Working Paper

From No-Man's Land to a Congested Paradise: An Environmental History of Mauritius

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WP-93-27
June 1993

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ABSTRACT

This Working Paper constitutes Chapter 5 of the book manuscript, *Understanding Population-Development-Environment Interactions: A Case Study on Mauritius.* The Mauritius case study was carried out by IIASA in scientific collaboration with the University of Mauritius and funded by the United Nations Population Fund (UNFPA).

This paper identifies long-term social, economic, and political processes that shaped natural resources and various ecological systems of Mauritius. The environmental history of the island demonstrates how various human activities transferred the landscape, fauna, and flora over the centuries. The balance of direct, local causes behind these interventions as opposed to remote and often indirect driving forces kept changing over time, but the analysis shows overall dominance of the second group. Even in the position of full political sovereignty, remote economic, political, and increasingly, environmental processes and forces tend to shape local structures. This is the main reason behind my confidence that the island's environmental history has useful lessons for the future in Mauritius and perhaps many other small islands.

The analysis shows that during the 400 years history of Mauritius, various forms of natural resource exploitation and environmental transformation were to a large extent results of fluctuating opportunities in international trade, changes in economic policies of the colonial power and other important trading partners, various forms of technological change, institutional transformation, and political changes. The dynamic combination of these factors conditioned the aspirations and behaviors of various economic and social actors in Mauritius over the centuries which, in turn, profoundly transformed all components of the natural environment in Mauritius. It is possible to tell the environmental history of Mauritius and the story of the Dodo without considering the external factors, but it is impossible to understand them. It is hoped that this paper provides some of the missing explanations.

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FROM NO-MAN'S LAND TO A CONGESTED PARADISE: AN ENVIRONMENTAL HISTORY OF MAURITIUS[1]

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The fascinating social, political, and economic history of Mauritius has been told by many (e.g. Barnwell and Toussaint 1949; Bissoondoyal 1963; Mannick 1979; Addison and Hazareesingh 1984). They all record changes of the colonial powers, register alien governors and prominent local people, enumerate calamities and periods of good fortune. This paper takes a different perspective. It attempts to describe and explain sudden changes and long term evolutionary processes that, over the centuries, shaped natural resources and various ecological systems of the island resulting in what contemporary inhabitants and visitors experience.

The environmental history of Mauritius is by no means less fascinating than its social history. Human intervention, in many cases inadvertently, profoundly transferred the landscape, fauna, and flora over the centuries. The balance of direct, local causes behind these interventions as opposed to remote and often indirect driving forces kept changing over time, but the following analysis will show overall dominance of the second group. Even in the position of full political sovereignty, remote economic, political, and increasingly, environmental processes and forces will tend to shape local structures. This is the main reason behind my confidence that the island's environmental history has useful lessons for the future in Mauritius and perhaps many other small islands.

Over the past three hundred years, the most dominant and persistent long term trend in the history of global environment was the expansion of agricultural land, mostly at the expense of prime forests. Land conversion proceeded at an increasing speed in Eastern Europe, the Americas, South and East Asia, and Australia as the European frontier was gradually extended in these regions. Richards (1986) gives a concise summary of driving forces: "[T]he driving impetus behind this spread of agricultural land is not due directly to pressures of population growth. ...Most land clearance and plowing has been undertaken...responding to market forces. ...Cash sale and profits were the motor propelling this trend..." (p. 56). These opportunities opened up as one after another peripheral regions of the globe became increasingly involved in the world economy centered on Western Europe (Wallerstein 1974, 1980). The environmental history of Mauritius is a unique blend of general patterns and special, local variations of processes of frontier development. Shifts in the relative importance of the island's linkages to regional centers and to the European core of the world economy triggered profoundly different motivations for and processes of economic development in Mauritius over the centuries. The implications for managing the island's natural resources clearly reflect these changes as many of them left long term, if not permanent marks on the environment.

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[1]Chapter 5 in the forthcoming book, *Understanding Population-Development-Environment Interactions: A Case Study on Mauritius*, edited by Wolfgang Lutz.

1. EXTREME FORMS OF EXPLOITIVE DEVELOPMENT: EARLY DAYS AND THE DUTCH

The preamble to the emergence of the modern world economy, the great sea-borne extension of the European core was marked by the Age of Discovery. Ships sailed across the world oceans in a search for new trading partners and for new trading routes to old ones. They discovered large continents and small islands. In the region of our interest, the Indian ocean, results were fascinating. Sailing around the Cape of Good Hope in Africa and than back to north-east through the Mozambique channel opened the sea-link to India. The next step was the establishment of trade linkages to Southeast Asia. Throughout the 16th century, majority of the trading ships used this so-called inner route and only a few of them passed east of Madagascar to have a stop-over at the Mascarene islands.

Human intervention and destruction of the native fauna and flora in Mauritius began more than a century before the establishment of even a temporary human settlement on the island. The Portuguese ship commanded by Domingos Fernandez (considered to be the European explorer of Mauritius) left pigs, goats, and cattle of Madagascar origin on the island as early as 1510. These alien species were soon followed by monkeys and rats. All these animals apparently found their niche among the local species of the island because ships stopping over on the island over the next few decades were able to replenish their food supplies not only with exotic but also with domestic animals.

