African poverty: A grand challenge for sustainability science

Robert W. Kates*† and Partha Dasgupta‡

**33 Popple Point, Trenton, ME 04605; and ‡Faculty of Economics, University of Cambridge, Cambridge CB3 9DD, United Kingdom*

When we began to put together this special feature on poverty and sustainability science, we sought significant science-based research and perspectives on poverty worldwide. However, the six articles that have emerged from a lengthy solicitation, preparation, and review process, with one exception, all focus on sub-Saharan Africa. The exception, the absolute poverty measures for the developing world by Chen and Ravallion (1), serve to provide the latest evidence for an African exceptionalism that dominates the development needs of today.

Briefly stated, all developing country regions have shown marked improvement in key indicators of poverty, health, economy, and food, except for sub-Saharan Africa. For poverty, the global number of people living below the extreme poverty line of $1 per day decreased between 1981 and 2004 from 1,470 million to 969 million. The percentage of extremely poor fell from 40% to 18%. However, in sub-Saharan Africa, the numbers almost doubled from 168 million to 298 million, and the percentage stayed almost constant from 42% to 41% (1). For health, the life expectancy at birth in sub-Saharan Africa peaked in 1990 at 50 years but has since declined to 46 years, while steadily rising in all developing country regions to an average of 65 years (2). Over the period 1960–2000, sub-Saharan Africa's per capita measure of annual economic growth (gross domestic product) was a mere 0.1%, whereas other developing country regions experienced accelerated growth averaging 3.6% (3). Food production per capita grew by 2.3% per year between 1980 and 2000 in Asia, grew by 0.9% in Latin America, and declined by 0.01% in tropical Africa (4).

Understanding African exceptionalism and contributing to its reduction is one of the grand challenges of sustainability science. In this brief introduction, we have characterized the ways in which scientists can contribute to meeting the challenges as describing poverty, understanding causation, and offering and evaluating policies and solutions.

Describing Poverty

A broad reading of the development literature might provide a composite description of poverty in developing countries as:

> In the world of the poor, people don't enjoy food security, don't own many assets, are stunted and wasted, don't live long, can't read or write, don't have access to easy credit, are unable to save much, aren't empowered, can't ensure themselves well against crop failure or household calamity, don't have control over their own lives, don't trade with the rest of the world, live in unhealthy surroundings, suffer from "incapabilities," are poorly governed.

And more rarely,

> . . . and suffer from a deteriorating natural resource base and have a high birth rate (5).

Poverty description, the most common form of poverty study and scholarship, takes three major forms: poverty line numbers, indices, and capabilities, all of which are found in the composite statement. Poverty line numbers describe who (individuals, households, places, nations) is poor, based on a poverty line below which basic necessities cannot be provided. These lines are often measured by nutritional requirements, incomes, or baskets of consumption. In Chen and Ravallion (1), the number of poor are those with less than $1 or $2 per day per capita expenditure on consumption, and this number is derived from 560 nationally representative household surveys in 100 low- and middle-income countries, representing 93% of the population of the developing world. They provide an adjustment to compare urban and rural poverty by compensating for the higher living costs in urban places. With the use of these surveys, Chen and Ravallion have developed the long-term data described above.

In contrast to these temporal changes, Okwi *et al.* (6) describe the spatial differentiation of poverty in Kenya, using a national poverty line for calculating and mapping the proportion of poor people in 2,232 small locations and 7 provinces.

However, as the composite descriptive sentence suggests, poverty is more than what one cannot afford to buy or consume. Many additional measures of human development and well-being have been identified and combined in indices. Common indices developed by the United Nations Development Programme are the human development index composed of three measures of development (per capita gross domestic product, life expectancy, and literacy) or the human poverty index composed of measures of deprivation in the development indices (child and young adult mortality, illiteracy, and lack of water and sanitation) (7).

The most recent definitions are derived from work by Sen (8, 9) and Nussbaum and colleagues (10, 11), who view poverty as the diminished capability or freedom to achieve valued beings and doings (called functionings). In a sense, functionings are both the ends and the means of human life and include the enormous range of both. However, although capabilities have attracted wide interest among scholars, humanists, and social scientists, when deprivation in capabilities is actually measured, many of the same indicators found in poverty line and development deprivation studies are employed.

