not reflected in the statistics of the Central Water Authority who has the monopoly of water distribution for domestic, commercial and industrial use. Although the legislation tends to correspond to a unique use of water (irrigation), certain sugar estates go beyond the normal context of a water right and the water is used for cooling and aquacultural purposes. Use of groundwater falls under the "Groundwater Act" which states that the use must be subjected to prior authorization.

5. PRESENT EXPLOITATION

More than 98% of the population has access to a public water supply system (see Figure 4). The water mobilized by the Central Water Authority for potable water production in 1989 is given in Table 2.

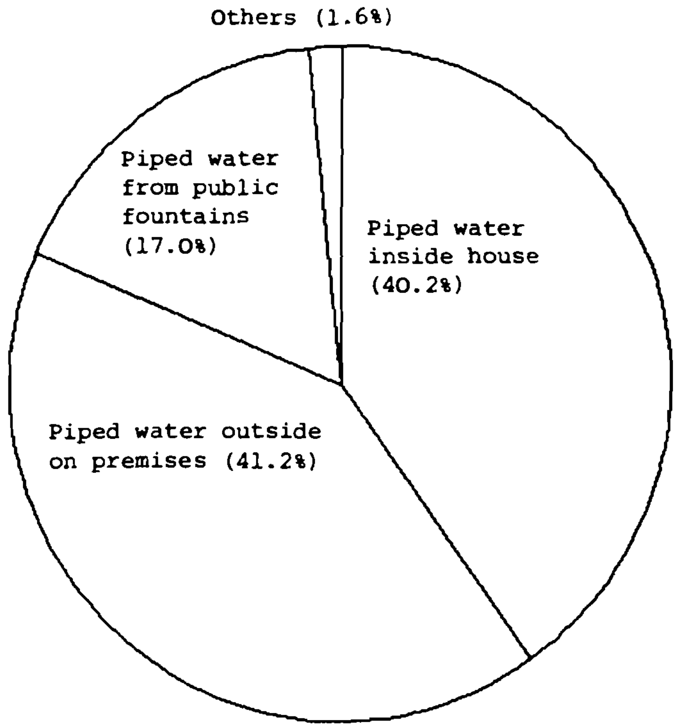

Figure 4. Water supply systems in Mauritius in 1983. Source: Central Statistical Office, 1985.

Table 2. Water mobilized for potable water production (1989).

		Production (m^3/day)	
Source	Nos	Dry season	Wet season
Reservoirs	3	105,500	133,500
Surface abstraction	13	53,100	96,300
Pumping stations	49	136,100	168,100
Total		294,700	397,900

Source: Central Water Authority, 1990a.

The contribution of surface and groundwater to the total water production since 1974 is shown in Figure 5. The share of groundwater production to total water production has increased from 21% in 1974 to 42% in 1989. The evolution of water production and sales as well as that of the number of consumers is given in Table 3.

Losses in the network are around 55% presently and the annual volume sold increases by 10% yearly, while the number of consumers increases regularly by 4% yearly. An average of 183,000 m^3 of potable water is sold daily. The major increase in terms of volume comes from the industrial and commercial sector where the volume sold has increased by an annual average rate of 15%. The figures above do not include the use of surface water for cooling purposes especially by the sugar industry.

An area of 15,000-22,000 ha is irrigated annually and a volume of the order of 1 Mm^3/day is used on average for irrigation. The irrigated zones are the north, the west and the coastal zones of the east and south. The water supply for irrigation per unit of surface irrigated is about 16,000 m^3/ha per year.

Hydroelectric production accounts for 25% of the total electrical energy production (maximum of 110 GWh) and considering that the demand growth rate is about 10%, hydroelectricity will become marginal in the long term.

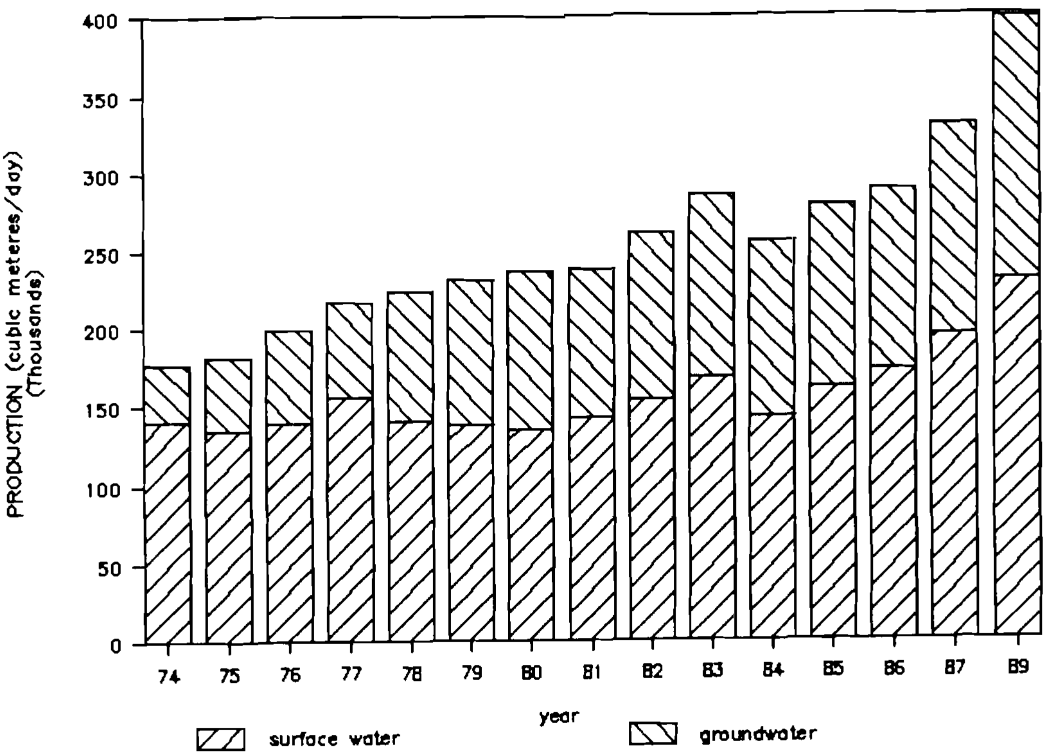

Figure 5. Water production (m^3/day). Source: Central Water Authority, 1987.

Table 3. Evolution of water production and potable water sales (Mm³) 1984-1989.

	1984	1985	1986	1987	1989
Total water produced	108.8	115.4	114.4	116.5	145.0
Domestic water sold	62.0	48.8	43.8	45.6	48.6
Industrial and commercial water sold	5.0	5.7	7.2	9.1	13.1
Government and administration water sold	2.0	2.2	2.5	2.5	2.8
Irrigation	1.4	1.3	1.4	1.2	1.0
Total water sold	70.4	58.0	54.9	58.4	65.5
% loss	35.4	49.7	52.0	49.8	55.0
Total consumers	124,300.0	136,900.0	142,200.0	147,600.0	157,700.0

Sources: Central Water Authority, 1990a; Ministry of Economic Planning and Development, 1988.

6. WATER DEMAND AND FUTURE EXPLOITATION

No comprehensive model of water demand has been developed in Mauritius especially due to the lack of a sufficient data base. The following considers the requirements for treated water for the domestic, industrial and touristic sectors based on surveys carried out by the Central Water Authority in 1989.

Domestic Water Demand

The household income and the hours of supply have been considered in the survey, the main conclusions of which are summarized in Table 4. The survey showed that there is a minimum requirement of 80 l/p/d (liters/person/day) with the higher limits varying between 180 and 250 l/p/d.

Table 4. Water demand for domestic use (liters/person/day).

Hours of supply	Lower limit of consumption	Upper limit of consumption
2-8	80	182
8-16	80	202
16-24	80	243
Monthly household income, rupees		
0-2000	80	224
2-6000	80	242
>6000	80	251

Source: Central Water Authority, 1990b.

Considering the results of the survey as well as different data obtained from other studies, an average domestic consumption of 180 l/p/d on the basis of a 24-hour supply can be assumed. The use of water resources increases with economic growth. Countries with a high specific water use have a lower growth rate of water use than countries with a small specific water use.

Industrial Water Demand

Based on a survey of 50 users, the following assumptions can be made to calculate water use:

- Industries which use water only for sanitary purposes: 40 l/employee/day.
- Industries which use water for sanitary purposes and industrial processes:
  - excluding dyeing: 200 l/employee/day
  - including dyeing: 3,000 l/employee/day.

According to a survey of 168 industries, they would be classified as follows:

- Industries using water for employees only: 70%.
- Industries using water for employees and industrial processes excluding dyeing: 20%.
- Industries using water for employees and for dyeing purposes: 10%.

These data suggest that the bulk of the consumption is accounted for by a small number of very large users and the remainder is spread amongst a multitude of small businesses with low demand. A better criteria to characterize industrial water consumption would have been the water demand per unit of output since, in the future, technological development will lead to a reduction of the number of employees for a given output.

Touristic Water Demand

Based on a survey of 20 hotels, the consumption per bed varies from 200 l/day for ordinary hotels to 1,000 l/day for five-star hotels. These figures show that further development in this sector may be limited by the water supply.

Future Water Requirement

A forecast of the potable water requirement has been made by the Central Water Authority for target years of 1990, 2000, 2010 and 2040 based on the assumptions that the present tendencies in employment distribution will remain the same, while the percentage of people employed will form 24% of the total population with a saturation level of 400,000 tourists annually. The forecast has been confined largely to the fitting of trends to the data on present demands, and experience in developed countries shows that the results are often not satisfactory. The forecasts are given in Table 5.

The theoretical water demand at present is of the order of 283,000 m^3/day, while water sales are of the order of 183,000 m^3/day, meaning a water supply satisfaction of around 63%. The total water demand is estimated to increase by about 20% over the next ten years and meeting future requirements will require intensive exploitation of our aquifers to 100% utilization by the year 2040.

The demand for water is largely affected by changes in technology, pricing policies and wastewater regulations, and the complexity of natural water resource systems makes an integrated approach to water resource management and development essential.

Table 5. Expected development of water demands, requirements and mobilization in Mauritius in 1990, 2000, 2010 and 2040.

	1990	Forecast 2000	Forecast 2010	Forecast 2040
Population	1,047,807	1,152,739	1,257,128	1,736,520
Domestic consumption (l/p/d)	180	200	230	250
Domestic demand (m^3/day)	181,000	221,000	278,000	387,000
Industrial demand (m^3/day)	89,000	98,000	106,000	136,000
Touristic demand (m^3/day	13,000	23,000	28,000	29,000
Total demand m^3/day)	283,000	342,000	412,000	558,000
% loss	55	45	35	30
Total requirement (m^3/day)	630,000	623,000	636,000	789,000
Groundwater mobilized (m^3/day)		277,000	325,000	357,000
Surface water mobilized (m^3/day)		241,000	327,000	447,000

Sources: Central Water Authority, 1990a, 1990b.

7. WATER QUALITY

The need for water resources goes beyond quantity and must also consider quality. The quality and characteristics of the surface and groundwater are more and more frequently showing signs of deterioration. The proverb "He who has health has hope, and he who has hope has everything" underscores the importance of public health as a resource in the process of economic development. The major sources of pollution in Mauritius are discussed below.

Domestic and Hotel Effluents

The population of Mauritius produces at least 100,000 m^3 of waste water per day and a minimum BOD load of 60 tons daily. Figure 6 shows the various sanitation systems used for waste disposal in Mauritius and indicates that the development of sanitation systems have not kept pace with the economic development of the country. The sewerage systems serve only 20% of the population and cover only the two urban districts of Port-Louis and Plaines-Wilhems. The sewage treatment works consist only of screening and mechanical grit removal prior to discharge of the raw sewage directly into the sea through four sewer outfalls. On-site disposal systems serve 80% of the population, representing a potential risk of pollution of the underground water resources, especially in areas of high density and where the water table is near the surface.