Nonetheless, the aliens took a heavy toll on natives. Except for two small birds, predators were missing from the fauna. This made possible the evolution of flightless birds and large but defenseless reptiles. The rich and versatile bird population was the worst affected by the newcomers. Monkeys destroyed nests and killed the young of endemic birds, rats robbed their nests, while pigs mainly affected ground-nesting birds. Other species suffered, too. Rats practically eliminated snakes and large lizards. But almost all endemic species were affected, at least indirectly, by the intervention and impacts of aliens on their habitats. Monkeys destroyed flowers, small branches, and fruits of trees in the canopy, pigs and grazing animals trampled and uprooted seedlings on the ground.

In the period of more than a century between the European discovery of Mauritius and the first Dutch settlement on the island, it was an open-access common property resource. Whoever casted anchor on the island could take as much as was needed and for free. But the limited number of users and their limited capacity to take things with them prevented the depletion of the island's resources.

By the early 17th century, improvements in vessels and navigation permitted sailing across the Indian ocean between the southern tip of Africa and South and Southeast Asia. As a result, an increasing number of ships was using the Mascarene islands, mainly Mauritius as a stop-over to stock up with freshwater, food, and wood for ship repair. The strategic importance of Mauritius was increasing and it was merely a question of time of who would claim exclusive rights over the island, and when.

Given the Dutch supremacy in the first decades of the 17th century in Southeast Asia and on the trading routes leading there, it was the Dutch who did it. They already had a

well-established settlement at their final destination in Batavia, on the island of Java since 1619. The primary interest of the Dutch East India company was trade and an uninhabited island had nothing to offer towards this end. The major motivation for the Dutch to take Mauritius was strategic: to prevent the French and English using Mauritius as their stop-over base. So the major source of attraction for the Dutch to settle in Mauritius was its geographical location. This resulted several special features in the environmental history of Mauritius. The typical motivations for establishing and expanding frontiers were access to arable land and cash crop production. Mauritius had to wait 200 years and for its third owner until these development goals got established.

In the emerging network of colonies controlled from the sea, securing a safe port to provide supplies and refuge for ship repair was extremely important.[2] Besides its strategic geographical location, all other resources and services provided by the island of Mauritius emerged only as by-products of this preventive use. This was clearly demonstrated by the fact that the Dutch kept Mauritius even after they established another settlement at the Cape of Good Hope and they returned to the island after a few years of temporary abandonment, although with the well-established settlement at the Cape, the strategic importance of Mauritius for them became much smaller by then.

The above order of priorities was also reflected by the Dutch attitude towards the island's resource base and their resource management practices. The first Dutch period in Mauritius (1638-1653) represented an extreme form of exploitive development: maximize output with the lowest possible amount of investments regardless of the short and longer term consequences of your action. Investments were limited to building a few roads for transporting timber to the port, and to constructing shelters for the small number of inhabitants. In the history of Mauritius, this period was the heaviest and most destructive human intervention in the natural environment per unit of time. In just two decades, the Dutch cleared huge tracts of the ebony forests, exterminated the dodo, continued the introduction of alien plant and animal species. Even the single forest conservation measure of this period had purely economic reasons. The market for ebony in Europe became saturated and falling prices did not justify the relatively high transport costs. As a pure market control measure, ebony felling was restricted to 400 trees per year.

Even the little the Dutch invested from the proceeds of the island's resources, was completely destroyed when they abandoned the island in 1653. Mauritius was left much poorer than it was two decades earlier not only ecologically but economically as well. Had the ebony forests been left uncut, the income from selling the timber later could have been an enormous investment potential for the local economy to take off. Instead, the proceeds became just a small fraction of the tremendous wealth accumulated by the Dutch empire in those decades.

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[2]It is worth noting that the first modern stock exchange in Amsterdam was largely based on shares of trading companies (Kostolany 1987). Besides the standard prompt deals, the Amsterdam Stock Exchange handled options and forward deals, compensation courses, report and deport deals. Dangers and uncertainties involved in the long sailing trips across the Indian ocean and on the Atlantic, real and, in many cases, manufactured news about the fate of the Companies' ships provided on excellent base for speculations at the stock exchange.

The second Dutch period (1664-1710) did not bring much more or better in either managing the island's abundant resources properly or developing it for a better future. The number of people on the island never exceeded 400 throughout the Dutch period. This was simply below the critical mass necessary to establish a developing community, let alone start the various accumulation processes (capital, land, labor). Neither the Dutch East Indian Company, nor its governors and employees stationed in Mauritius had the slightest short-term interest in doing anything in this direction. Apparently, natural resources of the island were so abundant relative to the number of people on the island that they provided sufficient supply despite very poor management. Failure to build up sufficient reserves, however, left early settlers at the mercy of external sources when their crops were destructed by natural calamities.

The tremendous enthusiasm for destruction, so typical of the first Dutch period, decreased somewhat in the second phase. Woodcutting continued, but the motivation changed: there was an increasing need for agricultural land. Thus the typical pattern of land conversion, that can be observed in many regions of the world over the centuries, can be identified in the early history of Mauritius. The first step of the sequences is forest degradation followed by total land clearing later. "Frequently, forest cutting and consequent degrading has been a prelude to clearance and conversion of land to sedentary agriculture (Richards 1986, p. 59). In Mauritius, selective cutting of the ebony deprived the forest of its most voluminous tree, disrupted the spatial and temporal balance of forest succession, and opened large gaps for unprecedented competition in regrowth. Fast growing, in many cases alien species, usually not the economically most valuable, got the chance to increase their share significantly. The result is that even in regions where there would have been sufficient time for the forest to regrow, the species composition and thus the economic value was much lower than those of the original forests. Thus they could be light-heartedly cleared for agriculture in the second Dutch period or later.