Understanding Causation

Describing poverty and explaining its causes are two very different tasks. Development experts nonetheless routinely write as though to describe were to explain. However, description offers little guidance for action. It does not say what is a cause and what is an effect, it does not distinguish between proximate and deep causes, it does not say what is a variable and what is a parameter in the environment in which the poor reside, and it does not say whether variables can be interpreted in samples to "move" together over time (time series data) or across parameter values at a point in time (cross-sectional data). Above all, description does not help to identify the pathways that lead to a state of affairs. Yet, an enormous literature has drawn on description to arrive directly at policy prescriptions. One senses that even the United Nations Millennium Development Goals and the plans the United

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†To whom correspondence should be addressed. E-mail: rwkates@verizon.net.

Nations identified for meeting them (12) reflect this methodological stance.

There is, however, a growing body of analysis on the causes of poverty in sub-Saharan Africa and its exceptional persistence. Geopolitics has been a favored explanation, focusing first on a heritage of colonialism that left little in the way of infrastructure, economy, health, and education and much that would lead to future problems with conflict-laden borders and many small landlocked nations. Added to this were the failures of effective and sufficient development aid and of a globalized economy to bring benefits to Africa. Poverty itself is often invoked in the form of the "poverty trap" that locks Africans into a vicious circle of little savings, leading to little capital investment, few skills, and truncated education. More recently, governance has emerged as a favored theme that attributes African exceptionalism to a culture that counters entrepreneurship with ties of ethnicity and family, leading to conflict and maintaining high levels of corruption. The newest approach has involved the rediscovery of geography, and addresses the extensive aridity, poor soils, and endemic disease of the continent as well as the scattered populations in many small landlocked nations, coupled ironically with the highest population growth rates in the world.

This special feature has three articles on understanding causation: a global analysis, a research perspective, and a national study that specifically address cause and effect. In one article (3), Paul Collier, Director of the Centre for the Study of African Economies at Oxford University, argues that the cause of worldwide poverty is the lack of economic growth. To explain the exceptional failures of African economies to grow over the last quarter century, he draws on extensive sets of statistical regressions of national growth and key physical (resource scarcity and wealth, coastal and landlocked locations) and human (small national populations and ethnic diversity) geographic features. In varying combinations, these features cause problems globally for many developing economies (13), but they are exceptionally prevalent in sub-Saharan Africa.

Another article, by G. Hyden (14), a political scientist at the University of Florida, provides perspective on the current widespread attribution of African exceptionalism to poor governance, with the implication that improved governance would lead to poverty reduction. A 50-year review of African politics and related studies (15) leads him to question, for two major reasons, the prevailing view in international development organizations that improved governance can serve as a principal mechanism to reduce poverty. The first is that most political scientists believe the economy shapes governance institutions more than the reverse. More importantly, however, is the finding that distinctive African socioeconomic and political conditions combine, so that poor people in Africa seek to meet their needs outside the "system" through an "economy of affection" and are less influenced either by the institutions of governance or by formal markets (16).

The third article comes from a team led by economist Paul Okwi (5) of the International Livestock Research Institute. It focuses on geographic causation, but within a single country, Kenya, for which the authors report on research using poverty mapping of 2,232 small locations and 7 provinces. Physical qualities such as land use, soil type, slope, elevation, and distance to public resources, as well as demographic and income inequality, explain more than half of the variation in rural poverty numbers. However, as with Africa as a whole, combinations vary from province to province.

Two other articles, described below, also add to this picture of causation. In the report by Sanchez *et al.* (17) on the efforts to create millennium villages, the authors understand causation as a poverty trap in which poverty itself, hunger and disease, rapid population growth, environmental degradation, and poor governance are all mutually reinforcing (4, 18). Thus, in rural areas where >70% of the population live, poverty prevents farmers from self financing or getting credit for needed farm inputs (fertilizer, improved seeds), and soils become depleted of nutrients after repeated crop cycles without sufficient replenishment (19). Poverty and environmental degradation interact with a health crisis, particularly hunger, malaria, and AIDS. The resulting high child mortality blocks the demographic transition to low fertility rates. Rapid population growth and large families exacerbate poverty. Finally, poverty also contributes to poor governance. The failure of international governance to provide sufficient public sector investment and aid and to make global markets accessible contributes as well.

Mabogunje (20), in his urban poverty experiment, adopts the Sachs view of a poverty trap (4) but adds to the mix of governance considerations of the failure of African governments to enhance the capabilities of their own people and the desirable, but insufficient, efforts of civil society institutions to take up the slack.