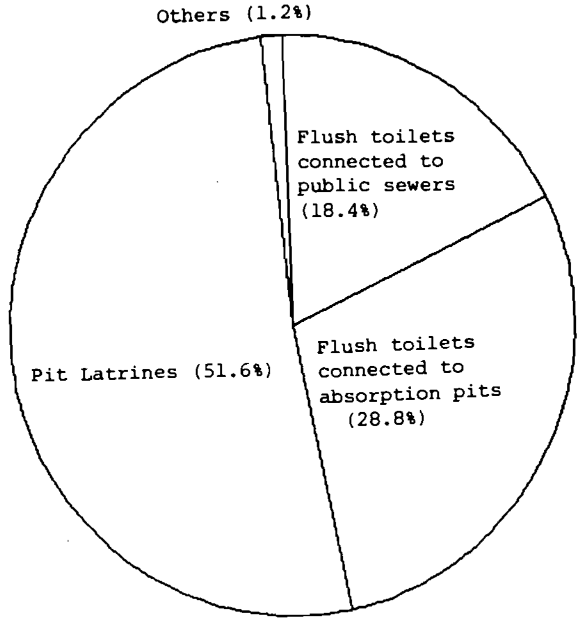

Figure 6. Sanitation systems in Mauritius. Source: Central Statistical Office, 1985.

Figure 7 shows the situation concerning hotels of more than 75 rooms. Out of 64 hotels, 44 are on the sea-front and many of them use on-site disposal systems, such as cesspits, representing a potential risk to the lagoon ecosystem.

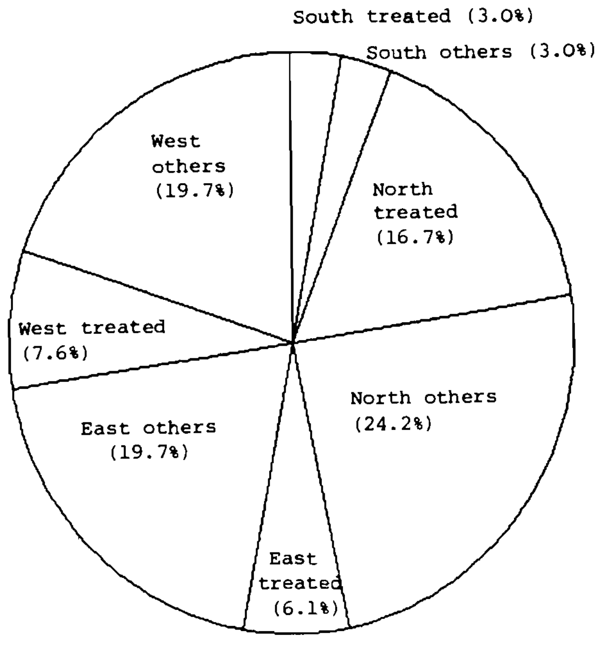

Figure 7. Hotels of more than 75 rooms provided with treatment plants. Source: Laulloo, 1990.

Industrial Effluents

Figure 8 shows the situation regarding industries as of December, 1989. There were some 615 manufacturing industries in Mauritius in 1989 with a predominance of food processing industries and textile industries. Out of the 225 textile industries, 35 dyeing industries were operating, mostly for dyeing cotton materials. These dyeing industries are not confined to any particular region and are huge consumers of water.

The wastes from industries are still largely untreated. Industries in the urban areas discharge their effluents either into the sewer or into rivers or soak pits. Discharge of the industries and especially that of the dyehouses in the subsoil represents a risk to the water table. The 19 sugar mills in operation mostly in the rural areas represent an important source of organic pollution. These industries are in close association with rivers for obvious water requirements and nearly half of them are within a few kilometers from the sea. A survey of sugar factories by the WHO (1970) indicates an average production of 300 gallons of waste water per ton of cane processed with a BOD of 570 mg/l and a total solids content of 2,500 mg/l. None of the sugar estates have adequate treatment plants, and the effluents are sometimes diluted with their cooling water and used for irrigation.

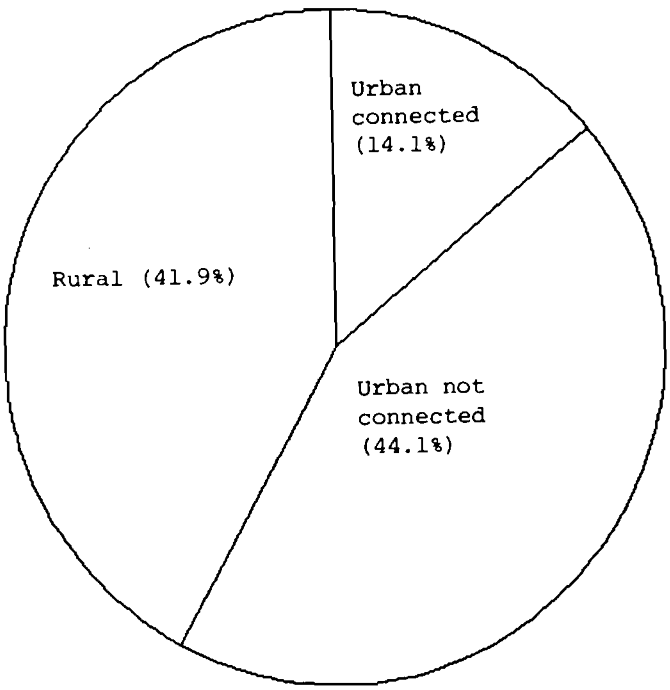

Figure 8. Industrial waste disposal systems, 1989. Source: Laulloo, 1990.

Agriculture

Agriculture is intensive in half the area of the island and constitutes an important non-point source of pollution. About 60,000 tons of fertilizers, mainly nitrates, are used annually, representing 600 kg of fertilizers per hectare per year. The potential for nutrient enrichment in the coastal lagoons is high through surface leaching and river flows. Occasionally high values of nitrates, between 30 and 50 mg/l have been measured in groundwater supplies, especially in regions under sugar cane plantations, but they are short-lived. There is no evident trend towards a general increase in concentration, but it would be important not to go beyond present values (see Figure 9).

More than 200 different kinds of pesticides are on sale, which represents an annual average use of 1,200 tons and makes the country one of the highest users. Herbicides used for sugar cane account for over 50% of the total annual pesticide imports while insecticides are heavily used in the production of green vegetables.

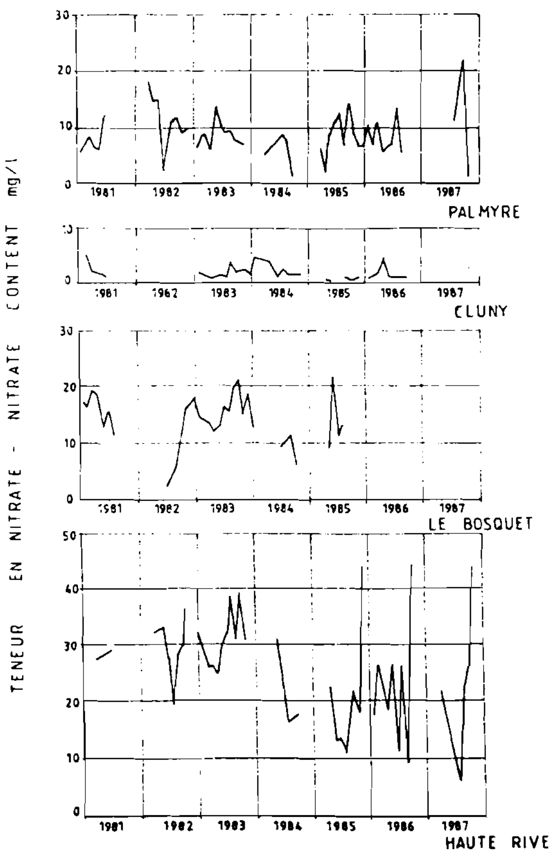

Figure 9. Nitrate levels on four boreholes. Source: Central Water Authority, 1990a.

8. THE COASTAL MARINE ENVIRONMENT

The lagoon around Mauritius is the ultimate sink for all the land-based sources of pollution. It is bound by coral reefs and is more or less a semi-enclosed system. Coral and sand are the only non-living resources exploited. 100,000 tons of sand and 5,000 tons of coral are removed annually for the building industry and the lime industry, respectively. The number of fishermen was 2,667 in 1986, and fish landings from the lagoon was at a mean of 962 tons from 1980 to 1986 (i.e. 4 tons of fish were produced per km^2 of lagoon per year). The mean productivity in 1978 and 1979 was 5.45 tons per km^2 per year. The decrease in production can be due both to a decrease in fishing effort and to a degradation of the lagoonal ecosystem. Tourism in Mauritius depends on the quality of the coastal environment, and tourist arrivals have increased substantially to reach 263,000 in 1989.

Table 6 estimates the economic value of the various activities which involve the utilization of coral reefs and the lagoonal waters around Mauritius for the year 1989.

Table 6. Present economic value of the coastal environment.

Activity	Economic value (million rupees)	Direct employment
Tourist industry	2,796	7,684
Fishing	41	2,667
Aquarium fish	3	20
Sand extraction (100,000 tons)	10	75
Coral extraction (4,500 tons of lime)	4	130
Total	2,853	10,576

Source: Ministry of Economic Planning and Development, 1988.

The coastal resources of the island have thus important economic and social benefits. Coral reefs and lagoons are the country's natural physical asset for the sustainable development of the tourist industry. Coral reefs play an important role to the shoreline and also contribute in terms of their high primary productivity and provision of shelter and nursery grounds. Reef habitats are comparable in complexity and diversity to tropical rain forests. Their conservation and protection is therefore a matter of priority. Recent surveys carried out around the coasts of Mauritius have shown that roughly two-thirds of the total corals are still alive, but that urgent immediate measures must be taken in order to prevent further deterioration of the coastal marine environment (United Nations Environment Program, 1982).

9. INTEGRATED WATER RESOURCES MANAGEMENT

The present development seen from a water-related perspective may be non-sustainable since both water quantity and quality may pose limitations in the future. Water sources are being polluted meaning that water will not be drinkable and/or not usable for industrial and irrigation purposes without treatment. It also means that aquatic ecosystems are deteriorating, and the productivity and species diversity of water bodies are decreasing. Water volume in rivers and aquifers may be small in comparison with the population and activities to be supplied. A man-generated water scarcity may happen due to overexploitation of local aquifers. The degree of utilization of potential groundwater resources is presently around 43% and is expected to reach 100% by 2040. This high degree of utilization of groundwater resources will cause the groundwater table to sink and make the water less accessible and also cause saline intrusion (United Nations, 1979).

An integrated surface-groundwater management is therefore imperative. Sustainable water development in Mauritius should include the following management options:

1) The gross water demand for domestic, industry, touristic, irrigation and hydroelectric uses should be kept below possible water barriers.

2) Groundwater supplies have to be used primarily for domestic supply, and industries should be exhorted to recycle their water as much as possible, and when feasible to use second-class water. The experience of numerous countries shows that a considerable reduction in water demand may be achieved by the widespread use of water recycling systems (Economic Commission for Europe, 1989).

3) Much importance should be attached to leakage detection, and the best possible material should be used for the distribution systems. It is necessary to strike a balance between high investment costs to mobilize water resources and the costs involved in reducing water losses.

4) New "economical" irrigation techniques should be adapted, such as the abandonment of wasteful surface irrigation methods to the profit of localized irrigation techniques.

5) Sewage is dumped into the sea, but by treating this water, it can be used for irrigation projects and artificial recharge. At the same time, a source of sea pollution would be eliminated.

6) Water-quality-impacting land use must be controlled so that no pollutant reduces groundwater quality and no polluted surface runoff reduces river quality for drinking water or for irrigation, or cause damage to the lagoon ecosystem. Through the enforcement of standards, biodegradable water pollution should be kept below the degradation capacity of the streams, while

non-degradable industrial pollution should be kept at a low level so that the concentration after dilution in the dry season river flows is below health limits.

7) Site location of industrial projects must be a fundamental preliminary activity. The south of the island seems to be more apt to receive industrial projects which are heavy water consumers since it is a region where water resources are abundant; the risks of pollution to the aquifer exist only for about 25-30% of the catchment area, and the lagoon does not exist or is only slightly closed.

