

THE GEOGRAPHY

Tropical climate and lack of access to sea trade have hurt the poorest nations. But new aid programs can point the way to prosperity

by Jeffrey D. Sachs, Andrew D. Mellinger and John L. Gallup

GLOBAL DISTRIBUTION of economic output is delineated in this world map showing GNP density—the product of population density and gross national product per capita. Output is concentrated along the seacoasts and sea-navigable waterways of the world's temperate zones.



OF POVERTY AND WEALTH

ILLUSTRATION BY SAMUEL VELASCO. SOURCES: THE WORLD BANK; THE WORLD FACTBOOK (CA, 1996 AND 1997); THE GLOBAL DEMOGRAPHY PROJECT AND THE ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE



R. GILING/Lineart/Peter Arnold, Inc.

ECONOMIC DISPARITIES can be partly attributed to geography. Coastal temperate-zone countries such as Germany (*opposite page*) have lower transportation costs and higher farm productivity than landlocked tropical-zone countries such as Uganda (*above*).

broad climate zones based on a classification scheme developed by German climatologists Wladimir P. Köppen and Rudolph Geiger. The five zones are tropical-subtropical (hereafter referred to as tropical), desert-steppe (desert), temperate-snow (temperate), highland and polar. The zones are defined by measurements of temperature and precipitation. We excluded the polar zone from our analysis because it is largely uninhabited.

Among the 28 economies categorized as high income by the World Bank (with populations of at least one million), only Hong Kong, Singapore and part of Taiwan are in the tropical zone, representing a mere 2 percent of the combined population of the high-income regions. Almost all the temperate-zone countries have either high-income economies (as in the cases of North America, western Europe, Korea and Japan) or middle-income economies burdened by socialist policies in the past (as in the cases of eastern Europe, the former Soviet Union and China). In addition, there is a strong temperate-tropical divide within countries that straddle both types of climates. Most of Brazil, for example, lies within the tropical zone, but the richest part of the nation—the southernmost states—is in the temperate zone.

The importance of access to sea trade is also evident in the world map of GNP per capita. Regions far from the sea, such as the landlocked countries of South America, Africa and Asia, tend to be considerably poorer than their coastal counterparts. The differences between coastal and interior areas show up even more strongly in a world map delineating GNP density—that is, the amount of economic output per square kilometer [see illustration on pages 70 and 71]. This map is based on a detailed survey of global population densities in 1994. Geographic information system software is used to divide the world's land area into five-minute-by-five-minute sections (about 100 square kilometers at the equator). One can estimate the GNP density for each section by multiplying its population density and its GNP per capita. Researchers must use national averages of GNP per capita when regional estimates are not available.

To make sense of the data, we have classified the world's regions in broad categories defined by climate and proximity to the sea. We call a region "near" if it lies within 100 kilometers of a sea-coast or a sea-navigable waterway (a river, lake or canal in which oceangoing vessels can operate) and "far" otherwise. Regions in each of the four climate zones we analyzed can be either near or far, resulting in a total of eight categories. The table on the next page shows how the world's population, income and land area are divided among these regions.

