WORKING PAPER

Population Growth, Changing Agricultural Practices, and Environmental Degradation in Zaire*

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ABSTRACT

This paper examines linkages between the demographic changes taking place in Zaire, particularly overall population growth and rapid urbanization, changes in agricultural practices, and related environmental degradation. Pressures to feed Zaire's rapidly increasing urban population, which fall on a rural population that has been growing relatively slowly in recent years, as well as population growth and increased population density in certain areas of the country, have resulted in changes in agricultural practices that are described in the paper. These changes in turn are leading to declining soil fertility, deforestation, and degradation of the natural resource base. Given present technology and the state of Zaire's economy, the changes in agricultural practices that have emerged in response to population growth, increased population density, and growth in demand for food production do not appear to be sustainable in the long run.

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I. Introduction

This paper examines some of the linkages between the demographic changes that are taking place in Zaire, particularly overall population growth and increasing urbanization, and corresponding changes in agricultural practices and in the environment. Russell (1988) has noted that the slash-and-burn or shifting cultivation system used in Zaire and elsewhere in the tropics is well-suited for conserving environmental resources, so long as population density remains low. Russell has also argued that "under population pressure ... this admirable system breaks down, with serious consequences for the environment" (Russell, 1988, p. 78). By contrast, in widely-cited works Boserup (1965, 1981) has argued that population growth in the past had a variety of effects on agricultural production techniques leading to intensified land use and increased agricultural production. However, concerns about rapid population growth and its consequences on fragile African soils have resulted in questioning of the appropriateness of the Boserup hypothesis in present-day circumstances in sub-Saharan Africa (Lele and Stone, 1989). There has also been considerable attention given, from a variety of perspectives, to questions pertaining to the impact of population change on the environment (Jolly, 1991).

The focus of this paper is on evaluating the likely consequences for food production and for the environment of the changes that are taking place in Zairian agriculture. In particular, we argue that the pressures to feed Zaire's rapidly increasing urban population, which fall on a rural population that has been growing only very slowly in recent years, along with population growth and increased population density, have resulted in changes in agricultural practices. These changes are leading to declining soil fertility and degradation of the natural resource base.

It will not be possible to sustain continued increases in food production under these conditions, in the absence of advances in scientific knowledge and technical innovation. That is, given present technology and the state of Zaire's economy, the changes in agricultural practices that have emerged in response to population growth, increased population density, and growth in demand for food production do not appear to be sustainable in the long run.

The following section selectively reviews literature on population growth, agricultural production techniques, deforestation and the environment. This is followed by an overview of the evidence regarding demographic change in Zaire. Both overall growth and the growth of rural and urban populations are considered. The consequences of this demographic change for demand for food production and for agricultural practices are then considered. This is followed by an analysis of the long-term impacts on the environment of the changes in agricultural practices that have been adopted, and a discussion of the issue of sustainability. The final section of the paper provides a summary and conclusions.

II. Population Growth, Agricultural Production Techniques, and the Environment

Boserup (1965, 1981) has argued that in response to population growth and increased population density, changes occur in cropping techniques in order to satisfy the higher demand for food. These include, first, expanding the area under cultivation, or land extensification. When that is no longer feasible, intensification takes place in the form of shortening of fallow periods, increasing labor inputs, and eventually, changes in the technology used in agricultural production. In addition to population growth, improved access to markets will also contribute to intensified agricultural production (Pingali et al., 1987, p. 4; National Research Council,

1986, p. 25).

Land extensification entails expansion of agriculture onto new lands, with land being cleared of trees and brush in order to plant crops and raise animals (Bilsborrow, 1992, p. 7). Typically, the land brought under cultivation through extensification is increasingly marginal land -- marginal in the sense of either poor quality soil, inadequate rainfall, or steep slopes.

Beyond extensification, further increases in agricultural production associated with population growth may be brought about through a variety of means. Rosenzweig et al. note that Boserup identifies eight principal effects of population growth on agriculture:

> (1) it reduces the fallow period; (2) it increases investment in land; (3) it encourages the shift from hand-hoe cultivation to animal traction; (4) it encourages soil fertility maintenance via manuring; (5) it reduces the average cost of infrastructure; (6) it permits more specialization in production activities; (7) it induces a change from general to specific land rights; and (8) it reduces the per capita availability of common property resources (forest, bush, and/or grass fallows; communal pastures) (Rosenzweig et al., 1988, p. 94).