8) Increasing importance is being attached to economic incentives to the rational use of water resources through the introduction of taxes for water intakes, penal sanctions, etc. (Ministry of Housing, Land and the Environment, 1990). Taxes will allow the creation of the proper conditions to motivate all users to preserve the resource, even when it corresponds to a water right and moves towards a more equitable distribution of the resource.

10. CONCLUSION

The availability of water is a key factor in the socioeconomic development of the country. Its use is subject to severe competition all over the island. A feature characteristic to the structure of water use in Mauritius is that determination of domestic water use is of basic importance for proper management of the groundwater resources, while the rational allocation of surface water resources will depend on the predictions of domestic, industrial and irrigation uses.

Both water quantity and quality may pose limitations in the future, rendering development unsustainable. Measures for the rational use and protection of both surface and groundwater resources as an integral part of overall economic development are considered necessary. The water demand in the long run may be met only through an integrated approach, including legislative, economic and technical measures, and public activities aimed at the rational use of water resources. Sustainable development must also be a question of the sustainable interaction between our society and the water cycle, including all the ecosystems fed by that cycle.

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Chapter 19

THE WATER PROBLEMS IN MAURITIUS IN AN INTERNATIONAL PERSPECTIVE

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The water management might be defined as conscious cooperation of the society and nature aimed at converting natural water resources into a property useful for man and his productive activities. The importance of rational water management for the proper functioning and development of societies increases as the difficulties in providing water for various needs of users accumulate. In the same country or region, functions performed by authorities and public services responsible for water resources development and utilization may change in time, sometimes radically. Three basic situations may be distinguished:

1. Region under consideration is rich enough in water resources to satisfy at any time water demands; the goals of water management concentrate on protecting qualitative characteristics of rivers and groundwater reservoirs, as well as on technical infrastructure of water supply systems.

2. The average water resources are rich enough to meet demands, but their random distribution in time and space result in periodical deficiencies; in addition to the previous tasks, water management should in this situation be oriented to increasing the reliability of supply by means of storage reservoirs and interregional transfer of water resources.

3. The third and most disadvantageous situation arises when scarcity of water leads to deep and long-lasting deficiencies; this may result in serious limitations of social and economic development or in a necessity for some expensive and unconventional means of water delivery, e.g. desalting water from the sea.

It is obvious that in consequence of demographic and economic changes, the same region can in turn experience each of the above situations. It should however be added that recently scientists have warned that global climatic change in many parts of the world may lead to serious decrease in freshwater availability.

It may be assumed that the first scenario corresponds to the water availability of 5000 cubic meters per year and capita, and the last one corresponds to 1000 cubic meters per year and capita.[1] Examples of water-rich countries are:

Canada	122000	cum/year,cap.
Brazil	38000	cum/year,cap.
Sweden	22000	cum/year,cap.
Austria	12000	cum/year,cap.

In contrast, the following water-poor countries may be mentioned:

Libya	190	cum/year,cap.
Kenya	720	cum/year,cap.
Egypt	1200	cum/year,cap.
India	2430	cum/year,cap.

It should be noted that most of the sub-Saharan Africa and the Middle-East have chronic water shortages.

It may be estimated that at present about 1300 cubic meters per year supplies one inhabitant of Mauritius.[2] This means that it belongs to the group of water-poor countries, close to the situation when water resources may create a serious barrier to the social and economic development.
Life cannot be sustained, crops cannot be grown, industry cannot produce essential goods and tourism cannot be developed without an adequate supply of fresh water. How much is adequate is an open and context-specific question, largely depending on the efficiency of water use.
The problem of freshwater availability in Mauritius seems to be serious enough at present, but it is obvious that it may be even worse in the future, depending on the population growth as well as on the climatic and other environmental changes.

In a country or region with scarce water resources, the main objectives of water management may be usually described as follows:

- to increase the disposability and reliability of water resources by constructing storage systems and by protecting surface and groundwater resources against point and non-point sources of pollution,

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[1]Figures are based on annual runoff from endogenous precipitation (m^3), divided by the population (the editors).

[2]This perhaps surprisingly low figure is due to high evapotranspiration and high population density (the editors).

- to increase the efficiency of water use by means of less water consuming irrigation systems by decreasing unnecessary losses in water supply systems, and by conservation of water in industry,

- to satisfy the reasonable needs of population, tourism, agriculture and industry according to socially justified priorities.

At any stage of hydrotechnical infrastructure water may be utilized sensibly or wasted. The process of wise and efficient water management depend on a number of factors, i.e. on competent definition and quantitative evaluation of objectives, on appropriate forecasting of future supply and demand, and on the application of reasonable decision-making techniques in rationally distributing water resources among competing users.

In the Master Plan formulated recently by the Central Water Authority of Mauritius the following assumptions were made:

1. The natural processes influencing hydrological situation of the inland -- precipitation, evapotranspiration and runoff -- will not change during the next 50 years.

2. Population will increase from 1.05 million inhabitants in 1990 to 1.74 million in the year 2040, that is, 66% in the next 50 years.

3. The total water requirements will increase by only 25% during the same time interval due to water conservation and decrease of water losses.

These are rather optimistic assumptions. For example, according to the GISS/GCM[3] estimate, by the doubling of CO_2 concentration the runoff at Mauritius may slightly decrease, but the water demand for irrigation may increase considerably. For all these reasons it seems reasonable to use several supply/demand scenarios in formulating future water resources strategy for Mauritius. It should always be remembered that planning for the development of water resources is undertaken in response to present needs as well as demands that may be anticipated for the future.

Finally, it must to stressed that institutional arrangements must always be consistent with the climatic, hydrological, economic, social and political characteristics of individual nations. They also change with time. But irrespective of all these differences, institutional arrangements for water management should always be such that water issues and problems are seen in a broad context of national needs.

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[3]Global Circulation Model (GCM) developed by the Goddard Institute for Space Studies in New York.

Chapter 20

POSSIBLE IMPACTS OF CLIMATE CHANGE ON MAURITIUS

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The geographical location of Mauritius in the South Indian Ocean provides at least one clear advantage for the island over most countries of the world: it has not been affected by any form of transboundary environmental pollution. This situation may change over the coming decades, however. Increasing anthropogenic emissions of radiatively active gases are expected to modify the climate attributes all over the world. Due to the long residence time of the greenhouse gases (GHGs) in the atmosphere, they mix and disperse globally independent of where they were emitted. The resulting climate change and the associated impacts seem to be the only external environmental nuisance Mauritius will face over the next few decades.

The proposed time horizon of the project is 40-60 years. This is approximately the time during which the changes in the global climate system will gradually occur from what we consider "present" climatic conditions to "doubled CO_2" climate. Significant changes associated with the doubled CO_2 conditions are expected to affect agriculture, forestry, water management, and other areas worldwide. Therefore, despite the immense uncertainties characterizing the climate change issue, the project needs to look at some of the most important impacts that might affect the people, the economy, and the environment in Mauritius.

1. THE CLIMATE OF MAURITIUS

Mauritius is a small land mass in the South Indian Ocean located at approximately 20°S and 57°E. The climate in general can be characterized as a pleasant tropical climate with annual mean temperatures of about 22°C and normal annual rainfall of 2122 mm. The mean annual duration of sunshine hours per day is between 7 and 8.

Despite the small area of the island, there are marked spatial differences in the climatic characteristics due to differences in elevation, distance from the coast, and windward-leeward locations on the island. Mean annual temperatures, for example, vary between 25°C in the low lying coastal areas (Fort William) and 19.6°C at higher elevations (Curepipe at 561 above mean sea level) (see Figure 1). Precipitation shows similar regional differences with normal annual rainfall of 800 to 1000 mm in the northeastern coastal areas and around 3600 mm in the central plateau area (see Figure 2).

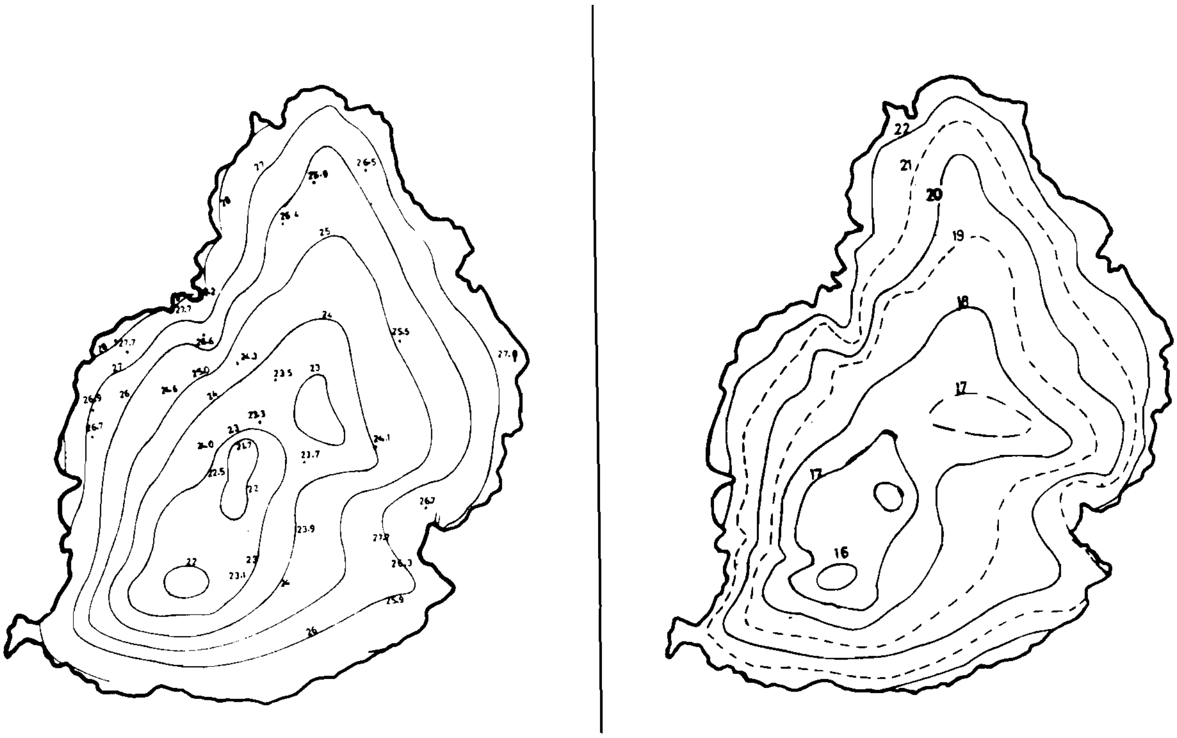

Figure 1. Mean monthly temperatures (°C) in Mauritius in February (a) and August (b). Source: Padya (1989, p. 235).

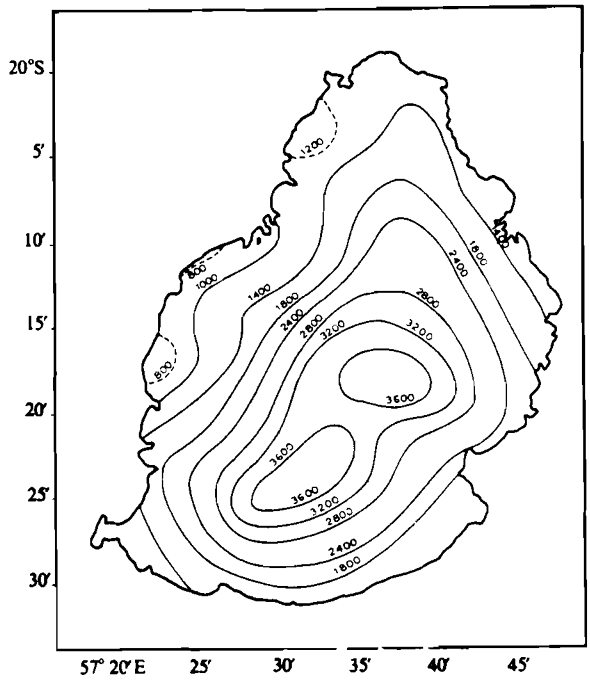

Figure 2. Mean annual rainfall (mm) in Mauritius (1951-1980). source: Padya (1989, p. 205).