The seven-decade Dutch period in Mauritius shows a reverse population-development relationship compared to the typical pattern of recent decades in many parts of the developing world. In the latter case, high population density and fast population growth absorb resources that would be required to initiate and accelerate economic development (see, for example, Keyfitz 1991). In the 17th century Mauritius, in addition to the lack of motivation, the small size of population prevented economic development despite external trade and economic linkages. This is not an unusual situation in small, island-based economies. Even in the last decades of the 20th century with all the blessings of modern transport and communication technologies, development processes are suppressed by low population densities and by the small size of local markets. The result is emigration of mainly the young and able, thus closing the loop in a downward spiral. These processes are neatly documented by Brookfield (1981) for the outer islands of Fiji.

The problem of low population density was further aggravated by the unbalanced sex ratio. The settler community was male dominated for whom the island was a temporary station. For them, there was simply no reason to worry about the future of the state of the resources there. There was a complete lack of concern to leave something useful for their descendants. On the contrary, they wanted to maximize what they could take with them.

In summary, the political and strategic interest (not to be used by others) and the resources extracted from the island (timber, food, freshwater) justified the not very high transaction costs of ensuring exclusivity for the Dutch. The Dutch era was also the transition period: Mauritius was not a common property resource anymore, but the owner, the Dutch East India Company did not consider it a high value property either. When its value relative to their other assets and to their management capacity became too low, the Company simply gave it up altogether, probably on the principle of "easy come, easy go".

2. ESTABLISHING AN AGRICULTURAL FRONTIER: FRENCH AND EARLY BRITISH COLONIAL TIMES

The French were late-comers among the West-European trading nations on the Indian ocean. In their effort to secure their own strategic naval ports they had to take whatever was left by others. In the region of our interest, they established two bases: one on Madagascar and another one on the small island of Bourbon. None of them was appropriate, however. The hostility of and regular attacks by the local population on Madagascar and the lack of a good port on Bourbon made the French East India Company eager to capture Mauritius when it became evident that the Dutch abandoned the island.

The intended role for Mauritius in the early French period was similar to that of under the Dutch. With a prospering coffee-based agricultural settlement on Bourbon, Mauritius was supposed to become a commercial port and strategic naval base. A necessary condition for this role, however, was a considerable improvement in the level of food self-sufficiency. High-yield, cyclone-resistent food crops were needed and manioc and cassava were successfully introduced. Maize and vegetables were also grown for human consumption and for animal feed. As a result of these efforts, the 3,000 or so population on the island in 1739 became self-sufficient for food just in a few years.

This period of agricultural expansion marked the first attempt in biological pest control in Mauritius. Grasshoppers caused major damages to agricultural crops therefore Myna birds were brought from India to control them. Mynas virtually wiped out the grasshopper population, but also caused a lot of damage to the exotic and native fauna and flora.

Sugar cane growing was spreading slowly in this period, nonetheless the first sugar factory was built in the early 1740s. Some considered sugar as the main industry in the future of the island despite the fact that the initial signs were not very promising. Even two decades after the establishment of sugar milling in Mauritius, the quality of locally produced sugar was so poor that it was used as cement in the construction industry and sugar for human consumption had to be imported.

Decisions about urban development and changes in coastal infrastructure also affected the environment. Shifting the naval base and main port from Port Bourbon on the southeast coast of the island to Port Louis in the north-west had several implications. Large construction projects required huge quantities of wood that was taken from the nearby slopes. The first river diversion was constructed to deliver water from Grand River North West in order to secure the fresh-water supply for Port Louis.

The program to increase food production was so successful that by 1756, the outbreak of the Seven-year War between France and England, Mauritius was able to provide a significant support to the French Navy on the Indian Ocean in terms of food supplies. This period also marked the origins of "export-oriented" industrial production: Mauritius provided arms and gun-powder for the French troops. But this period also showed the limitations and vulnerability of a small economy on a small island. Stocks and reserves were soon depleted leaving the islanders totally dependent on fluctuating current production. When crops were destroyed by a cyclone in 1760, the situation became hopeless. After the breakdown of trade links to India, where Britain took over all French trading posts, clothes and other imported manufactured goods became scarce. The island with its 19,000 desperate inhabitants was transferred from the bankrupt French East India Company to become property of the French Crown in 1766.

The first 15 years of French Crown rule was a period of improvements and prosperity. The balance of agricultural production shifted again towards commercial products, especially spices, that provided higher profits. Less attention was devoted to food self-sufficiency, and once again, an increasing fraction of food supplies was imported from Madagascar. Sugar cane kept its relative share but it was produced to satisfy domestic needs only as the still limited European demand was largely satisfied from Caribbean sources. Bulk of the production from the sugar mills was used to produce spirits for local consumption.