The breakdown reveals some striking

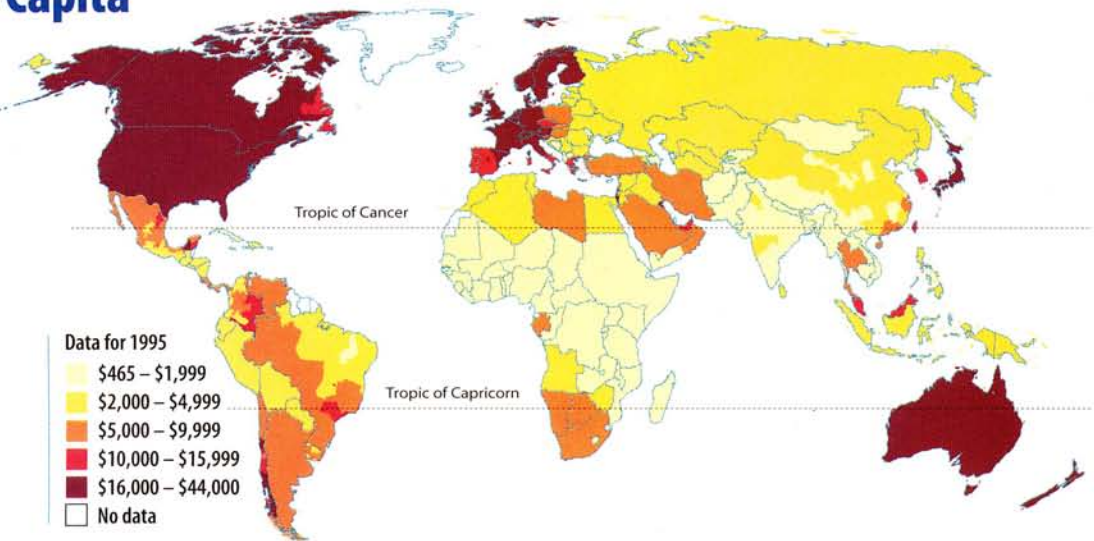
patterns. Global production is highly concentrated in the coastal regions of temperate climate zones. Regions in the "temperate-near" category constitute a mere 8.4 percent of the world's inhabited land area, but they hold 22.8 percent of the world's population and produce 52.9 percent of the world's GNP. Per capita income in these regions is 2.3 times greater than the global average, and population density is 2.7 times greater. In contrast, the "tropical-far" category is the poorest, with a per capita GNP only about one third of the world average.

Interpreting the Patterns

In our research we have examined three major ways in which geography affects economic development. First, as Adam Smith noted, economies differ in their ease of transporting goods, people and ideas. Because sea trade is less costly than land- or air-based trade, economies near coastlines have a great advantage over hinterland economies. The per-kilometer costs of overland trade within Africa, for example, are often an order of magnitude greater than the costs of sea trade to an African port. Here are some figures we found recently: The cost of shipping a six-meter-long container from Rotterdam, the Netherlands, to Dar-es-Salaam, Tanzania—an air distance of 7,300 kilometers—was about \$1,400. But transporting the same container overland from Dar-es-Salaam to Kigali, Rwanda—a distance of 1,280 kilometers by road—cost

GNP per Capita

WEALTH AND CLIMATE are inextricably linked. By comparing world maps showing GNP per capita (right) and climate zones (opposite page), one notices that temperate-zone countries are generally much more prosperous than tropical-zone nations. And in each climate zone, the regions near seacoasts and waterways are richer than the hinterlands (table below).



about \$2,500, or nearly twice as much.

Second, geography affects the prevalence of disease. Many kinds of infectious diseases are endemic to the tropical and subtropical zones. This tends to be true of diseases in which the pathogen spends part of its life cycle outside the human host: for instance, malaria (carried by mosquitoes) and helminthic infections (caused by parasitic worms). Although epidemics of malaria have occurred sporadically as far north as Boston in the past century, the disease has never gained a lasting foothold in the temperate zones, because the cold winters naturally control the mosquito-based transmission of the disease. (Winter could be considered the world's most effective public health intervention.) It is much more difficult to control malaria in tropical regions, where transmission takes place year-round and affects a large part of the population.

According to the World Health Organization, 300 million to 500 million new cases of malaria occur every year, almost entirely concentrated in the tropics. The disease is so common in these areas that no one really knows how many people it kills annually—at least one million and perhaps as many as 2.3 million. Widespread illness and early deaths obviously hold back a nation's economic performance by significantly reducing worker productivity. But there are also long-term effects that may be amplified over time through various social feedbacks.

For example, a high incidence of disease can alter the age structure of a country's population. Societies with high levels of child mortality tend to have high levels of fertility: mothers bear many children to guarantee that at least some will survive to adulthood. Young children

will therefore constitute a large proportion of that country's population. With so many children, poor families cannot invest much in each child's education. High fertility also constrains the role of women in society, because child rearing takes up so much of their adult lives.