The first four effects in particular are the result of efforts to increase land productivity and to offset the increased labor requirements stemming from more intensive cultivation.

Boserup's view is thus that (once opportunities for extensification have been exhausted) increasing population density will, via the increased scarcity of land, lead to substitution of other factors of production and induce technological change. Hence, for example, she identifies several purposes served by fallowing, including preventing exhaustion of soil fertility, reducing weed growth, and limiting the spread of plant disease, and then points out that in high-technology settings chemical fertilizers, herbicides, and pesticides accomplish these same objectives (Boserup, 1981, pp. 23-24).

Boserup notes that high rates of population growth, particularly in densely populated

areas, may mitigate the prospective benefits from agricultural intensification (Boserup, 1965, p. 118). She clearly recognizes that the adoption of improved technology as population density increases is by no means an automatic process:

> If it is true, as suggested here, that certain types of technical change will occur only when a certain density of population has been reached, it of course does not follow, conversely, that this technical change will occur whenever the demographic prerequisite is present. It has no doubt happened in many cases that a population, faced with a critically increasing density was without knowledge of any types of fertilization techniques. They might then shorten the period of fallow without any other changes in methods. This constellation would typically lead to a decline of crop yields and sometimes to an exhaustion of land resources (Boserup, 1965, p. 41).

Indeed, Lele and Stone, based on a review of evidence from half a dozen countries in sub-Saharan Africa, conclude that "the environmental damage from the reduction of bush fallow, the more intensive use of land without supplementary biological and chemical inputs, and the depletion of forestry resources complicates the transition from low to more densely populated areas as originally envisaged in the Boserup hypothesis" (Lele and Stone, 1989, p. 7). They also argue that the prospective beneficial effects of intensification induced by population growth may well be outweighed by the environmental damage caused by declining soil fertility and deforestation.

Shorter fallow periods and deforestation reduce the vegetative cover that retains moisture and protects the soil, increasing the likelihood of soil erosion. In addition, tropical soils often do not have the same capacity for intensified production as do soils in temperate areas. Frequently tropical soils are deficient in important minerals such as phosphorous and nitrogen, and because they are poor in humus they have a reduced capacity with fertilizer. Further, many tropical clays have low absorptive capacity, and in conjunction with heavy rainfall this makes

for rapid leaching of important minerals from the soil (National Research Council, 1986, p. 22). Hence, the fragile nature of African soils and their dependence on vegetative cover for moisture and stability are underneath the environmental concerns expressed by Lele and Stone.

As mentioned earlier, one of the effects of population growth identified by Boserup is to reduce the per capita availability of common property resources such as forest and bush fallows. Geores and Bilsborrow (1991) point out that population growth induces changes in land use that result in changes in the environment, including deforestation. Bilsborrow (1992) notes that deforestation in the 1980s appeared to be roughly twice as great as in the 1970s. He argues that growing populations expanding their agricultural activities onto increasingly marginal lands and up steeper slopes -- i.e., land extensification -- is the major overall proximate cause of the loss of forests.

Geores and Bilsborrow (1991) identify two types of land extensification that are pertinent with respect to the links between population growth and deforestation: extensification onto marginal lands in areas of established agricultural settlement and colonization of new lands. The first of these is most relevant with respect to open forests (open woodlands or dry forests and upland forests), while the second is more likely to involve deforestation of closed-canopy forests (tropical moist forests and semi-tropical forests).

In addition to land extensification, fuelwood production and consumption is an important factor contributing to deforestation. As fuelwood becomes scarcer, more time is required to collect it, and this impinges on the time available for carrying out agricultural tasks. This has contributed to lower agricultural productivity and unsustainable agricultural practices, such as failure to maintain terraces (Geores and Bilsborrow, 1991, p. 7).

This overview of the literature thus suggests that population growth and increasing population density lead to changes in agricultural production techniques which may ultimately contribute to adoption of improved technology and significantly higher food production. At the same time, however, there are clearly concerns about the environmental consequences of these changes, especially with respect to soil fertility and forestry resources. In this context, it is important to consider what role (if any) public policy can and should play to ameliorate the situation.