Increasing population and expanding agriculture apparently led to massive deforestation. As early as 1761, a law was passed to stop cutting down of the forests. As it was not observed, it had to be reinforced a few years later. Interestingly, the reasons behind these laws did not include the prime consequence, namely erosion of the fertile top soil, but rather the secondary impacts: damage to the harbor of Port Louis due to siltation and drying up of the land surface in the absence of trees that prevents plant development. Obviously, first victims of demand for wood for construction and fuel were the forests near the larger settlements. As a sharp contrast to the reports by early travellers who described the animals and the vegetation cover of the island so glowingly 200 years earlier, Bernadin de Saint-Pierre's vision of Port Louis environs in the late 1770s is rather unattractive: the city "was surrounded by rocky hills without trees or bushes, ...the mountainsides were covered with burnt grass for six months of every year..." (Mannick 1979, p. 28).

The slowly but steadily increasing economic power of Mauritius was clearly demonstrated by the role it played in the next war between the French and British between 1778 and 1783. The island was able to support huge fleets of the French Navy with food, arms and ammunition.

The increasing appreciation of the value and environmental services of forests was demonstrated in the next cycle of agricultural expansion. In the 1780s a large number of new farmers settled on the island. They were allowed to clear land for agriculture in the southern region, but new forests were planted in other parts of the island where soils and terrain were deemed less suitable for agriculture. This was also the time of the first large-scale environmental redevelopment program in Mauritius. The reforestation program initiated in 1781 resulted in more than 100,000 trees planted along the coast where ebony

forests were cut by the Dutch and early French settlers. Yet again, the program involved new tree species (ravanala and casuarina) brought to the island from East India thus the newly planted forests further increased the share of alien vegetation.

The 1780s was not only a period of economic expansion and prosperity, but also that of fraud (use of public funds for personal benefits), power abuses (speculations with real estate properties), macroeconomic mismanagement (uncontrolled printing of paper money leading to inflation), and scandals. As in many occasions before and after in the history of natural resources, scandals also involved the forests. Ignoring the reinforced 1761 law against forest cutting, a friend of the then governor, for example, cleared huge tracts of government-owned forests and sold the wood back to the government.

The historical changes in Europe, and especially in France, and the repeated wars between France and England made little impact on Mauritius. Even the transfer of political power over the island from the French to the British in 1810 was relatively smooth. The ownership of private property, including those of agricultural land and plantations was left untouched. Inhabitants were allowed to preserve their languages, laws, customs, and religions. Even outlawed conditions survived several decades of British rule, the most prominent example being slavery and slave trade. As early as 1794 the French government passed a law to abolish slavery and ordered slaves to be freed without compensation to their owners. Nothing happened in Mauritius except that the two officers who came to enforce the law were expelled. Slave trading had been abolished in all British colonies years before Mauritius became under British rule. Yet, some 25,000 slaves were brought to Mauritius between 1810 and 1835, almost half of them just in the last eight years.

The first decades of the 19th century were still characterized by patterns of exploitive development in Mauritius. Most planters and farmers strived for quick profits in order to accumulate some wealth to establish their new life back in Europe. Successful planters returned to Europe with their accumulated capital rather than investing it in Mauritius. This attitude resulted in a series of negative impacts on the natural resource base, social morale, and general economic conditions. In an attempt to reduce costs and increase profits, no fertilizers were applied on the plantations. Instead, the response to declining yields due to depleted soil fertility was to open up new lands for agriculture. Land clearing took the most destructive form of land conversion. Trees, bushes, and other vegetation were simply burnt down, the area was cultivated for a few years, and then abandoned. Sugar cane area declined (total area around 4,000 ha in 1810) at the expense of coffee and tea plantations, grape, fruit, and vegetable cultivations.

Despite the general patterns of exploitive development, there were several attempts in these decades to improve local conditions. At least part of the government revenue raised in Mauritius was invested locally. New roads were built and the old ones upgraded, and bridges were constructed as part of the effort to improve access to the newly opened agricultural areas inland. The coastal defense system was fortified and institutions to provide primary education were established. But the vigor and success of these efforts largely depended on the talent, vision, and determination of individual governors.

As the island became more densely populated, it ceased to be such a healthy place as it used to. Less then two centuries before, the Dutch brought sick people to Mauritius to recover because it had a pleasant climate and was free of diseases. The smallpox epidemic of 1792 apparently failed to create sufficient concerns about public health. By the early 19th century the large population of mixed origin, the increasing number of visiting ships and poor hygienic conditions lead to a series of disease outbreaks: small-pox in 1811, rabies two years later, and cholera in 1819. The latter killed almost one-fifth of the population.

In the first decades of the 18th century, the primary importance of Mauritius for its owner was still its strategic location. The island's involvement in the world economy began, but it was in the early phase of the process. Political control over Mauritius was exercised from Europe, but many important economic linkages were restricted to the South Asian and East African regions. Slave labor required to extend agricultural production was imported from Madagascar. The island was more or less self-reliant in agricultural products, but imported most manufactures. The rate of population increase was low, mainly driven by the labor need of the slowly increasing European settler population. The white-slave ratio of 1 to 6 was roughly maintained throughout the whole period.

3. CLOSING THE AGRICULTURAL FRONTIER: 1830s TO WORLD WAR II

Similar to the Dutch motivations to conquer Mauritius, the original objective of the British to take the island was to wipe out the nuisance of corsairs attacking and robbing their merchant ships from Mauritius as their base. They simply wanted to secure their rule in and their trade routes to India. Yet, a series of developments in the 1820s and 1830s led to the increasing involvement of Mauritius in the British Colonial Empire and thus in the world economy. Without them, the island could have become a forgotten land by the second half of the century when the proliferation of steam vessels and opening of the Suez canal robbed Mauritius of its original strategic and geographic importance on the main trading route of the expanding world economy.