The island of Mauritius is embedded in the climate system of the Indian Ocean. The land mass is too small to exert any influence on the major weather processes but significant to have a distinctively different climate from the surrounding ocean. The island is affected by several shorter and longer term climatic anomalies and fluctuations, therefore the annual differences in weather parameters can be significant.

The annual variation of weather in Mauritius corresponds to the generally observed magnitudes of variation in the tropical zone. The mean monthly temperatures reach their maxima in February and their minima in August. The temperature difference between the hottest and coldest months is around 5°C. Rainfall distribution is not even over the year, but we cannot distinguish characteristic wet and dry seasons in Mauritius. About two-thirds of the precipitation comes during the summer, between December and May, and the rest occurs in the relatively cooler June-November period.

These overall very agreeable climatic conditions are considerably degraded by the regular developments of tropical depressions and by the irregular returns of devastating tropical cyclones during the summer months. The atmospheric conditions necessary for cyclone development, and the structure and movement of the cyclones are well understood (Padya, 1989). This knowledge helped the Mauritians to adapt to these climatic extremes by introducing appropriate construction regulations and warning systems. Although the loss of life and damages in buildings were reduced to minimum since the extremely violent cyclone of 1960, reports over the past two decades had regularly mentioned damages to the sugar crop, telephone and electric wires, and weaker structures.

2. PATTERNS OF CLIMATE CHANGE IN MAURITIUS

The most advanced climate simulation models, the three-dimensional Global Circulation Models (GCMs) are generally agreed to perform relatively well at predicting changes in global mean values of climate parameters as a result of changes in the atmospheric concentration of GHGs. Climate change at the regional level is much more difficult to predict, and the reliability of these estimates is agreed to be much lower. The GCM outputs for Mauritius should be treated with special care because the models operate at 3-5 degrees of resolution (longitude and latitude), that is, they do not even notice the land mass within this cell. In order to illustrate this scale problem, consider just three approximate numbers: the area represented by one grid point value around the Equator is 968,129 km^2 in the GISS model, and 411,731 km^2 in the GFDL model, while the area of Mauritius is 1,852 km^2. This means that for studying the impacts of climate change in Mauritius, we need to assume that there will be no significant change in the land-ocean differences compared to those in the past.

Various statistical techniques have been developed to prepare scenarios of local climate change based on GCM output values for the region and historical data sets recorded at the meteorological stations in the region. The standard procedure (Eddy et al., 1989) involves bilinear interpolations of monthly GCM output data (temperature and precipitation) to locations of meteorological stations with long and reliable daily time series of basic weather data. The obtained 12 monthly long-term mean ratios are then interpolated to generate 366 daily ratios. In the final step, the long-term historical records of daily data are modified using the 366 daily ratios to generate GCM-based daily climate scenarios under $2*CO_2$ conditions.

In addition to the general problems of climate modeling, the uncertainties of forecasting climate change in Mauritius originate from several sources. Very little is known about how climate change will modify the atmospheric circulation and the large-scale climatic systems over the South Indian Ocean, what will be the impact on the Intertropical Convergence Zone and on the El Nino Southern Oscillation.

Ironically, tropical cyclones cause not only damage, but they also bring the rainfall necessary for plant development. In the past, years with few tropical depressions often turned out to be drought years. Among the several background climatological conditions affecting cyclone formation and development (Padya, 1989, pp. 98-100), at least two factors are expected to change in the "wrong" direction. Surface air temperatures of at least 28°C are required for cyclone formation and this condition is more likely to be fulfilled with the overall warming under $2*CO_2$ climate. At least 40 per cent of mean relative humidity at 3-5 km altitude is necessary to maintain the convective activity for the development of the cloud cluster. Higher temperatures and higher evaporation ratios are more likely to produce these conditions under $2*CO_2$ climate compared to the present circumstances. Changes in other conditions for cyclone formation are more difficult to assess, and they might enhance or counterbalance the factors mentioned above. Moreover, there is a general agreement, that forecasting the changes in the nature, magnitude, and frequency of extreme events under $2*CO_2$ conditions is the weakest part of climate modeling.

After all the above warnings and disclaimers, a set of data is presented in Table 1 from two of the most sophisticated and most widely used GCMs (namely GFDL and GISS) for two grid points in the South Indian Ocean. The locations are 57.5°E and 20.5°S (just off the southeast "corner" of Mauritius), and 55.5°E and 21.5°S (further off in the southwestern direction on the Indian Ocean).

Table 1. Sample GCM results for Mauritius.

Model/Grid points	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	Monthly precipitation in percentage terms $2*CO_2$ over $1*CO_2$											
GFDL												
57.5°E, 20.5°S	107	53	147	127	163	63	113	87	127	77	123	57
55.5°E, 21.5°S	123	80	177	87	123	60	103	63	120	100	130	60
GISS												
57.5°E, 20.5°S	93	93	127	147	167	133	107	123	127	87	117	100
55.5°E, 21.5°S	107	97	127	150	177	133	107	127	130	73	103	110
	Monthly mean temperature increases (°C) $2*CO_2$ over $1*CO_2$											
GFDL												
57.5°E, 20.5°S	2.9	2.6	2.6	1.9	1.7	1.7	2.3	2.6	2.4	2.2	3.0	2.5
55.5°E, 21.5°S	3.0	2.8	2.6	1.8	1.9	1.9	2.5	3.0	2.6	2.0	2.8	2.8
GISS												
57.5°E, 20.5°S	3.5	3.5	3.7	4.1	3.5	3.8	3.0	3.7	3.4	3.3	3.4	3.6
55.5°E, 21.5°S	3.7	3.7	3.8	3.9	3.1	3.7	2.9	3.7	3.4	3.4	3.4	3.6

Note: GFDL: Geophysical Fluid Dydnamics Laboratory of the National Oceanic and Atmospheric Administration at Princeton.
GISS: Goddard Institute for Space Studies in New York.

Source: IIASA's GCM data base interpolated at 0.5 by 0.5 degree resolution.

There are remarkable differences between the two model outputs. The monthly temperature increases calculated by the GISS model are considerably higher than those of GFDL. The mean annual temperature increase (3.5°C) from the GISS model is higher by 1.1°C than in the GFDL model (2.4°C) (see Figure 3). The precipitation forecasts are even further apart. The GFDL model provides a 37 per cent decrease in rainfall for June, while the corresponding GISS figure shows a 33 per cent increase (see Figure 4). One should keep in mind, however, that it is not that much the individual figures that are important, rather the general patterns of climate change, especially for a small region, like Mauritius. Moreover, results from different GCMs cannot be considered error bounds around each other. The general conclusion is that Mauritius is likely to become hotter and wetter than today. The current pleasant tropical climate may turn into hot and humid tropical for an extended period of the year. More detailed climate change scenarios will need to be developed for use in local climate impact assessments after a thorough analysis of other GCM outputs and using the best historical records from weather stations in Mauritius.

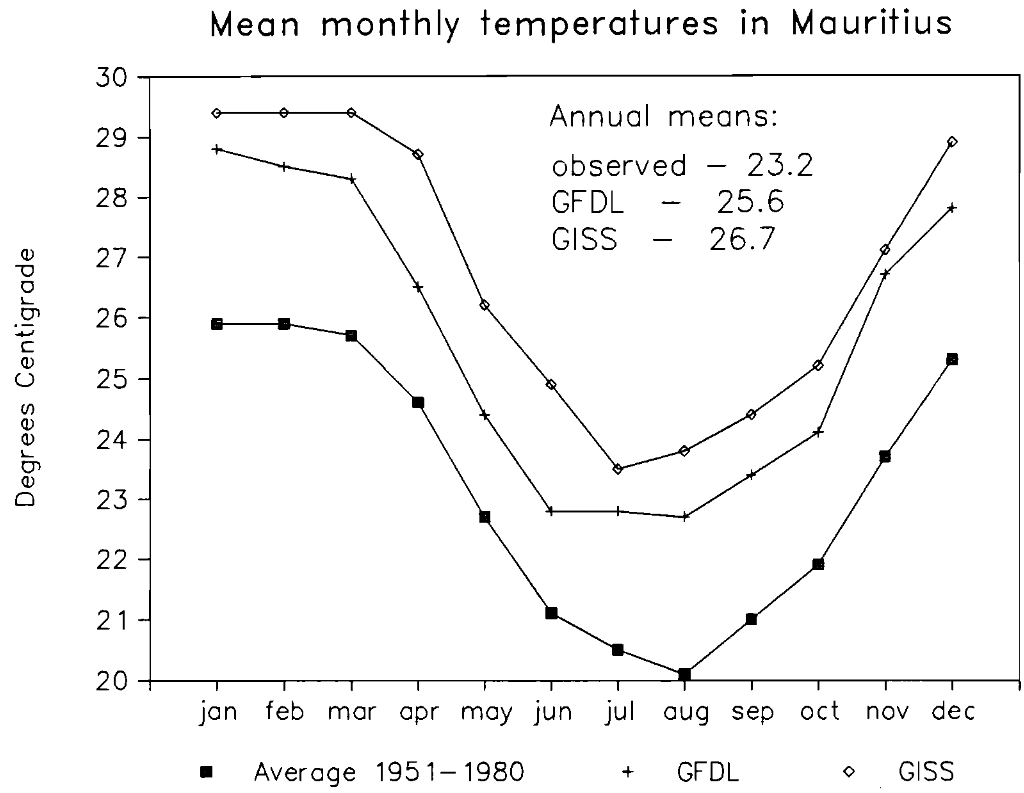

Figure 3. Hisotrical ($1*CO_2$) and GCM-computed ($2*CO_2$) mean monthly temperatures at Labourdonnais. Sources: Padya (1989, p. 238) for historical values and IIASA's GCM data base for the $2*CO_2$ values.

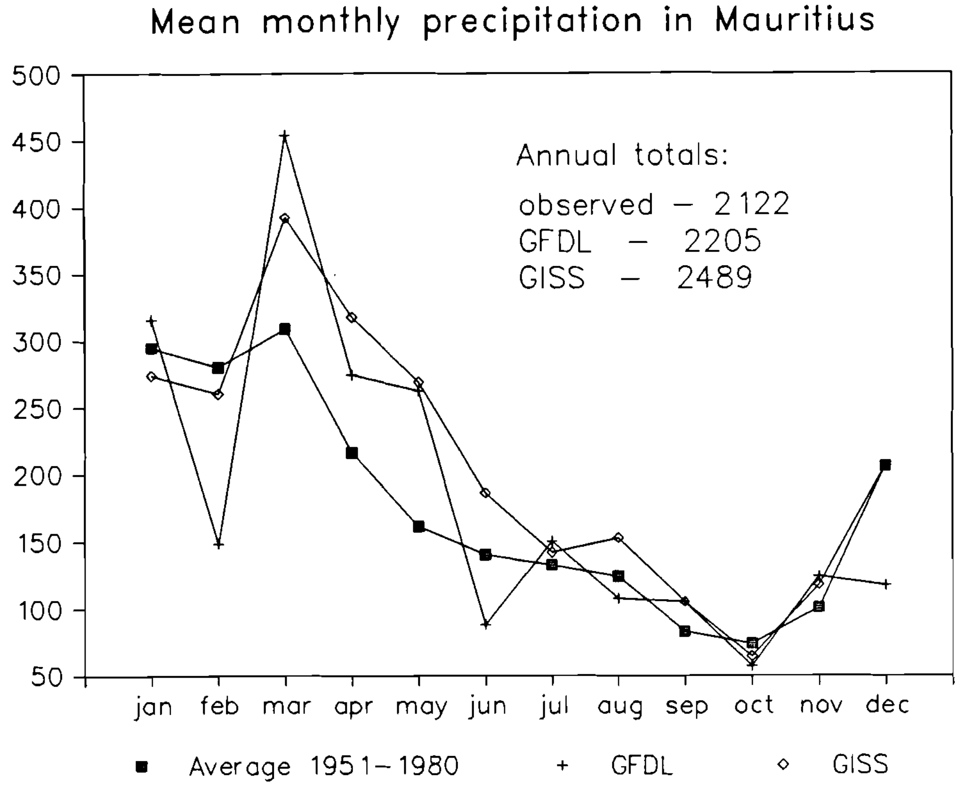

Figure 4. Historical ($1*CO_2$) and GCM-computed ($2*CO_2$) mean monthly precipitations in Mauritius. Sources: Padya (1989, p. 205) for historical values and IIASA's GCM data base for the $2*CO_2$ values.