Jolly (1991) points out that different perspectives on the relationship between population growth and the environment have differing implications with regard to the desirability of public policy interventions. However, even from the perspective of neoclassical economics, the approach reviewed by Jolly which is least oriented toward policy interventions because of a reliance on markets to correct problems of resource allocation, there is acknowledgement that markets are not complete and often function with distortions (National Research Council, 1986, pp. 16-17).

Frequently, market distortions may themselves be the result of public policies. For example, policy may contribute to environmental problems due to poor economic policies generally and urban bias in particular (Bilsborrow, 1992, p. 25). On the pro-active side, Lele and Stone argue that "a policy-led approach to intensification is critical to maintaining and preserving resources otherwise degraded through more intensive use" (Lele and Stone, 1989, p. 7). They argue that the sort of autonomous intensification described by Boserup will be inadequate, and that the state must play an active role in encouraging agricultural intensification. They cite Binswanger and Pingali:

> ...the transition to...new technologies depends on many factors -- the relative cost of labor, capital, and fertilizers; the cost and availability of credit; the reliability of markets for inputs and output; the access to spare parts and repair facilities; and the adequacy of information and training systems (Binswanger and Pingali, 1988, p. 84).

From this perspective, then, Lele and Stone conclude that the specifics of agricultural sector policies will determine whether or not it is possible to make a successful transition to more intensive and sustainable agricultural production in the face of population increase.

III. Demographic Change in Zaire

Overall, Zaire's population growth over the past thirty years or so has been at an average annual rate of approximately 3 percent. This is comparable to population growth rates elsewhere in contemporary sub-Saharan Africa. At the same time, these high growth rates are a relatively recent phenomenon: from 1930 to 1950 Zaire's population grew at an annual rate of a little over 1 percent, and prior to 1930 population growth was slower still due to higher levels of mortality.

As indicated in Table 1, during the period since independence in 1960 there has been relatively modest growth in the rural population (average annual increase of 2.3 percent) accompanied by distinctly more rapid growth in the urban population (average annual increase of 5.4 percent). It should be noted, however, that the "modest" rural growth can be characterized as such only in relation to the corresponding urban growth. In particular, rural population growth well above 2 percent per year substantially exceeds overall rates of population growth in Europe even at the peak growth rates experienced during the demographic transition.

In recent years, the disparity between rural and urban population growth has widened: from 1975 to 1984 the urban population grew at an annual rate of roughly 7 percent, compared

to only 1.6 percent growth per year for the rural population. In fact, the rural population in 1984 was less than 15 percent larger than it had been in 1970, while the urban population was more than four times more numerous, representing in excess of an additional 9 million urban residents.

It is of interest that this slowing down of growth of the rural population, accompanied by continued urban growth, was predicted by Saint Moulin (1977) over a decade ago. He provided estimates of Zaire's urban population for five-year intervals from 1970 until 2000, and his estimates for 1975-1985 are quite close to those shown in Table 1 here.

The greater growth of the urban population that has taken place has resulted in an increasing portion of Zaire's population consisting of urban residents. As is apparent in Table 1, this shift in the rural-urban composition of the population continues a trend that is apparent back at least to 1930. That trend was interrupted during the early 1960s because of the civil strife that took place, but it appears to have accelerated since resuming in 1965.[1]

Figure 1 shows the principal areas of population concentration in Zaire. The most densely populated area of the country is in North and South Kivu, along the eastern border. This area, with nearly a fifth of the country's population, presently has a population density approaching 75 per square kilometer (the national figure is approximately 17/km^2). Of particular relevance for this paper is the Southern Band that stretches across the country and encompasses 40 percent of the population (including most major urban centers). Population

[1]In view of the economic and political chaos in Zaire over the past three years, it seems likely that the trend has slowed and that the gap in population growth rates between rural and urban areas has diminished, since migration to cities has probably declined and there may well have been some migration from urban to rural areas.

density in the Southern Band is presently about 35/km^2.