Some of these developments were rooted in the internal biophysical and socioeconomic conditions of Mauritius, but a variety of really significant ones originated from outside. Probably the most important factor was the increasing importance of sugar in the European diet. Sold as a luxury good first and as medicine later, it gradually became a commodity in the 18th century. Between 1700 and 1800, sugar consumption in England increased 15 fold. About the same time, per capita consumption in Paris was estimated at 5 kilograms but this seems to be high in view of another estimate of 1 kilogram per capita for France as a whole. Braudel's warning is fully justified: although sugar was increasingly popular, it still counted as a luxury good. In many French peasant households, a cone of sugar was hanging above the table. Instruction for use: lift your cup for a second so that the melting sugar can sweeten its content (Braudel 1979).

By 1750 the world economy emerged from the relative recession that began around 1620. The first target for new geographical expansion was the Caribbean region. Here one of the most profitable activity was sugar-cane growing based on slave labor. No wonder that the French government paid special premium for slave trading ships transporting slaves

to the French West Indies (French Antilles) in order to promote sugar production (Hopkins 1973). In the 18th century, sugar was the most important import commodity from overseas to France. It was also the biggest import item to England. Sugar cane growing and sugar production conquered Southeast Brazil and the Caribbean: Martinique, Guadeloupe, Curaçao, Jamaica, and San Domingo. While on most of these islands, sugar was the prime reason behind land conversion and it remained the main crop for centuries, in other regions it was only a transient factor in the long term environmental transformation process. In the subtropical coastal provinces of Southeast Brazil, for example, aboriginal swidden cultivation was intensified in the first phase of European expansion that left greater effect on the forests of the region than sugar later (Dean 1983). Gold and diamond mining pushed land conversion one step further when demand for local food production (manioc, corn, rice, and ranching) significantly increased (Williams 1990). It was only between 1750 and 1830 when plantation sugar as an export crop was the main driving force behind the deforestation of the region (Richards 1986). By 1830, coffee became the main export commodity.

In Mauritius, following a devastating cyclone in 1818, a thorough reconsideration of agricultural policy was initiated by the governor. The conclusion was that sugar cane proved to be the most resistant crop to cyclones, and once again the hundred-year old vision of sugar cane as the main agricultural crop of Mauritius had been revived. In addition to beans, manioc, and barley which were grown for local consumption, sugar cane in fact became the dominant crop. The area of sugar plantations doubled in less than a decade, reaching 20,000 hectares by 1830.

At about the same time, a technological innovation further energized the sugar industry. The first modern sugar factory was built that revolutionized the process of sugar extraction. In addition to reducing labor requirement, it also provided higher rates of juice extraction. The ultimate result was a dramatic improvement in the profitability of sugar production. Higher sugar extraction ratios also made less fertile soils profitable to cultivate.

Probably the most significant impulse for the expansion of sugar industry was a change in British economic policy. Mauritius enjoyed a special status among the British colonies. It was allowed to trade freely with all countries of the world, but its sugar export to Britain was subject to a special duty which made it less competitive compared to sugar from the West Indies. After fierce negotiations with the British Government, the discriminative duty was abolished in 1825 but the free trading right was retained. These events generated profound changes in the social structure, economic conditions, and natural resource use over the next decades.

Owners of sugar plantations in the West Indies, where slavery was in fact abolished feared that Mauritius could gain a competitive edge by producing sugar cheaper with its still existing slaves. The primary concern behind these protests was in fact not Mauritius. Plantation owners in the West Indies wanted protection against competition with slavery-based production in Brazil and Cuba (Williams 1964). External political pressure to abolish slavery in Mauritius accumulated, and in 1835 slaves were finally freed in the frame of a complex compensation and transition arrangement. Slave owners were handsomely compensated for their losses in property. Slaves were ordered to continue

working on the plantation as wage laborers for some period of time in order to prevent economic disruptions due to a sudden drop in labor supply. These arrangements provided sufficient capital for plantation owners to experiment with different sugar cane varieties and cultivation methods. As a result, both yields and quality of the sugar were improving.

The abolishment of slavery did not only bring major transformation of the social structure in Mauritius. It also induced major changes in the number and demographic composition of the population over the next few decades (see Lutz and Wils 1991). Already in the first few years after slavery was outlawed, some 24,000 indentured laborers arrived from India to replace slaves on the sugar plantations. In just a decade their number doubled and by 1870 over 70 per cent of the island's 316,000 population was Indian or Indian descendent.[3] It took more than a century for the population to slowly increase from virtually zero to 100,000. As a response to a political institutional change and a series of external economic changes, the population tripled in less than thirty years. As we will see below, it took almost another century to add the next 100,000 people to the island's population.[4]

The vacuum of increasing market opportunities and the feared labor shortage in a period of rapid expansion of the agricultural frontier pulled these huge crowds to Mauritius. (This lies in contrast to land conversion due to increasing population pressures in many regions of the developing world a century later.) A continuous flow of indentured laborers was necessary to keep labor prices low. Securing cheap and reliable labor was the top priority of old plantation owners and new European settlers. The historical significance and root causes of these processes can be compared to what happened in Eastern-Europe in the early phase of the European agricultural expansion in the 16th and 17th centuries. Responding to the fast increasing grain market in Western Europe, cultivation areas in the East were extended and required labor. "Only a harshly repressive system could hold peasants in a labor-scarce economy" (Richards 1990, p. 168) leading to a revived manorial system (zweite Leibeigenschaft) east of the Elba. The Mauritian equivalent was the requirement to save the return fare to India, an efficient way to keep laborers on the plantations for an extended period of time.