Our own assessment is that geopolitics, poverty, governance, and geography all contribute to African exceptionalism, although their respective importance varies by region, country, and place. We have developed this view at greater length in Kates' early analysis of "least development" (21) and Dasgupta's more recent emphasis on the interplay among poverty, reproduction, and the state of the local environmental resource base (5). A similar emphasis on the importance of context in understanding causation in human-environment systems is central to the PNAS special feature on the need to move "beyond panaceas" in the governance of natural resource systems, published earlier this year under the leadership of Elinor Ostrom (22).

Policies and Solutions

Describing African exceptionalism and understanding its causes are prerequisites to policies and solutions for reducing African poverty. The most promising efforts deal with the varied causes. Some efforts are already underway. Addressing geopolitics is the New Partnership for Africa's Development (NEPAD). This pan-African initiative seeks to promote peace, democracy, good governance, and enhanced cooperation with development partners and civil society. Increasing aid for development is emerging through debt forgiveness and the entrance of new development partners such as China. A limited U.S. and European trade policy gives Africa some trade preferences (Africa Growth and Opportunity Act, Everything but Arms), but in general, it still blocks African access to global markets.

Governance has improved despite the failure to end conflicts in Chad, Sudan, and Somalia and the retreat from democracy in Zimbabwe. Violent conflicts have ended in the Congo, Ivory Coast, Liberia, and Sierra Leone and have been prevented in Burundi and Togo. Most hopeful has been the increasing leadership from major African nations and the way peaceful transitions of power are slowly emerging as a norm.

Finally, the limits of geography are being addressed, particularly illness (spearheaded by the Gates Foundation). Population growth continues to slow, with reduced births from the demographic transition and unfortunately increased deaths from AIDS and tuberculosis. In addition, in the first few years of this century, economic growth in Africa has increased, and the trend of rising poverty in Africa has reversed, although the numbers (because of population growth) are still high. Increasingly, education and science are also

seen as a mechanism to escape the poverty trap. New initiatives to rebuild major universities, provide access to scientific literature, make Internet connections widely available, and provide $100 laptops seek to overcome the knowledge limits of small poor countries.

Sustainability science and technology can also address these needs as a user-inspired science, both fundamental and applied. They can address cutting-edge questions regarding interactive nature–society systems and their evolving dynamics, as in the effort to understand the causes of exceptional African poverty. However, they also recognize the concurrent need to address sustainability concerns in problem-solving modes, applying what we already know in science-based action programs and learning from the results. Thus, small-scale but important efforts can provide new experiments in poverty reduction. Two of these are reported on in this special feature, one rural and one urban.

In the rural-oriented experiment, Sanchez *et al.* (17) report on the concept, strategy, and initial results of the Millennium Village Project (78 villages, 12 major agroecological zones, and 10 African countries). The project seeks to address critical interacting needs in agriculture, health, and infrastructure in rural Africa through science-based interventions funded both by public investments and local efforts. First- and second-year results from villages in Kenya, Ethiopia, and Malawi have generated crop surpluses that have met caloric requirements, enabled school feeding programs, and provided cash earnings for farm families while reducing malaria prevalence. There are still significant questions as to project sustainability and the scaling up of the favorable initial results. The agricultural portion of the project is intended to be self-financing in 5 years, but the public good initiatives in health, education, and infrastructure will need continuing central government support. Indeed, the Millennium Village Project will continue to require major increases in international development assistance and continuing science-based assistance for a green revolution in Africa for major advances in treating malaria, HIV–AIDS, and neglected tropical diseases, and for improvements in information technology. The experiment is very much an ongoing one.

The urban experiment in poverty reduction reported on by Akin Mabogunje (21), Chairman Emeritus of the Development Policy Centre (Ibadan, Nigeria), was whether poverty can be dramatically reduced through a city consultation process that seeks to mobilize an entire community along with its extensive diaspora. Such a consultation took place in 1998 in the city of Ijebu-Ode, in Southwestern Nigeria (estimated 1999 population, 163,000), where, except for remittances from relatives away from home, an estimated 90% of the population lived in extreme poverty. The consultation brought together the traditional authorities, local government, neighborhood associations, market women, businesses, and citizens in other cities and abroad. The Ijebu-Ode experiment finds increasing evidence that poverty in the city has been reduced significantly through the microfinancing of existing and new productive activities and through the estimated 8,000 jobs these have created. Many of these jobs came from new or more productive activities for which training was provided by local practitioners and scientists. However, community-based poverty reduction efforts also have limitations of continued leadership, staffing, and funding. To help cope with these limitations, Mabogunje (21) argues that increased national and international aid in the form of credit funds should be made available and that national efforts should continue to improve the capability of poor people through education. However, his research also suggests a major opportunity to improve the credit standing of poor people through a more determined effort at land reforms that would release much of the land assets of the poor from a kinship nexus and align them with the demands of the free market economy.