IV. Demographic Change, Demand for Food, and Agricultural Practices

Other things equal, population growth of 3 percent per year entails growth in food demand of the same magnitude. In Zaire, declining real incomes have probably reduced the growth in food demand somewhat (from the three percent figure), but since the overall demand for food is undoubtedly income-inelastic the reduction most likely has been modest, and accompanied by shifts to less costly (and less nutritional) foods. What is particularly relevant about population growth in Zaire is the fact that it has been concentrated most heavily in urban areas. Since 1970, for example, urban population growth represents more than 80 percent of Zaire's total population growth. Nearly all rural households are involved in food production. However, the slow growth of the rural population over the past two decades means that the number of these producers has increased only very modestly while the number of consumers has continued to grow steadily. As shown in Table 1, from 1970 to 1984 Zaire's population grew by well in excess of 50 percent, representing more than an additional 11 million consumers; while the number of producers of food in rural areas increased by only 13 percent. Hence, there is increasing and persistent pressure on producers to augment food production.

Data on foodcrop production suggest that the agricultural sector has managed to respond to this pressure with increased production (Shapiro and Tollens, 1992, Table 1.1). While these data are notoriously weak (cf., Shapiro and Tollens, 1992, p. 37, n. 1), the absence of sustained increases in the real price of food in Kinshasa is consistent with the notion that production has been able to keep up with increased demand. At the same time, there are a number of

indications that this increased foodcrop production has been achieved in part through changes in agricultural practices. One response to the increased demand for food and to higher population density is that new land has been brought under cultivation at an increasingly rapid rate. This extensification initially entails clearing of forest land, where soil fertility is greater than on open savanna. In some areas, however, forest land has become increasingly scarce (e.g., as is the case in much of central Bandundu, the region immediately to the east of Kinshasa, Zaire's capital and largest city) and the new fields that are being opened are found principally in more marginal savanna areas. These fields are typically located at greater distances from villages than older fields.

Further, there is considerable evidence that fallow periods are being shortened (cf. Fresco, 1986, pp. 157-160; also, personal communications from D. Olson, C. Reid, and C. Smith, PROCAR project staff, Bandundu). Instead of the long fallow periods of up to 20 years and more that are required to fully restore soil fertility under the shifting cultivation techniques that prevail in Zaire, farmers are now frequently resorting to fallow periods of less than ten years and sometimes (particularly in areas close to urban centers) as short as three years. In the case of Bandundu, this intensification of agriculture was also encouraged by the improved access to urban markets following the opening in 1979 of a paved road linking Kinshasa to the region's largest city, Kikwit. In addition, a severe drought in the late 1970s in Bas-Zaire, the region immediately to the west of Kinshasa, also contributed significantly to the expansion of food production in Bandundu destined for the Kinshasa market.

In addition to the shortening of fallow periods that is taking place in response to increased demand for food to feed urban consumers, there are also some areas (e.g., in parts of Kivu at

the eastern edge of the country and in Bas-Zaire at the western edge) where high rural population density contributes to shorter fallow periods. As noted above, mountainous Kivu, where there are rich volcanic soils, has the country's highest population density, and this high density has resulted in a considerable amount of steep hillside farming and corresponding problems of soil erosion. High population density in Bas-Zaire has contributed to loss of forest resources (Shapiro and Tollens, 1992).

Other agricultural practices have also changed. Crop rotations have been modified and have become less varied, as farmers increasingly rely on cassava, which does relatively well even in poor soils. Less care goes into field preparation, less weeding takes place, there is greater variation in planting and harvesting dates, and there have also been increases in plant densities as farmers attempt to sustain and increase production levels. Fresco (1982, 1986) has studied changing agricultural practices in Zaire closely. On the basis of a detailed review of cassava cultural practices in central and southern Bandundu, she concludes that

> "...there has been a considerable shift in cassava cultural practices in the Kwango-Kwilu over the last thirty years. A trend seems to be emerging towards reduced fallows, monocropping of cassava at higher plant densities (with limited numbers of intercrops) while ridging [a form of field preparation on savanna fields] and weeding are more neglected than in the past. Cassava is harvested from an earlier date onwards than before and planting dates are adjusted accordingly" (Fresco, 1986, p. 167).

She describes these changes as a breakdown of classical shifting cultivation practices.