The order and causal relationships of population growth and land conversion were opposite in most regions that had indigenous populations prior to the frontier expansion. Newly established market relationships relaxed the constraints on local land use and the need for self-sufficiency in food production which kept local population numbers at the endogenously sustainable level for centuries. Once it was possible to obtain food from

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[3]In addition to the strong "pull factor" in Mauritius, severe "push" forces were at work in India as well. The population pressure there was clearly signed by a series of famines in the first decades of the 18th century.

[4]The prospect for a boom of the sugar industry was already in the air in the 1830s. When Charles Darwin visited Mauritius in 1836 he was impressed with the landscape and the mixed population of various races. He noted in his diary: "... the country on this side of the island appears pretty well cultivated, the whole being divided into fields & studded with farmhouses. I am, however, assured that of the whole land not more than half is yet in a productive state; if such is the case & considering the present great export of sugar, at some future period this island when thickly peopled, will be of great value" (Darwin 1934).

outside in exchange for cash crops, population started to grow even in the absence of any change in life-styles, sanitary conditions, or modern medicine (Roth 1983).

The population boom in Mauritius gave rise to severe problems because with new people came new diseases. A series of cholera outbreaks in the 1850s and a major malaria epidemic in 1865 killed almost 100,000 people. These days, Mauritius was obviously one of the most unhealthy colonies of the British Empire. Sanitary conditions were below any standard and health precautions virtually nonexistent. Domestic wastes were dumped in nearby streams and rivers making the outbreak and spread of water-born diseases easy. These practices existed for many decades and did not cause major problems, but with the dramatically increasing population density, waste load soon exceeded the absorptive capacities of freshwater systems. The British governor of the time found all streams and rivers on the island severely polluted. Yet, it was not before 1895 when the first clean drinking water supply was put into operation.

The change in the mode of production from slave labor to free indentured laborers was yet another component of productivity and profitability improvements in sugar production. Although working and living conditions of the two groups did not significantly differ, their incentives and attitudes were quiet different. Indians were considered to be good and reliable workers and this soon resulted in higher yields and better quality of the crop.

Expanding market opportunities induced an extension of sugar cane lands and required even more labor. As yields and profitability of sugar production were improving, the attitude of planters began to change. Instead of running away with their profits, they invested their money locally. After a long period of exploitive development and permanent land degradation, investments were made to improve land productivity. The first canals were built to support small-scale irrigation schemes. Soil fertilization also began in this period using guano imported from the nearby Seychelles and the distant Peru. As labor was not that cheap any more, better machines were used on the plantations. After 1850 a railway network was built to transport processed sugar to Port Louis.

By 1853, in less than two decades, sugar cane area grew to over 50,000 hectares (almost one-third of the island's total area) and remained at that level for a few decades. Annual sugar production was around 115,000 tons. Starting this period sugar determined the fate of the island, especially after 1869 when opening of the Suez Canal stripped its income from trade, ship-repair and other services related to long-distance trade between Europe and South-Asia.

Given the general climatic conditions in Mauritius, sugar proved to be by far the most profitable crop. Yet, its overwhelming dominance made the island totally vulnerable to local weather variabilities and global economic fluctuations. When yields were high and prices were favorable, Mauritius prospered. When cyclones destroyed the crop or world market prices for sugar were depressed, it often needed external assistance to survive. The vulnerability of this practically single-crop economy is illustrated by mentioning just a few ups and downs in the history of Mauritius: the worst cyclone in history destroyed sugar cane plantations and damaged sugar factories in 1892; the first decade of the 20th

century brought depressed sugar prices and economic downturn. Starting with the first World War, the next 15 years were a period of economic boom until sugar prices fell again in 1927 and many mills had to be closed down. The great depression of the world economy and another big cyclone in 1931 resulted again hard times with no economic revival until 1937.

We recall that common driving forces for both processes, population growth and expansion of the agricultural frontier originated from outside. External market opportunities for sugar were grabbed by local entrepreneurs and large number of people were imported to make use of those opportunities feasible. These two decades in the history of Mauritius between 1835 and 1855 is a clear example of how geographically remote causes and forces of the world economy were shaping local structures, created and intensified or suppressed local social, demographic, economic, and ecological processes. The magnitude of local impacts is especially astounding if we consider that the role of Mauritius in world trade, both in value and tonnage terms, was practically negligible.

Sugar is a forest killer in two respects. First, huge tract of forests had to be cleared to increase plantation area. Second, sugar processing is an energy-intensive process. Efficiency was low and the process required enormous quantities of wood. Before the arrival of steam-powered vacuum-pans in the modern mills of the late 19th century, crystallization of cane juice was very wasteful of fuel. In the sugar cane growing regions of the Philippines, for example, wood had become so scarce around 1850 that planters had to use the pulp of pressed sugar cane as fuel (Roth 1983).

No wonder, that by 1882 less than three per cent of the original 1,800 km^2 of virgin forests survived, almost entirely in the least accessible high-altitude regions. In a new wave of environmental rehabilitation efforts, the government began to buy back land, planted trees, and introduced a series of reafforestation laws. These ecosystem redevelopment efforts were partly oriented towards protection of water resources as new forests stands were mainly planted along streams and rivers.