Other articles in this special feature also report research on the likely efficacy of alternative policies and other interventions. For example, Okwi *et al.* (6) use their regression models to test two specific proposed solutions for sub-Saharan African agriculture, increased soil fertility and improved access to markets. The first provincial-level simulation finds that improved fertility, either by fertilizer or by improved management techniques, would reduce poverty significantly, a finding supported by the Sanchez *et al.* experiment (17). However, improving travel time to the nearest market centers had only a minuscule effect on poverty.

Hyden's findings (14) have suggestions for policy that run counter to most development aid policy. In his evolution approach, he would build on already-existing informal institutions that might evolve in a direction in line with the formal requirements of national development. In a diffusion approach, he would look for "pockets of productivity" and "champions of success" and support these. In his insulation approach, he would seek to contain the detrimental aspects of informal institutions, such as clientelism, by a troika made up of representatives of government, civil society, and resource providers. Additionally, he would pursue all three approaches at the same time.

Collier's research (3) identifies four sets of policies that international and regional institutions might undertake, guided by his framework of major geographic differences. Resource-rich countries with high ethnic diversity especially need to have strong checks and balances on how governments use their power and distribute funding. International policies on transparency and financial disclosure can help. Such countries are also prone to violent internal conflicts and expanding international and regional peacekeeping, and security guarantees could help. Resource-scarce coastal countries that have missed the opportunities to develop Asian-style export-based manufacturing will require temporary preferential market access. Finally, countries that are both resource-scarce and landlocked have the least opportunity for growth. They will need substantial foreign aid, not for fostering economic growth but for direct provision and consumption of basic necessities.

Reflections on this Special Feature

This is one of several inaugural special features in the Sustainability Science section of PNAS (23). Here we reflect on our special feature as a whole, both for its findings and as sustainability science. Three major collective findings stand out: place matters, cause is complicated, and experimentation is necessary.

Place matters because sub-Saharan Africa is different from the rest of the developing world. Its poverty differs by agroecological zones, its urban poverty differs from rural poverty, its resource-rich countries differ from resource-scarce countries, and its coastal locations differ from its landlocked locations. Within a single country, Kenya, poverty differs by province and location, and in Nigeria, poverty differs by city. Thus, policies and solution need to reflect the different causes, problems, and opportunities of specific contexts and places.

Cause is complicated because geopolitics, poverty, governance, and geography all contribute to African exceptionalism. However, the research reported here, together with other recent findings in a similar vein, is far more nuanced than previous efforts that simply or singly blamed history, geography, culture, or the industrialized North. A coherent story of the causes of African exception-

alism and how they can be overcome, however, remains to be told.

Experimentation is necessary, as in all science; the examples given in this special feature whet our appetites for more. Socioecological experiments in poverty reduction suffer from many of the same problems encountered by large-scale health intervention experiments but lack the mitigating experience and tradition of gold-standard case-control studies, rigorous evidence collection and analysis, frank discussions of ethical issues, and, probably most important, a societal willingness to fund and support long-term studies. Thus, to an unusual degree, we are relegated to so-called "natural experiments" and the second-best use of regression techniques to extract reliable lessons from them.

Finally, this special feature is sustainability science, but still in early development. It is an exemplar of sustainability science because it tackles a big problem (in current jargon, a grand challenge). In our judgment, it is a challenge rivaled in our time perhaps only by climate change and peace and security. It illustrates sustainability science because it is clearly interdisciplinary, with lead authors and editors from economics, geography, political science, and soil science. It is international: the lead authors and editors all come from different countries, including two from Africa itself, and all have worked in developing countries. Most importantly, it asks fundamental questions but seeks practical and place-based solutions.

But it is also lacking in other qualities. Although interdisciplinary overall as a special feature, some of our articles nonetheless overly reflect their disciplinary origins. The transdisciplinary goal of fully integrating the natural and social sciences and of using truly socioecological models is not realized. Major contributions from technology and the health sciences are absent but should be forthcoming in other special features. And, as in previous work, our special feature remains stronger on critical analysis than on offering practical and place-based solutions.

Yet there is hope. Among them, the authors and editors have several centuries of professional experience to draw on, and several exhibit a touch of skepticism, perhaps even cynicism. However, none evidence the loss of hope that poverty can be overcome and that science has much to contribute to that effort.

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