Overall, the combination of bringing new land into cultivation and recycling old land more quickly (i.e., shortening fallow periods), by increasing the area under cultivation at any moment, has been responsible for the observed increase in food production (Fresco, 1986; Shapiro and Tollens, 1992). In particular, it should be emphasized that there is no indication

that this increased production has been due to increases in yields per unit of land. There have been no widespread changes in agricultural technology applied in Zaire (e.g., broad-based use of improved seeds, fertilizers, etc.) that would lead to increased yields.

On the contrary, a number of the practices that have been described here will result in declining yields and environmental degradation. We now turn to a consideration of the effects of changes in agricultural practices on both yields and on natural resources.

V. Impacts of Changes in Agricultural Practices and Sustainability

Bringing of new land under cultivation, in conjunction with the severe shortening of fallow periods, contributes to deforestation. During the 1980s, Zaire lost over 20 thousand hectares of open forest, the third largest loss of open forest internationally behind Brazil and Sudan (Bilsborrow, 1992, Fig. 4, p. 46). Major food production areas in Bandundu and in the Shaba region in the south of the country, which serve Zaire's principal urban centers, are experiencing a continuing loss of forest. In addition, fuelwood demand has contributed to the emergence of deforested "halos" of 150 km surrounding Kinshasa and Lubumbashi (Zaire's second largest city in Shaba), as well as less extensive halos around smaller cities and overcutting of the humid upland forest in densely-populated Kivu (Shapiro and Tollens, 1992).

The replacement of the forest by open savanna, i.e., deforestation and loss of tree cover, reduces soil fertility. The increased proportion of fields found on more marginal savanna land contributes to reductions in yields, and the longer travel time to these distant fields hinders labor productivity. The shortening of fallow periods that has taken place also has an adverse impact on agricultural yields because it does not allow sufficient time for nutrients to be returned to the

topsoil. Hence, soil fertility declines, and other things equal, yields will decline as well. Less care in field preparation and less frequent weeding, which presumably reflect efforts to economize on labor as labor is spread across greater land areas, also will diminish yields. In addition, the reduction in the varieties of foodcrops found in crop rotations and increasing reliance on cassava, which reflects reduced soil fertility, may very well have adverse impacts on the nutritional status of the population.

Clearly, then, the longterm prospects for sustainability of the increases in food production that have been obtained are not good. Increases in areas under cultivation in the future will likely be limited. Even if extensification were to continue or accelerate, however, the prognosis would not be a good one: bringing more new land into cultivation and continued shortening of fallow periods would result ultimately in more rapid and very serious degradation of soil and forest resources, with a large adverse impact on yields.

Until now, the effects of having more land under cultivation at any moment have outweighed the tendency toward declining yields, so overall production has increased. Eventually, however, the negative effect of declining yields will outweigh the positive effect of increasing area cultivated; particularly since it seems likely that the declines in yields will accelerate while the amount of new land brought under cultivation will necessarily diminish.

Historically, the shifting cultivation system with long fallow periods that characterizes Zaire and many other countries in sub-Saharan Africa has been sustainable, but the necessary conditions are low population density and slow population growth. In Zaire as elsewhere, as population growth has quickened and population density increased, short fallow systems have emerged. Under these conditions, the consequences have often been soil degradation,

deforestation, and declining productivity.

Intensification of agricultural production with improved technology (via use of fertilizers, for example) is one means of attempting to remedy this situation. However, in the presence of abundant land, the extensification that has been taking place provides an easier and cheaper means of increasing output, at least in the short run. In addition, it appears at present that the use of fertilizers is not an economically viable activity in Zaire, except in very limited areas surrounding a few major urban centers (cf., Smits-Stabo Engineering, 1986). Use of improved varieties of cassava and high-yield seed varieties for maize and other crops was promoted by the National Seed Office during the 1980s. However, coverage was fairly limited and the office was only able to function thanks to substantial donor support (Shapiro and Tollens, 1992, pp. 34-35, 147-148). Given the withdrawal of donors following civil disorder in September 1991, prospects for increased productivity via use of high-yielding varieties are presently effectively nil.