External linkages of Mauritius in the second half of the 19th century were rather atypical compared to other parts of the British colonial system. In South and Southeast Asia a nested hierarchy of economic relations and political administration emerged in which regional centers and their subcenters directed resource extraction and agricultural frontier expansion in their subregions and hinterlands (Richards 1990, p. 165). In contrast, Mauritius was directly governed from London and major economic policies affecting the island (abolishment of slavery, foreign trade rights, export duties) were also drafted in the European core. Although trade linkages with England were apparently important and significant (witness the debate about special tariffs on sugar exports and the concern of Caribbean sugar producers about the competitiveness of Mauritian sugar due to slave labor), they were complemented by a series of export-import relationships with other regions in the Indian ocean. For example, a significant portion of sugar exports went to India in exchange for rice imports to feed the Mauritian population of Indian origin. Madagascar was also an important absorber of Mauritian sugar and rum exports until 1895 when it was conquered by the French and trade links broke down.

Wallerstein's (1976) analysis about the three zones of African production is valid to some extent for Mauritius in a special form. In Wallerstein's scheme, the first zone is producing for the world market directly (sugar production in Mauritius), the second zone is producing food for workers in the first zone (rice imports from India). The third zone is providing labor for the first and, to some extent for the second, zone (import of indentured laborers from India to Mauritius). The form of social organization of production in the first zone involved either white settlers/farmers and/or companies/concessions. Labor in the first zone consisted mainly of indentured laborers. This form kept labor costs worldwide at a low level. The slow increase of the economic power of indentured laborers and their descendants resulted in their "peasantization": an increasing number of them was able to purchase and work on their own land.

This process, however, was combined with a series of other forces at work. They included fluctuations in prices and market opportunities, technological changes in growing and milling sugar cane and alike. The net outcome in Mauritius involved major shifts in the number and average size of sugar cane plantations and sugar factories. A delayed and long-lasting effect of the major social and technological changes was a concentration of landed properties in the hands of those who adapted fastest to changing conditions and grabbed emerging new opportunities. The number of planters decreased from 4,000 in 1846 to 1,600 by 1871, although the plantation area increased five fold in about the same period. Beginning in the 1880s, the tendency reversed as large estates were subdivided and sold to Indians who accumulated sufficient capital to start their own small-scale plantations.

Given the technologies and land management practices of the time, there was hardly any increasing return-to-scale in sugar cane growing. Yet, land use on small-scale plantations was probably more intensive than on large estates. In the absence of any reserve capital and appropriate credit schemes, however, investments affecting soil fertility were more or less direct function of fluctuating income.

The concentration trend was more apparent in the sugar milling sector. Largely due to the economic slump of the 1880s, four out of five sugar mills closed down, but the surviving ones were modernized. The result was higher sugar extraction rates from the cane and improving profitability of sugar production and milling.

Land management practices generally improved in the early 20th century. Unused parts of the cane were increasingly returned to the fields as fertilizers. As sugar cane plantations were extended to drier areas, expansion of the irrigation network became necessary to reduce losses from droughts and to increase yields in these areas. This involved large-scale hydrological projects, at least under Mauritian conditions. La Ferme reservoir constructed in 1914 for irrigation with 11.8 Mm^3 useful capacity is still the second largest reservoir on the island.

As another attempt in biological control in agriculture, mongoose was introduced from India in the early 1900s to control rats in the sugar cane fields. The effort brought mixed results in terms of its original objective, but yet again, the side-effects were clearly unfavorable. The mongoose completed the elimination of native ground-nesting birds that was began centuries earlier by pigs.

4. HIGH POPULATION DENSITY: WORLD WAR II TO INDEPENDENCE

Following the economically prosperous years of the second World War, a new period started in the environmental history of Mauritius. It was dominated by changing population-environment relations largely due to high rates of population growth. As a result of sustained high birth rates and a sudden fall in mortality following the eradication of malaria, average annual rate of natural population increase between 1948 and 1958 was around 3 per cent. Total population increased by 36 per cent in this decade, adding 158,000 people to the population. (See Brookfield (1957) for a thorough analysis of the demographic situation of the early 1950s.) It was not the growth rates themselves alarming, since many other countries at that time and many more in subsequent decades experienced this kind of population explosion, but none of them started from this level of already high population density in relation to land and other natural resources.

The prospects and disastrous consequences of continued fast population growth alerted the British Colonial administrators and the local government. A series of committees were set up and reports commissioned to evaluate the situation and propose action. They all pointed out at the poor natural resource endowments of the island as a severe constraint in its future development, but their major focus was on the combination of potential economic, social, and political disasters as a result of overpopulation. None of them addressed environmental issues directly. This is not surprising because environmental quality does not really matter when there are threats that the economy is disintegrating, social services completely break down, and potential social unrest may call for a really cruel, repressive system.[5]

One would expect that the combination of rapidly increasing population from an already high density level and finite land and natural resources could have made Mauritius a showcase of Malthusian collapse in the 1950s. On the contrary, analysts of the situation (see, for example, Brookfield 1957; Meade 1967) deny the relevance of the Malthusian scheme in the case of Mauritius. A superficial observer could easily draw false conclusions related to population-environment interactions from some of the developments in Mauritius in the period of fast population growth. Real national income per capita declined by more than 10 per cent between 1953 and 1958, sugar output per head of total population decreased at the same rate despite an increase of sugar cane land area. The popular conclusion would be that increasing population pressure enforced bringing less fertile areas into production and this, combined with diminishing returns on earlier cultivated areas, lead to lower output per head and declining standard of living.