Third, geography affects agricultural productivity. Of the major food grains—wheat, maize and rice—wheat grows only in temperate climates, and maize and rice crops are generally more productive in temperate and subtropical climates than in tropical zones. On average, a hectare of land in the tropics yields 2.3 metric tons of maize, whereas a hectare in the temperate zone yields 6.4 tons. Farming in tropical rain-forest environments is hampered by the fragility of the soil: high temperatures mineralize the organic materials, and the intense rainfall leaches them out of the soil. In tropical environments that have wet and

dry seasons—such as the African savanna—farmers must contend with the rapid loss of soil moisture resulting from high temperatures, the great variability of precipitation, and the ever present risk of drought. Moreover, tropical environments are plagued with diverse infestations of pests and parasites that can devastate both crops and livestock.

Many of the efforts to improve food output in tropical regions—attempted first by the colonial powers and then in recent decades by donor agencies—have ended in failure. Typically the agricultural experts blithely tried to transfer temperate-zone farming practices to the tropics, only to watch livestock and crops succumb to pests, disease and climate barriers. What makes the problem even more complex is that food productivity in tropical regions is also influenced by geologic and topographic conditions that vary greatly from place to place. The island of Java, for example, can support highly productive farms because the volcanic soil there suffers less nutrient depletion than the nonvolcanic soil of the neighboring islands of Indonesia.

Moderate advantages or disadvantages in geography can lead to big differences in long-term economic performance. For example, favorable agricultural or health conditions may boost per capita income in temperate-zone nations and hence increase the size of their economies. This growth encourages inventors in those nations to create products and services to sell into the larger and richer markets. The resulting inventions further raise economic output, spurring yet more inventive activity. The moderate geographical advantage is thus amplified through innovation.

In contrast, the low food output per

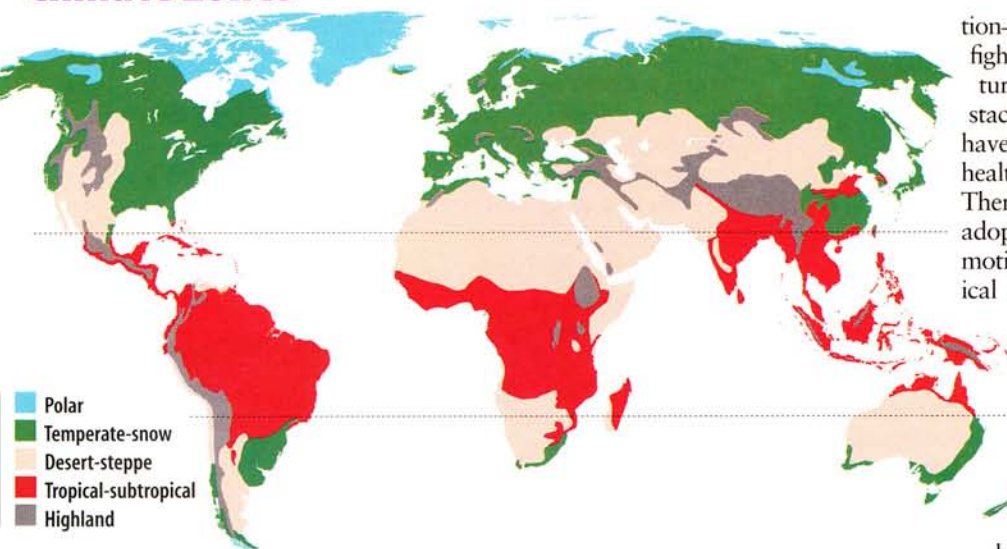
The Wealth of Regions

Climate Zone (percent of world total)	Near*	Far*
Tropical		
Land area	19.9%	5.5% 14.4%
Population	40.3%	21.8% 18.5%
GNP	17.4%	10.5% 6.9%
Desert		
Land area	29.6%	3.0% 26.6%
Population	18.0%	4.4% 13.6%
GNP	10.1%	3.2% 6.8%
Highland		
Land area	7.3%	0.4% 6.9%
Population	6.8%	0.9% 5.9%
GNP	5.3%	0.9% 4.4%
Temperate		
Land area	39.2%	8.4% 30.9%
Population	34.9%	22.8% 12.1%
GNP	67.2%	52.9% 14.3%