3. POSSIBLE IMPACTS IN MAURITIUS

Due to the limitations presented in the previous section and lacking the data necessary for detailed impact assessments, only a few possible but important first order (biophysical) impacts of climate change can be discussed in the remainder of the paper. The focus will be on agriculture, water management, and coastal areas. A detailed account of the economic activities, settlements, and infrastructure will be required to prepare a full-scale socioeconomic impact assessment.

Impacts on Agriculture

The Mauritian agriculture is still dominated by sugar cane, although efforts to diversify the agricultural sector and to grow at least part of the nation's food requirements have been successful over the past 10 years. Sugar cane still occupies over 90 per cent of the agricultural area, and sugar exports contribute to foreign exchange earnings on the order of 30 per cent. Therefore impacts of climate change on sugar cane are a major concern to the long-term future of the Mauritian agricultural sector and the national economy.

Although Mauritius is a small island, it has remarkably diverse microclimatic conditions. As it is apparent from the maps presented in Section 1, differences in rainfall amount to more than 300 per cent between the eastern coastal areas and the high elevation areas in the center of the island. There is also a more than 5°C difference in the mean annual temperatures. Similarly, potential evapotranspiration and other bioclimatic parameters vary across a wide range under present climatic conditions. This has made necessary to breed different varieties of sugar cane in Mauritius to suit the microclimatic conditions and to provide the highest possible yields.

As climate is expected to change over the coming decades and Mauritius in general is becoming hotter and wetter, the present microclimatic regions will gradually shift towards higher elevations. The availability of different clones, as well as the time and expertise available to breed new clones are likely to make the adaptation of the sugar cane sector to the changing climate patterns easier. Studies to analyze the behavior of sugar cane and the performance of different varieties in hot and wet regions under the present climate in other regions of the world might also provide useful guidance on what the sugar sector in Mauritius might expect over the coming decades.

Unfortunately, there are additional factor associated with climate change that might make the above smooth adaptation scenario more troublesome even in Mauritius. The first group of factors is related to the exact weather patterns prevailing under the $2*CO_2$ climate. The increased amount of rainfall predicted by both GCMs may be delivered in the form of light rainfall extending over several hours or by intense storms. In the first case, the amount of water infiltrating into the soils and available to the plants is higher, but the longer cloud cover decreases the solar radiation received at the surface and the result is a reduced photosynthetic process. In the second case, when the increased rainfall is delivered by intense thunderstorms, the amount of water available to plants is much lower due to low infiltration rates. At the same time, increased run-off may result in severe erosion of fertile soils washing fertilizers and other chemicals into the streams, rivers, and lakes.

The second group of factors to be considered when we evaluate the impacts of climate change on the Mauritian agriculture are the indirect impacts. Climate impact studies conducted in various regions of the world concluded that in many cases it is not the changing climatic parameters that might cause problems to crop production, rather the changes in other factors that affect agriculture indirectly. Changes in temperature and humidity, for example, are bound to change the pest-crop relationships in their present associations. As new clones are introduced in response to changing microclimatic conditions, new associations will be formed and the new varieties may turn out to be much more sensitive to pests and diseases than the old ones. Very little is known about the possible changes in the pest-crop interactions, although this information would be needed soon by plant breeders to develop pest resistant species.

Another indirect impact of climate change on agriculture is related to changes in water availability. Sugar cane fields and other crops are irrigated during the relatively drier months to ensure proper plant development and to increase yields. The GCMs predict smaller increases in rainfall in this part of the year and higher temperatures will lead to higher evapotranspiration ratios. The net outcome is a higher demand for irrigation exactly at the time when the water is just not available. The resulting water stress might affect plant development and yields more seriously than the direct impacts of changing temperatures and precipitation regimes.

Over the past few years, Mauritius has initiated an ambitious agricultural diversification program to reduce the vulnerability of the domestic food supply to foreign supplies and to decrease the amount of foreign exchange spent on food purchases. The selection of crops was based on present bioclimatic conditions and considerable effort was devoted to convert land areas to these new crops. They mainly include vegetables (potatoes, tomatoes, and others) and fruits (bananas) for local consumption. For some of these crops, $2*CO_2$ climate may easily turn out to be intolerable, at least in their present locations. Careful analysis and planning will be required to decide whether these plants can be grown economically efficiently as basic climate attributes change considerably in the future.

The agricultural diversification program is expected to continue as higher yields from the sugar cane sector permit release of land currently occupied by the number one crop. In addition to improved food self-sufficiency, high value agricultural products for exports (e.g. horticulture) are also considered. To establish some of these crops in Mauritius is likely to require major initial investments in terms of land preparations, machinery, and manpower training. Studies about the agroclimatic suitability of the potential new crops under changing climatic conditions seem to be highly appropriate in order to avoid losses from having to abandon the new crops well before the initial investments are paid off.

Water Management

Some water related problems have already been mentioned above in association with the impacts on agriculture. Data in Table 1 indicate that both models predict a 30 to 50 per cent increase in precipitation under $2*CO_2$ climate mainly in the already wet summer months. If we assume that the regional distribution of rainfall does not change, and combine the GCM results with the historical spatial differences, the result is that the bulk of the rainfall increase will occur in the high elevation areas. These changes will produce increased run-off, especially if the frequency of thunderstorms is increasing, and will increase the risk of severe floods. The small area of the island does not permit building extensive flood mitigation dams, or at least makes the opportunity costs of dam construction very high. Increased precipitation in the mountains would also bring some benefits by increasing the hydroelectric potential of the already existing power plants.

Increasing run-off may lead to more severe soil erosion. The result is increased sedimentation in dams and reservoirs that reduces their storage capacity. Detailed hydrological studies and thorough flood frequency estimations based on the new precipitation regimes will be required to determine the optimal size and locations of flood mitigation dams, new land zoning schemes, and other mitigative measures.

The problem of excess water during the summer is likely to reverse in the June-November period. Neither the GFDL nor the GISS model predicts significantly more rainfall than the historical mean values (see Figure 4). Temperatures, however, are calculated to be 3-4°C higher (Figure 3), and this increases the potential evapotranspiration ratios tremendously. The result is an enormous increase in the irrigation water demand. Unless appropriate water storage facilities are available, the water stress in this period of the year might pose a serious limitation for agricultural production on the island.

The water stress conditions may lead to increased use of water from the underground aquifers for irrigation. The depletion and replenishment ratios of the aquifers are relatively well documented and understood under present climatic conditions. Increased water stress, especially in drought years, will inevitably affect the depletion rates, but it is highly uncertain whether higher precipitation will contribute to a proportional increase in the replenishment rates of the aquifers. If the excess water comes in the form of intense rainfall, it is more likely to increase run-off and leave infiltration, thus aquifer replenishment unchanged. The net result might be a gradual depletion of the aquifers, a vital source of freshwater supply in Mauritius.

Sea Level Rise

GCMs predict that the increasing concentration of GHGs in the atmosphere up to the level of $2*CO_2$ equivalent will result in an increase of 1.5 to 4°C in the mean surface temperature of the globe. This would be accompanied by the expansion of the volume of near-surface ocean water, and the world-wide rise of the mean sea level. Various estimates have been prepared about the rate and magnitude of the sea level rise. The Intergovernmental Panel on Climate Change (IPCC) Business-as-Usual Scenario is forecasting the global mean sea level to be by 8-29 cm higher than today, with the best estimate of 18 cm. For 2070, the forecasted range is 21-71 cm, with the best estimate of 44 cm (Houghton et al, 1990, p. 277).

Various impacts of sea level rise have been investigated over the past few years in many regions of the world. Undoubtedly, the most seriously affected regions will be those where large land areas are already below or near the mean sea level (e.g. Bangladesh) and those where the coastline is characterized by a wide strip of low lying areas. The land area losses due to inundation will be the most severe and the most difficult to prevent in these regions.

A detailed, high resolution topographical map would be required to estimate the area threatened by direct inundation under different magnitudes of sea level rise. For a small island, each square meter of land area inundated by the ocean is a painful loss, especially if it affects the sandy beaches, that are the major attractions for tourists. Regional studies of impacts of sea level rise have shown, however that inundation of low lying coastal areas is not the only, and not even the most serious impact. Secondary and indirect impacts might present more severe threats to coastal ecosystems and socioeconomic activities. Some of these possible implications will be discussed below.

In Mauritius the sea level rise impact assessment is complicated by the presence of the coral reefs around the island. This belt provides an important protective function by breaking the high energy waves off the coasts. Therefore, the future fate of this reef belt is a major factor determining the impacts of sea level rise in Mauritius. Unfortunately, there are several stresses affecting the coral reefs already making their future not very promising.

The rate of upward growth of healthy corals is in the rather wide range of 0.4 to 7 mm/year. Actual rates depend heavily on local conditions (temperatures, nutrient availability, turbidity in the coastal waters, and others). If the projected global rates of sea level rise will characterize the South Indian Ocean around Mauritius, then the best estimates of the IPCC Business-as-Usual scenarios provide annual average rates of increase of 4.5 mm until 2030 and 5.5 mm between 2030 and 2070. These rates are sufficiently slow to permit coral reefs grow upwards as the mean sea level is rising.

The pollution of the lagoons is one of the several factors that may prevent corals to adapt to the rising mean sea level. Agricultural effluents, industrial wastes, commercial and domestic sewage reach the lagoons directly or indirectly. Due to the low exchange of water between the lagoons and the deep ocean, the accumulation of these pollutants may reach alarming rates. This would adversely affect the growth of corals. Coral reefs are also damaged by the use of explosives by fishermen (this practice is illegal, and enforcement has improved over the past few years). In addition, 100,000 tones of sand and 5,000 tones of coral are removed annually from the lagoons. The impacts of decreasing the depth of the lagoons are controversial. The increasing circulation is likely to enhance water exchange between the lagoons and the ocean, thus reducing the concentration of pollutants in the lagoons. Increased turbidity, however, might slow down the formation and upward growth of corals.

Coastline erosion is already a problem in the sandy beach areas of the coasts in Mauritius. This normally slow process is altered at several points by sand extraction from the beaches and also by beach creation. In general, sea level rise will accelerate beach erosion mainly as a result of deepening the nearshore water that permits high energy waves breaking on the shore instead of breaking off shore. Thus, in addition to the areas lost due to direct inundation, more valuable coastal land would be lost due to beach erosion.

The rivers in Mauritius are short and their water yields are uneven due to the uneven annual distribution of precipitation and to the increased water use (mainly for irrigation) in the drier months. The complex processes of sedimentation (advancing the coastline) and submergence (retreating the coastline) will be intercepted by the rising sea level. Detailed studies are required to estimate the net results of these counteracting processes at the river mouths.

The other factor affecting river deltas is saline intrusion upstream of rivers. This involves tidal flooding reaching areas far upstream from the river mouths, especially when river maintenance flow is lower. The result is the saline contamination of freshwater sources of potable water and irrigation for the densely populated coastal settlements and fertile agricultural areas. These water abstraction points might need to be relocated further upstream.

The area of mangrove forests has considerably reduced in Mauritius due to intensive on-shore development and conversion to other uses such as agriculture or aquaculture. Yet, the mangroves are important to sustain the productivity of fish and shrimps. Theoretically, mangroves could migrate landward in response to sea level rise if adequate freshwater supplies and the necessary landward space are available. If the hinterland is already developed, mangroves will face gradual drowning as the increasing saline water level prevents freshwater dilution. Implications for the productivity of the lagoon fisheries and aquaculture might be dramatic.