A closer look, however, reveals a completely different situation. Production, land area, and employment data for two "normal" years are summarized in Table 1. (Normal here refers to years, if at all this is possible in Mauritius, in which neither cyclones nor drought had major effects on yields.) Land area and sugar production had increased significantly between 1950 and 1959 (by 24 per cent and 27 per cent, respectively), whereas the number of people employed in the sugar sector grew by a meager 3 per cent. In addition,

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[5]Richard L. Meier (1959) suggested that fast population growth could lead to martial law or even to establishing concentration camps as a way to handle the large number of unemployed people.

output per area and output per employee had also increased, making the question of diminishing returns irrelevant.

In the light of the small increase in the number of people earning their living in the sugar industry, the argument for population pressure to expand agricultural land seems to be false, too. Once again, the reason is purely economic and originates outside of Mauritius. After several decades of market and price uncertainties, the Commonwealth Sugar Agreement provided fix quotas and guaranteed prices for the bulk of the Mauritian sugar exports. Negotiated prices regularly exceeded the world market prices and the arrangement, though well-intended, further distorted an already extreme economic structure. Meade et al. (1968) provide a detailed explanation of economic disincentives, marketing problems, and institutional rigidities that prevented agricultural diversification, except a little increase in tea production.

Table 1. Sugar production, area, and employment. Source: Meade et al. 1968, p. 15, and author's calculations.

	Production (1000 tons)	Area (1000 ha)	Average employment (1000 persons)	Output/area (tons/ha)	Output/ employment (tons/person)
1950	457	63.6	55.5	7.19	9.86
1959	580	79.2	57.4	7.32	10.10

Despite increasing land under cultivation, employment opportunities in agriculture remained relatively stable. One consequence of this situation could also lead to false conclusions. The number of persons applying for medical assistance because of sickness other than chronic diseases increased over six times between 1953 and 1959 (Titmuss and Abel-Smith 1968, p. 11). With a view to the fast rate of population growth, one would assume that this was a result of increasing congestion, declining living standards, and deteriorating public hygiene. In fact, the reason is economic rather than environmental. Majority of the applicants for medical treatment simply failed to find employment and used the medical system to get financial assistance. In the 1950s public health conditions were improving: malaria had already been wiped out, and tuberculosis was getting under control resulting in sharply declining mortality rates.

As a result of fast increase of sugar cane area in the 1950s, virtually no other land was left that could be reclaimed for further agricultural expansion. The only way to increase output was more intensive land use. An important part of this effort was a major soil survey and land classification project completed by 1962. The survey suggested most suitable crops for various soil types in different regions, together with cultivation practices including irrigation and fertilizer use. Soil conservation was an important part of the project as it identified areas where cultivation should be abandoned due to high rates of soil erosion.

Some of the new areas brought under sugar cane cultivation in the 1950s were located in the relatively drier regions of the island. Droughts had always been a problem in Mauritius. An obvious solution to both problems was to improve the utilization of water resources. No reservoir was built since 1929 when La Nicolière was constructed. In 1953-54, three reservoirs were completed (Piton du Milieu, Mare Longue, and Tamarind Falls) two of which were built for a combined purpose of irrigation and hydroelectricity generation with a total useful capacity of 7.7 Mm^3. They both supported current production and encouraged agricultural expansion in the dry areas.

These efforts of the Mauritian government were reconfirmed by the Meade report. "Much capital has already been invested in schemes to provide water for agriculture and further schemes are under investigation, and we can think of no safer or more profitable form of investment" (Meade et al. 1968). It is highly unlikely that it was the direct result of this report, but the so far largest reservoir in Mauritius was completed in 1961 (Mare aux Vacoas, 22 Mm^3 useful capacity), and yet another in 1962 (Eau Bleue, 6 Mm^3 useful capacity).

Another convenient method to increase sugar output, especially when prices were high and guaranteed, was increasing the input of chemical pesticides and fertilizers. Despite abundant labor and high rates of unemployment, the application of herbicides began in the early 1950s and gained an uninterruptedly increasing popularity ever since. The use of chemical fertilizers shows a similar pattern making Mauritius one of the heaviest users per unit of area in the world.

5. SUMMARY AND CONCLUSIONS

The preceding analysis shows that during the 400 years history of Mauritius, various forms of natural resource exploitation and environmental transformation were to a large extent results of fluctuating opportunities in international trade (fluctuations of the sugar price, availability of food for imports), changes in economic policies of the colonial power and other important trading partners (reduction of sugar export tax to Britain in the 1830s, setting up a tariff and quota system after World War II), various forms of technological change (diffusion of more efficient sugar milling technologies, construction of railways, improving agrotechniques), institutional change (abolition of slavery), and political changes (shift of colonial power from France to Britain, changes in policies of consecutive governors and other local political authorities). The dynamic combination of these factors conditioned the aspirations and behaviors of various economic and social actors in Mauritius over the centuries. It is possible to tell the story of the Dodo without considering the external factors, but it is impossible to understand it. It is hoped that this paper was able to provide some of the missing explanations.

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