* "Near" means within 100 kilometers of seacoast or sea-navigable waterway; "far" means otherwise.

SOURCE: ANDREW D. MELLINGER

Climate Zones



farm worker in tropical regions tends to diminish the size of cities, which depend on the agricultural hinterland for their sustenance. With a smaller proportion of the population in urban areas, the rate of technological advance is usually slower. The tropical regions therefore remain more rural than the temperate regions, with most of their economic activity concentrated in low-technology agriculture rather than in high-technology manufacturing and services.

We must stress, however, that geographical factors are only part of the story. Social and economic institutions are critical to long-term economic performance. It is particularly instructive to compare the post-World War II performance of free-market and socialist economies in neighboring countries that share the same geographical characteristics: North and South Korea, East and West Germany, the Czech Republic and Austria, and Estonia and Finland. In each case we find that free-market institutions vastly outperformed socialist ones.

The main implication of our findings is that policymakers should pay more attention to the developmental barriers associated with geography—specifically, poor health, low agricultural produc-

tivity and high transportation costs. For example, tropical economies should strive to diversify production into manufacturing and service sectors that are not hindered by climate conditions. The successful countries of tropical Southeast Asia, most notably Malaysia, have achieved stunning advances in the past 30 years, in part by addressing public health problems and in part by moving their economies away from climate-dependent commodity exports (rubber, palm oil and so on) to electronics, semiconductors and other industrial sectors. They were helped by the high concentration of their populations in coastal areas near international sea lanes and by the relatively tractable conditions for the control of malaria and other tropical diseases. Sub-Saharan Africa is not so fortunate: most of its population is located far from the coasts, and its ecological conditions are harsher on human health and agriculture.

The World Bank and the International Monetary Fund, the two international agencies that are most influential in advising developing countries, currently place more emphasis on institutional reforms—for instance, overhauling a nation's civil service or its tax administra-

tion—than on the technologies needed to fight tropical diseases and low agricultural productivity. One formidable obstacle is that pharmaceutical companies have no market incentive to address the health problems of the world's poor. Therefore, wealthier nations should adopt policies to increase the companies' motivation to work on vaccines for tropical diseases. In one of our own initiatives, we called on the governments of wealthy nations to foster greater research and development by pledging to buy vaccines for malaria, HIV/AIDS and tuberculosis from the pharmaceutical companies at a reasonable price. Similarly, biotechnology and agricultural research companies need more incentive to study how to improve farm output in tropical regions.

The poorest countries in the world surely lack the resources to relieve their geographical burdens on their own. Sub-Saharan African countries have per capita income levels of around \$1 a day. Even when such countries invest as much as 3 or 4 percent of their GNP in public health—a large proportion of national income for a very poor country—the result is only about \$10 to \$15 per year per person. This is certainly not enough to control endemic malaria, much less to fight other rampant diseases such as HIV/AIDS, tuberculosis and helminthic infections.

A serious effort at global development will require not just better economic policies in the poor countries but far more financial support from the rich countries to help overcome the special problems imposed by geography. A preliminary estimate suggests that even a modest increase in donor financing of about \$25 billion per year—only 0.1 percent of the total GNP of the wealthy nations, or about \$28 per person—could make a tremendous difference in reducing disease and increasing food productivity in the world's poorest countries. ■

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Further Information

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Additional data and research papers are available at www.cid.harvard.edu and sedac.ciesin.org on the Web.