In summary, then, current agricultural practices are incompatible in the long run with continued increases in food production to feed growing urban populations. Even if one abstracts from Zaire's present economic crisis, Vernon Ruttan's observation would appear to be on the mark: "...the scientific and technical knowledge is not yet available that will enable farmers in most tropical countries to meet the current demand their societies are placing on them or to sustain the increases that are currently being achieved" (Ruttan, 1989, p. 9).

VI. Summary and Conclusions

Over the course of the past two decades in Zaire, a relatively slowly growing rural population has managed to increase food production in order to feed itself plus a very rapidly

growing urban population. The growth in foodcrop production has been achieved by increases in the land area under cultivation. At the same time, there have been changes in agricultural practices, including shortening of fallow periods, increased rate of bringing new land and more marginal land under cultivation, less effort put into field preparation, and reduced weeding, that have contributed to declining yields per hectare.

The land extensification and shortening of fallow periods that have been taking place correspond to the Boserup scenario. Other changes, reflecting increased pressure on labor, fail to support agricultural intensification, and in Boserup's words will "lead to a decline of crop yields and ...an exhaustion of land resources" (Boserup, 1965, p. 41). The degradation of soil and forest resources that is resulting and will continue to result from these practices, and particularly their impact on soil fertility, means that the increases in foodcrop production that have been achieved to date will not be sustainable over the long haul. In effect, then, the concerns expressed by Lele and Stone regarding the adverse environmental consequences of shortened fallow periods and more intensive use of land in the absence of supplementary inputs are clearly very pertinent in the case of Zaire.

Continued high fertility and rapid population growth are expected to persist for some time in Zaire. The analysis in this paper clearly indicates that lower fertility and reduced rates of population increase would be desirable, since such changes would diminish growth in demand for food and thereby alleviate somewhat the pressure on the agricultural system and on the environment.

In principle, as suggested above, public policy could serve to facilitate agricultural intensification and adoption of improved technology. Zaire's record with regard to agricultural

policy is dismal, however, even when the current economic and political crisis that began in 1990 is left out of consideration. Although frequently described as the "priority of priorities," Zairian agriculture in the 1970s and much of the 1980s was largely neglected and seriously underfunded. The extension service was essentially nonfunctional, and while there were some important donor-supported research activities their weak links to extension prevented them from having much impact. The overall poor macroeconomic climate and deteriorated transportation infrastructure contributed to the lack of economic viability of use of modern inputs (Shapiro and Tollens, 1992).

Some sort of intensification of agricultural production, under which nutrients are returned to the soil instead of being continually extracted from the soil, would seem to be required. However, the scientific and technical knowledge required to bring about this intensification under the economic conditions prevailing in Zaire (and elsewhere in much of sub-Saharan Africa) does not yet exist.

In discussing the need for sustaining and enhancing agricultural productivity in tropical countries, Ruttan (1989, p. 9) has argued that "...achievement of sustainable agricultural surpluses is dependent on advances in scientific knowledge and on technical and institutional innovation." This means that there is a strong need for systems-oriented research -- that is, research focused not simply on enhancing production of this or that crop, but rather research that is aimed at developing productive and sustainable agricultural systems.

The problem of unsustainable agricultural practices resulting in environmental degradation is a difficult one to address, in part because of its longterm nature. The problem appears to be on the horizon, rather than staring us in the face. However, it seems quite likely that the

transition from being a remote problem to being an immediate concern may take place very quickly.

Table 1. Population Estimates, 1930-1984

Year	Total population	Rural population Number	%	Urban population Number	%
1930	8,803,513	8,433,766	95.8	369,747	4.2
1940	10,353,909	9,336,010	90.2	1,017,899	9.8
1950	11,331,793	9,169,396	80.9	2,162,397	19.1
1960	14,217,732	10,805,412	76.0	3,412,320	24.0
1965	16,562,503	15,018,192	89.0	1,825,187	11.0
1970	19,286,207	16,422,700	85.1	2,863,507	14.9
1975	22,582,230	16,105,091	71.3	6,477,139	28.7
1980	26,377,260	17,366,917	63.8	9,010,343	34.2
1984	30,729,443	18,591,313	60.5	12,138,130	39.5

N.B. For 1984, the total population figure is from Institut National de la Statistique, 1991; while the breakdown of that population between rural and urban components is based on the projections in Département du Plan, 1978. A change in the definition of "urban" effective as of the 1984 census makes the published data on the urban population in 1984 not comparable to the data for earlier years.