Several processes affecting the coastline in Mauritius as a result of sea level rise are likely to be much more sever if the off-shore natural protection functions provided by the coral reefs are lost. According to a recent survey, one third of the coral reef is already dead. Therefore, preserving the reef is important not only because it is a major attraction for tourists, but also because without it the shoreline response and associated socioeconomic impacts of sea level rise will be much more severe.

4. CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

The impacts of climate change will have to be addressed by a research project seeking to identify sustainable development strategies for Mauritius. Based on more detailed impact assessments, appropriate mitigation strategies can be formulated to adapt to the changing conditions and to reduce their adverse impacts on the biophysical systems, as well as their economic and social implications.

The consequences of changes in the climatic parameters and sea level rise outlined in the previous section may cause severe disruptions in the Mauritian economy and society if they are caught unprepared. Given our present knowledge and the magnitude of uncertainties related to climate change, it is difficult to propose major investments to be committed now in order to mitigate impacts of uncertain threats in the distant future. A recent study conducted in Southeast Asia has shown, however, that by linking climate impact assessments to the long-term changes in the affected natural resource base and to the associated long-term trends in the social and economic systems, appropriate "tie-in" strategies can be designed that make the society better prepared to mitigate adverse impacts and simultaneously provide generally agreed social, economic, and environmental benefits (Toth, 1990). Tie-in adaptations to the potential impacts of climate change involve a series of protective and rehabilitative measures in natural resource management; modified price, subsidy, export, and import strategies in economic policy; and a variety of research and development options in agricultural, coastal protection, and water management technologies. The resulting improvements in soil erosion, drainage, flood mitigation, water supply, water quality and ecosystem protection in the coastal lagoons, and many other areas would handsomely pay-off even if the impacts of climate change in Mauritius turned out to be far less dramatic than those discussed in this paper.

Tie-in adaptations to local impacts of climate change are related to one important small-scale criterion of sustainable development, namely resilience. It is the increased capacity of a region or nation to absorb external shocks (economic or environmental) and the ability to adapt to large-scale changes over which it has no or very limited control. Thus, tie-in adaptation strategies also provide a meaningful option for small regions to reduce their sensitivity to global risks.

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Chapter 21

ASPECTS OF GEOGRAPHICAL DISTRIBUTION ON A SMALL ISLAND:
Future Settlement Patterns in Mauritius, Costs and Benefits

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1. AIM OF THE PAPER

Would a settlement pattern policy in Mauritius increase the living standard of the population and at the same time save money? The aim of this paper is to analyze how different settlement policies will affect the economy of Mauritius in the long run. By adapting a strategy for the development of the settlement pattern system, it should be possible for the population of Mauritius to earn some billion rupees during the next decades. History shows that several mistakes have been made in policies for settlement patterns in other countries. Also today many mistakes are being made mainly because some costs and benefits of different settlement patterns are counter-intuitive. There is thus a clear need for a system analysis approach, including both qualitative and quantitative methods, to clarify characteristics of different patterns. In this paper only some preliminary calculations will be presented. Empirical estimations, more theoretical analysis, and more knowledge about the planning system in Mauritius will be needed to ensure that the policy will have the implied benefits.

Settlement policies are aimed at specific geographical distributions of physical infrastructure, e.g. housing areas, work places, roads, railways, etc. Where should new housing areas be located? How much should be invested in roads and vehicles in order to connect cities, towns and villages to a well-functioning system of settlements? Where should these investments be located? Should the population be dispersed or concentrated to make the system more efficient?

If we were to approach Mauritius in an airplane from the southwest, the topography of the small island with its less than 2000 km^2 would look something like the following (Figure 1):

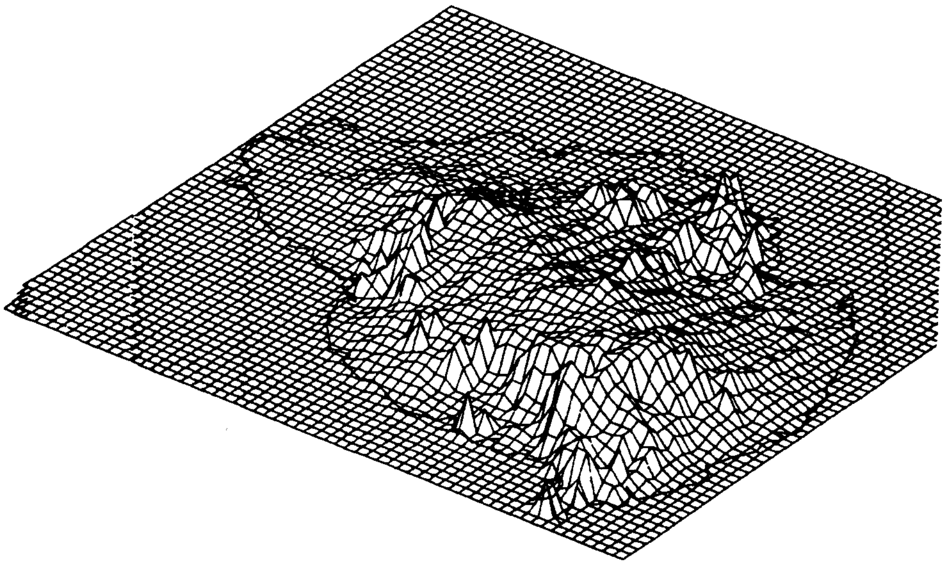

Figure 1. The topography of Mauritius.

If the topography of the island changed as we came closer, so that the mountain heights became proportional to the density of the population, then a new landscape would emerge (see Figure 2). The main "mountains," the most densely population areas, are located along a 15 kilometer corridor starting at Port Louis and going south.[1]

One of the questions in the research project behind this paper is whether new settlements should be located at this corridor or whether they should be more spread out. What would an economic analysis show? What are the political conditions for a settlement policy based on rational economic analysis? Is there a geographical dimension in the political system? The majority of the voters are living outside the corridor; do they want new housing areas in the corridor or not?

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[1]This map is drawn by Danne Mikula (Uppsala), using a standard GIS, Surfer. The basic data were mapped by Urban Lindgren (Umeå), Christopher Prinz and Anne Wils (IIASA).

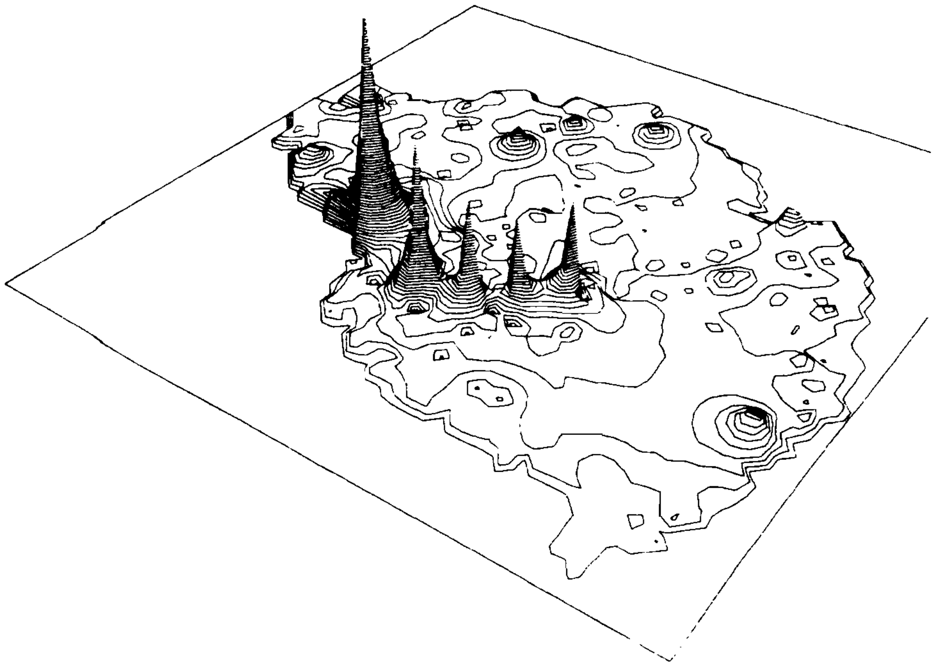


Figure 2. The population density of Mauritius. The height of the "mountains" is proportional to the number of inhabitants.

2. METHODS

The methods used in this progress report will consist of a verbal analysis of investment processes, some conventional calculations of costs and benefits of marginal changes in existing systems, and geographical network analysis. The existing settlement system in Mauritius will thus be simplified to a computerized network where existing cities, towns and villages make up nodes, and the roads between them are the links. In this way there will be quite a few methods of analysis available to handle networks with different characteristics, e.g. graph-theory, matrix-algebra, and object-oriented high-level languages.

3. IS PLANNING NEEDED?

Is it not the right and privilege of individuals to build their houses wherever they can and want to? Is there a need for planning? Could not the free market handle settlement patterns? From the neoclassical theoretical point of view, market forces could allocate new housing areas in an efficient way if some premises exist. We will come back to these questions in the paper.

Here, it should only be pointed out that in practice, individual solutions do not always work well when they make up parts of an integrated system. Market solutions are as unpractical in certain contexts as they are excellent in others. Their limitations will often make economic (and military) actors, like companies and government agencies, organize internally in hierarchical structure, where the managers decide upon important investments. This is, of course, common practice in business, in small family firms, as well as in large multinational corporations.

It is also common practice in some public spheres. In all countries the state, directly or indirectly, governs the maintenance and development of the road system. In Mauritius, the state has the direct responsibility even if parts of construction work and maintenance are delegated to private enterprises. The latest additions of main roads have, for instance, been built by a Yugoslavian company. In other countries, the work is sometimes delegated to regional or local authorities who, in turn, often buy services from private companies. However, we may observe that the nation states always decide over the transportation network and that in Mauritius, like in all other countries, they will do so. Thus, communications and transport are regarded as being so important and fundamental to the functioning of societies that the highest level of decision is always responsible for the operation of them.

4. A SHORT RETROSPECT

History teaches us how fundamentally important transportation systems have always been when it has come to organizing trade, or creating systems of production. In the old days, nature provided transport, e.g. in the history of Europe there are two often-quoted examples of powers using water as a means of transportation: The Hanseatic League in the north, and Venice in the south. One single ship could load as much as a whole caravan of horses or camels. (A strong horse or camel usually carries around 200 kg, but only for short daily marches.) The history of Mauritius is also heavily influenced by European seafaring colonial nations.

The geographical distribution of cities, towns and villages is a result of historical processes. History thus shows that settlement patterns seldom are efficient. Different older requirements from the production system can be seen in existing structures at any point in time. The dependence on boat traffic earlier and road traffic today, as well as earlier dependence on agriculture will show in the present distribution of the population in Mauritius, as well as in many other countries. The future geographical distribution of the population is, however, not only dependent on transportation technology and the present production system.

This is where politics, or lack of politics, comes in. We will shortly recapitulate some of the basic ideas behind the development of physical infrastructures, and the organization of their development.

Many concepts can be used in order to promote the understanding of organization forms. "Bureaucracy" and "market," a pair of opposites, belong to the classic ones (Weber, 1957). A bureaucracy is a hierarchical organization whose purpose is to plan and carry out major endeavors. The aims of the work concerned may, in their turn, have been laid down by a dictator or decided in a democratic process. The market form represents an organization form where many buyers and sellers exist simultaneously. In theory, the market is so big, in relation to the many consumers and manufacturers, that nobody is in control of the formation of prices.

The market has many advantages. For instance, decisions may be made more quickly when many people are able to take initiatives. Furthermore, competition between business companies is held to egg competitors on towards increased productivity. It has its drawbacks, too. Competition often leads to mismanagement and to short-term considerations taking over. The sum of many small rational decisions may be an impractical society or, at worst, a doomed society.

When the railway network was extended in the nineteenth century, either of these two organization forms was used in the individual countries. We might recapitulate history on this point, as the example is illustrative where differences in geographical effects are concerned.

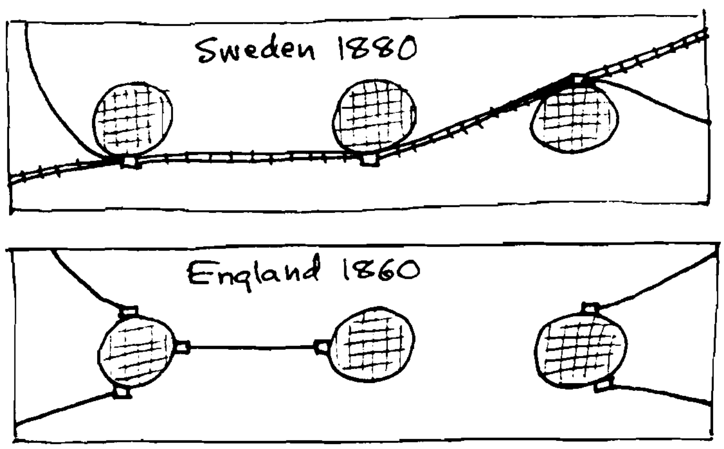
Table 1 shows how the bureaucratic principle and the market principle respectively, have been allowed to govern the extension of the railway network in a few countries. Countries whose planning ideology was a traditionally conservative one at the time have favored stringent state control of the infrastructure. This entails national solutions in respect of the location of railway lines (see Figure 3). The conservative planning ideology of those days (where the extension of the physical infrastructure was concerned) is closely related to the socialist planning ideas of our time. Countries with a modern liberal planning ideology at the relevant time allowed market forces, in the shape of a number of competing railway companies, to govern the emergence of the railway network. Local solutions are a result of this.

The degree of joint planning in different countries can be perceived from maps. At the top of Figure 3, a planned innovation can be seen. The state, with a conservative planning ideology, has caused a main line to be built, passing the cities. The main line forms part of a national network. Private railway companies may build connections leading to peripheral towns, villages, etc., and have them linked to the main line, if they possess enough means to make the investment.

A non-planned innovation can be seen in the lower part of the map. In a liberal market economy, private railway companies have connected the city with various neighboring towns and cities. The local perspective turns out to be more important than the national one. Obviously, the expansion has taken place in a market economy operating on the basis of a laissez-faire philosophy. In Great Britain, railway planning was not coordinated until a century after the extension. British Railways was founded in 1949.

Table 1. Examples of countries with different organization forms in connection with the extension of the railway network during the latter half of the nineteenth century.

		Political principle	
		Absolute rule	Multiple rule
Distributive principle	Bureaucracy	Russia	Sweden
	Market	Austria	England



Main public railway line
Private railway
Railway station
City

Figure 3. Geographical consequences of planned and non-planned innovations.

If we should extend the analysis to consider how the two allocation principles, bureaucracy and market, influence investments in housing, then we would find that in most non-communist countries it is the market principle that dominates. Building companies, both public and private, build in areas they select themselves. Households migrate to villages, towns and cities they prefer.

We thus have two different allocation principles working in many countries. Roads are located by the public sector. They connect housing areas which are located mainly by the private sector. Let us now discuss factors that have an influence on investments in housing areas.

5. LOCATION OF NEW HOUSING AREAS: PRINCIPLE EXAMPLES

In a hypothetical example, where all settlement on an island is located in a small area and where there are plans to build a new housing area (for example 10,000 inhabitants), we could discuss the costs and benefits of a close location of this area as one alternative and a more remote location as the other.

For the building company, an important actor, the price of land is one of the main factors behind the decision on where to locate the new dwellings. Usually land is cheaper further away from existing settlements. Automatically there is a strong force to decentralize housing areas. For people moving into the new houses, it is also an advantage if the cost of land is kept low. Many consumers have to care about the short term costs when they buy the house and thus an "entrance cost" could be more important than the long term costs, which would include commuting costs, road taxes, etc.

These important actors also favor a dispersed location of housing areas, especially so when road costs are divided among the whole population and not only paid by the inhabitants in the new town (see Figure 4).

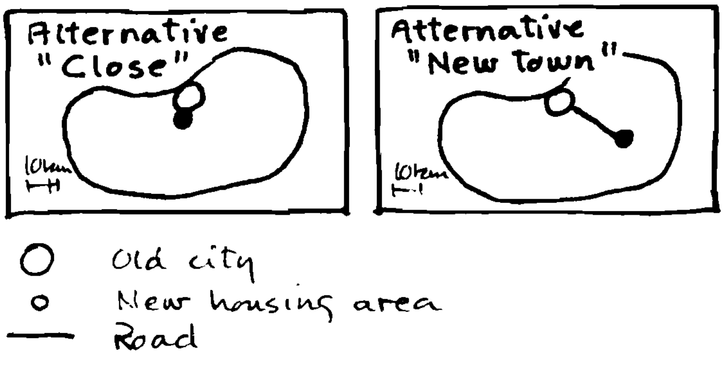


Figure 4. In this example a new housing area is built either close to existing settlements (to the left) or further away as a new town (to the right).

The road costs are important for the government or other actors responsible for roads. If there is an initial cost for a new road, these costs could be significant. However, if an old road exists, nothing has to be decided when the new town is growing. It is first in the long run that the responsible actor has to improve the road. Thus a totally new road would need resources and decisions and is therefore a force against the new town. If the new settlement is within reach in the existing road network, investment needs are not directly correlated to the new town and thus they do not hinder a dispersed development of new housing areas.

Of course, other costs also have to be investigated carefully, not only the investment costs that often dominate the decision process. In a cost-benefit study, the following costs should be included:

Investment costs:

- Land
- Roads
- Housing
- Other

Running costs:

- Road maintenance
- Housing maintenance
- Vehicles (= import)
- Fuel (= import)
- Commuting time
- Casualties in traffic
- Environmental costs

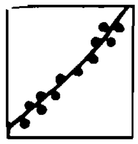
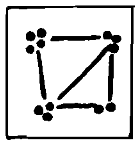
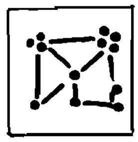
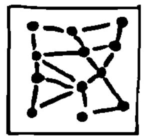
Dynamic costs

- Changes caused by the investment

Dynamic costs are developing in the settlement system as an effect of changes in behavior. A road improvement to save commuter time for inhabitants in a new town could result in new dispersed settlements, more commuters and a total loss of time.

Benefits are usually more difficult to estimate but they are as important as costs. In our hypothetical example there are no differences in social or other benefits if the new housing area is located close or remote from existing settlements. Thus the costs will decide the location. The total costs are much higher in the alternative "new town," but these costs are not too important for the main actors in the decision process. For the building company, investment costs are lower in the alternative "new town" and thus there is a high probability that this alternative will be the outcome of a decision process in the real world. If we should extend the example and have a principal discussion of how several new settlements could be located, the cost picture would probably look as follows (Table 2):

Table 2. Different settlement patterns corresponding to different cost levels. (Communication and transportation costs are dependent on physical form to a large extent.)

Settlement Pattern				
Costs for:				
Roads				
Investments	Low	Medium	High	Very high
Maintenance	Low	Medium	High	Very high
Commuting				
Cars	Medium	Medium	High	Very high
Buses	Very low	Medium	High	Very high
Railways				
Investments	Medium	Very high	Impossible	Impossible
Other networks				
Tele, etc.	Low	Medium	High	High

6. CONCENTRATED OR DISPERSED LOCATION OF NEW HOUSING AREAS IN MAURITIUS - IMPACT ON TRAVEL DEMAND

In order to explore some more realistic consequences of alternate spatial population distributions, a small GIS model of Mauritius and its transport system has been developed (and implemented as 500 lines of Pascal code). The model aims specifically at estimating the relation between increase in population and increase in transport work, given different policies about where to locate new housing areas on the island.

Model, Data, and Assumptions

The population of Mauritius in mid-1987 was divided into 195 localities. The number of inhabitants, together with x- and y-coordinates for each locality, as well as for many points on the coastline of the island, is one basis for computing the series of maps (Figures 4-7). The area of each open circle on the map is proportional to the number of inhabitants in the locality at the center of the circle. For each of the nine districts a small fraction of the population lives outside those localities. They have been included proportionally.

For the road system, 75 of the localities - evenly distributed among the districts - were chosen as nodes in a representation of the network on the island. The nodes are interconnected with 114 direct links, altogether representing most of the main road infrastructure found on the island. In the model, this information is represented both as a linked list and as a connectivity - and a distance array. The roads are classified in three speed classes: motorway, main road, and other road, as shown on the maps.

The population of localities not chosen as nodes in the transport network are separately added to those chosen based on distance when the model computes transport work. Hence, variations in distances from home and place of work to those 75 nodes are supposed not to affect the general results of the experiments presented below. After that, the shortest path and the distance on the shortest path between each pair of nodes (75x75) are calculated.

Thereafter, the volume of individual and aggregate travel work (sum of all individual distances travelled daily) for the entire 1987 population is computed based on the following set of assumptions:

- A certain fraction of the population in each node travels each day between home and Port Louis, reflecting its importance as the main center of occupation on the island (one fifth of the population in the examples below).

- Another fraction of the population has to reach an activity each day located where other people live (i.e. working in, and/or using more specialized services). The distance for each person is calculated as the mean distance to all other persons. The average of those distances is the expected value of the distance between two randomly chosen individuals on the island (this fraction is set to one tenth in the examples below).

- In addition, everybody on average travels some distance each day locally in order to get on the network, to reach local services, to visit neighbors or to work in the local fields, etc. (In the example below, this distance is set to 2 km.)

The resulting estimate of the total daily travel volume performed by the 1987 population is then compared with the travel volume performed in the same way by an increased new population. Different combinations of population increase (20% in the examples below) and relative location of this increased population can be chosen in each model run.

It is, of course, also possible to change the fractions for Port Louis and other people in order to test the sensitivity or use more accurate data when available. However crude, sensitivity tests reveal that the estimate of the relative increase in transport work is quite robust and insensitive to changes in local distances and fractions of population travelling for different purposes.

Four Experiments

Figures 5 to 8 below summarize the results of one experiment. In all four of them, all the population increase, the local daily travel distance, the fraction of population going to Port Louis and the fraction randomly visiting "each other" remains the same.

1. Dispersed new settlement. Figure 5 shows the location of nearly 200,000 new inhabitants (the filled circles) when they settle in all the 75 different nodes in proportion to the number of inhabitants already living there. As the new inhabitants settle (nearly) in the same way as the old population and they also behave identically, they contribute proportionately to the travel load. The population increases by 20% and so does the volume of travel work.

2. Semi-dispersed new settlement. In the next experiment (Figure 6), all new settlements are concentrated to the 40 nodes located on the main roads and the motorways. This alternative gives rise to a small reduction in the increase of travel load, 17% instead of 20%. The majority of the old population also lives in those nodes. So, the difference in settlement pattern and therefore reduction in travel load is not as large as the decrease in number of locations might imply.

3. Concentrated new settlement. If all new settlements are concentrated to the seven nodes on the motorway (Figure 7), then the increase in travel load becomes considerably lower - 10% compared to 20%. On average, the new inhabitants travel just half the distance travelled by the old population.

4. Semi-concentrated new settlement. If a planning agency is strong enough to enforce a concentration of all new settlements to seven locations, then it probably also has the power to consider other obvious circumstances. In the experiment shown in Figure 8 this agency has put a roof on the expansion of the old center - Port Louis - due to expected congestion and pollution. Therefore, the new 200,000 inhabitants have to settle on the remaining six nodes on the motorway. Now, those who otherwise would have settled in the center experience longer distances to that center, so the average increase in travel load becomes 13% compared to 10% otherwise. Still, the result is much better than what can be obtained by any "semi-dispersed" settlement pattern.