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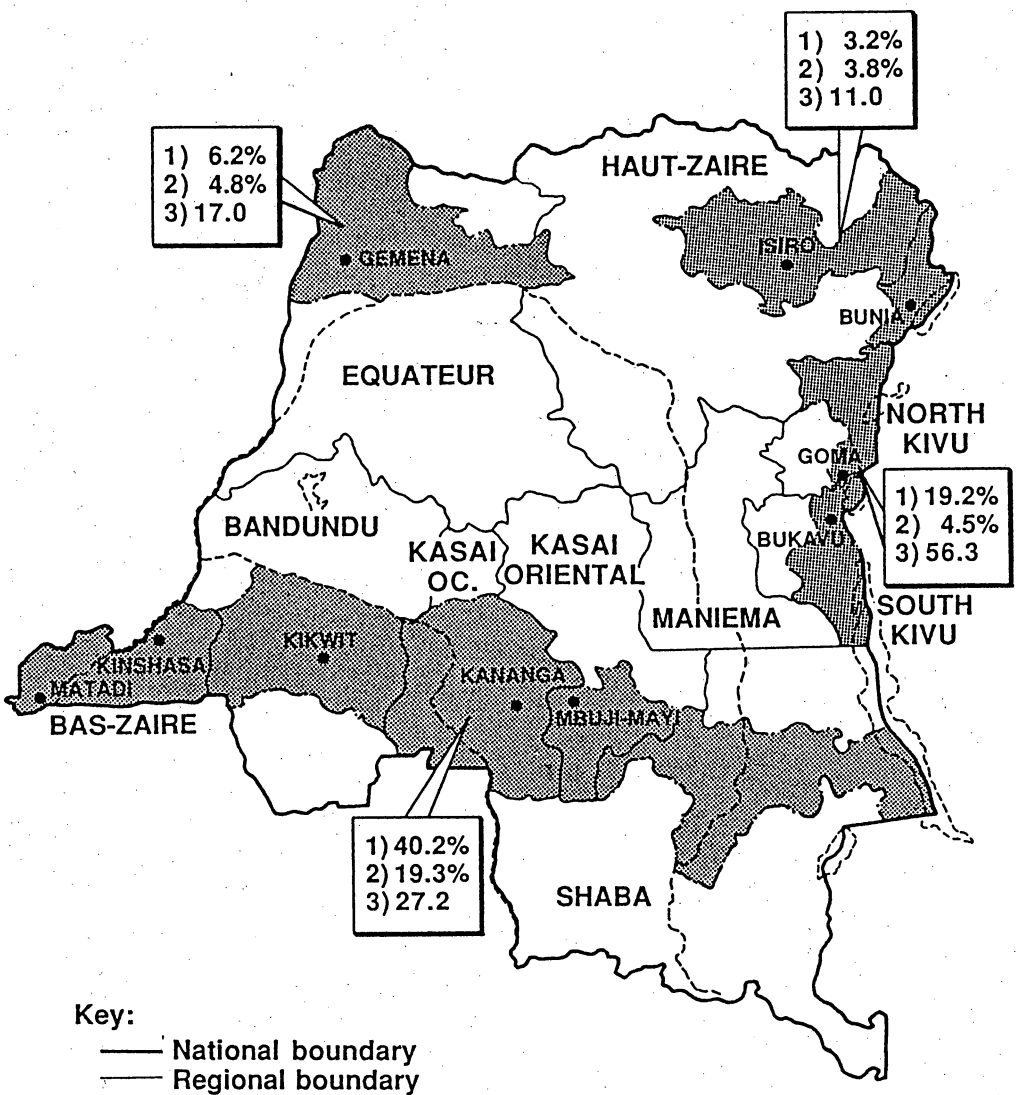

Figure 1 Principal areas of population concentration

Source: Calculated from data on population and land area reported in Institut National de la Statistique, *Zaïre Recensement scientifique de la Population - Juillet 1984 - Totaux Définitifs*, 1991.

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