To sum up the results of the four alternatives, a proportional population growth in the settlement system will in the long run mean a proportional growth in travel, if behavior, etc. do not change. A concentration of new settlements to existing larger towns along the densely populated corridor between Pamplemousses and Curepipe will save a lot of travel efforts in the system (with the given assumptions on travel behavior and job location). The difference between these two alternatives is 10% in traffic volume. Considering the traffic and transportation means of today, then for Mauritius this 10% increase in traffic volume would:

- add to GDP
- add to consumption costs
- add to production costs
- not add to welfare (measured by, e.g. social indicators)
- increase import, e.g. by 1000 vehicles (per year), including 300 cars and 150 million liter motor spirit
- increase demand for hospital care (12 fatal casualties and 280 serious injuries per year)
- increase commuting time

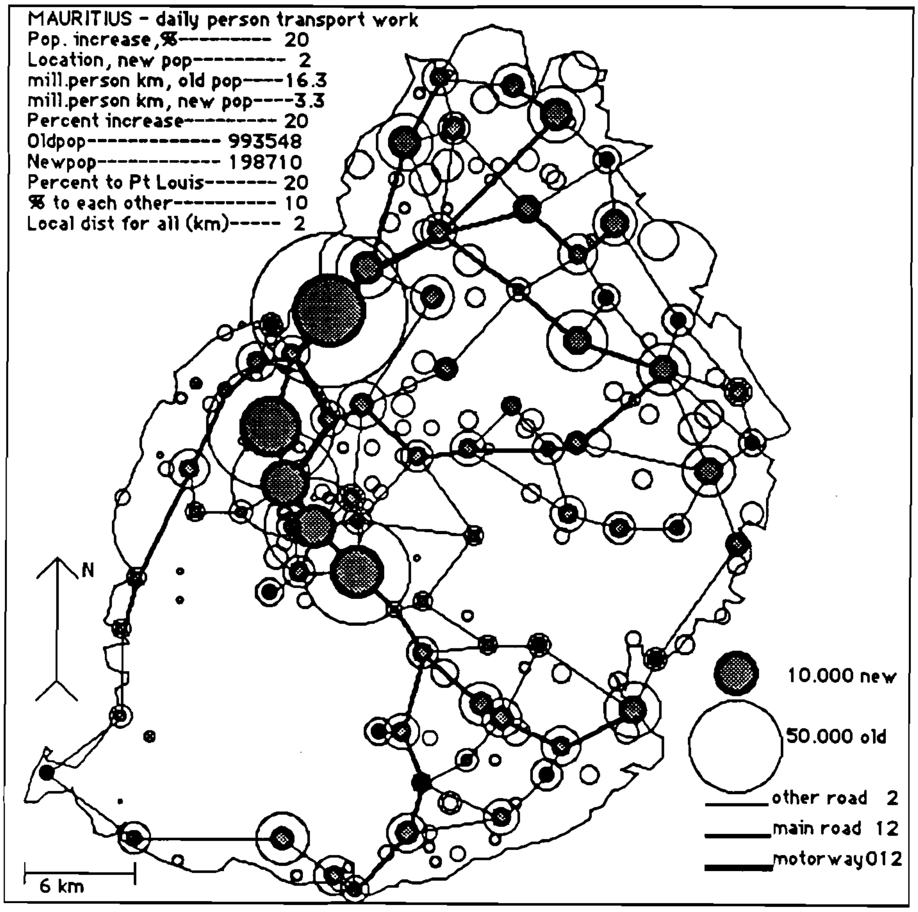


Figure 5. Dispersed new settlements. In this alternative a 20% increase in the population is distributed proportionally to existing settlement pattern. In the long run this new population will add 20% to the traffic volume if they have the same travel behavior as the existing population.

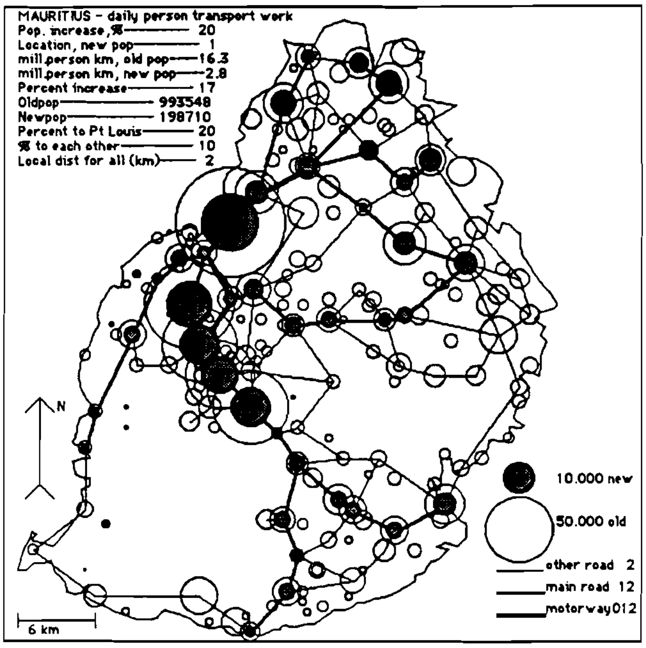


Figure 6. Semi-dispersed new settlement. A 20% population increase is located to 40 settlements located on the main roads and motorways. The traffic volume will increase by 17% in our experiment.

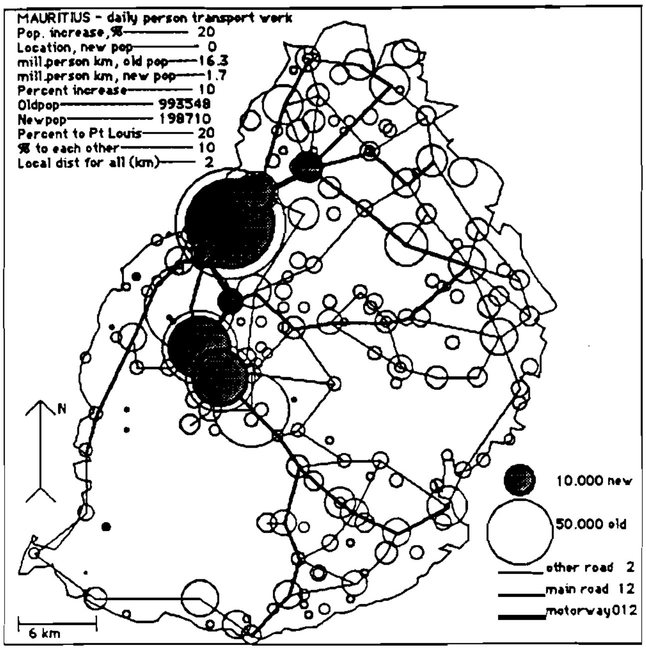


Figure 7. Concentrated new settlement. A 20% population increase will add 10% to the traffic volume in this example where all new settlement areas are concentrated to seven existing towns.

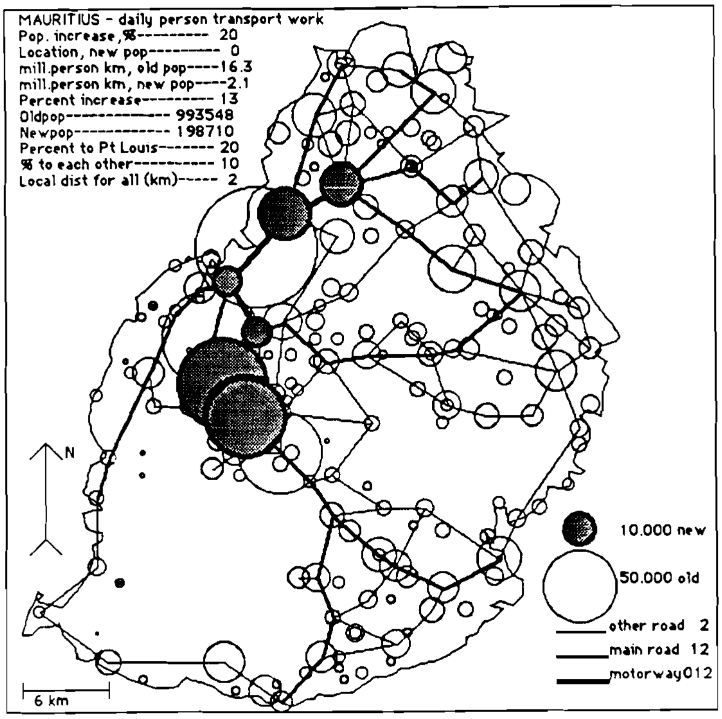


Figure 8. Semi-concentrated new settlement. In this example a 20% increase in the population will add 13% to the traffic volume.

CONCLUSION

The difference between the result of an almost pure market solution (dispersed settlement) and a solution demanding a powerful intervention (concentrated settlement) is in the example about 10% of the level of travel load (or a 50% reduction of the maximum increase in load) over a time period corresponding to 20% population growth. Is it worthwhile? Or rather, is it enough from an economic and environmental point of view?

Any effective measure to reduce the population increase and/or to concentrate also the old population, is at least equally important for reducing traffic load. Even so, most of the potential benefit from concentrating the population to the southeast corridor from Port Louis will not be released until other supplementing measures are employed. One obvious catalyst for saving resources and environment is the development of efficient means for public transport in the corridor.

Finally, the calculations made so far have to be adapted more to the actual behavior of the population in Mauritius. The next step in our research will thus be to get accurate data for the spatial distribution of jobs and commuting behavior. After that it is important to investigate how the planning system is working. After all, theoretical knowledge always have to meet real conditions before fruitful changes in behavior can be achieved.

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POPULATION AND SUSTAINABLE DEVELOPMENT IN MAURITIUS

Closing Remarks

Nathan Keyfitz
IIASA

International conferences are the style, but few small conferences are as international as this one. Citizens of some 15 countries have been involved, representing more than that number of cultures. Wolfgang Lutz, speaking in the first session, referred to Mauritius as a microcosm, and it is indeed one, in a way additional to his statement. It has the advantage of a combined Indian, African, French and British cultural heritage, every component of which is rich in its own right, and new features are brought out by the combination.

There is one part of that heritage that is not in the papers, and has not to my knowledge been mentioned in the discussions. That is the attitude of Asian religion to the natural world, sharply contrasting with the stand of Christian religion. The latter, in the very first chapter of its Holy Book, instructs man to multiply and fill the earth, and to have dominion over all other beings, in other words to use the earth for his own purposes. I remember once in a discussion, when I was taking the side of the trees in British Columbia against ruthless harvesting, being told by an economist at the meeting that long before the last of the trees was cut wood would be substituted by aluminum in some uses and plastics in others, and so the right policy was to cut those trees while they were still worth something in the market. It seemed to me then, and does now, extremely dangerous, quite aside from the arrogance, to take such a course on the basis of the half-knowledge that we possess, and in ignorance of what those trees do for us other than making houses and furniture.

Let me quote an American historian Lynn White Jr. on the stand of Christianity:

> By destroying pagan animism, Christianity made it possible to exploit nature in a mood of indifference to the feelings of natural objects.

The religions of Asia, especially Buddhism and Hinduism, take a very different stand. Let me quote on this Soedjatmoko, an Indonesian who is in the company of the century's most distinguished intellectuals:

> The religions of Asia have a world view in which the natural world is much more of a continuum, with the human a part of nature rather than a privileged being standing outside of nature. There is here at least the rootstock for a sense of obligation to the rest of creation which could do much to moderate the more brutally destructive interface of modern technology with nature. The very idea of reincarnation expresses a sense of solidarity with other

> creatures, just as the idea of an endless cycle of rebirth expands the temporal horizon of the individual.

But Soedjatmoko is honest when he goes on

> Having said this, these particular spiritual values have not prevailed over short-term, materialistic values to protect the integrity of the Asian environment.[1]

The problem of this Workshop, as of the project of which it is a part, and of the 1992 United Nations Conference on Environment and Development to which its work will contribute, is to narrow the economic gap between a developing country like Mauritius and the more developed countries of Europe, America and Asia, but without falling into some of the environmental mistakes that the latter now have cause to regret.

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[1]Rector's introductory remarks for the Symposium on Science, Technology, and Spiritual Values, "On Different Ways of Knowing." Prior to a term as Rector of the United Nations University in Tokyo, Soedjatmoko (1922-1989) had been the Indonesian Ambassador to the United States, and had filled other official functions, but it is as an independent intellectual that he is mainly remembered.

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