Infrastructure and economic development

An EIR statistical survey
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We present here a statistical grid and comparison of five economies: the United States, pre-unification Federal Republic of Germany, India, Japan, and the People's Republic of China. The purpose of the grid is to assist in the development of a set of standards, and therefore also, of requirements, for the development of basic economic infrastructure in its relationship with the economy as a whole.

Basic economic infrastructure is subdivided into two principal categories: 1) the provision of economic functions, the supply of water, power, and transportation, especially the transportation of freight; and 2) the supply of social services, namely education and health. The comparison presented here is developed on the basis of where things stood in the United States in 1970.

The objective is not so much to develop a time-line statistical profile of how various sectors of economic activity, including whole countries and even regions of the world, have been pushed into an abyss over the past generation or so. Rather, by comparing key features of what are considered to be "industrialized" nations' economies with analogous such features of countries in the developing sector, the intention is to develop, for discussion, a working profile of investment requirements to change the course of the world economy as a whole. Not, at first pass, monetary requirements for investment, but rather physical investment, in capital improvements to the land, and quality of life.

The five countries selected for this, the first part in such a series, represent about one-half of the world's population of rather more than 5 billion, and probably about one-half of its currently developed productive industrial capacity. Germany, Japan, and the United States are, still, the core of the world's productive capacity—although that core is now threatened. China and India, with their vast populations, represent the potentials that will increasingly dominate the twenty-first century, if today's neo-malthusian genocidalists are stopped. Thus, among these five countries, are sharply posed the civilization-threatening crises which mankind will have to overcome in the years ahead.

People need water! It is the job of competent economic planning to ensure that adequate supplies of fresh, clean water are available for a growing world population. But today, our water infrastructure is increasingly antiquated and unreliable. Shown here are youngsters on New York City's Lower East Side.

This does not mean, by any kind of implication, that this series of articles will be developing country-by-country development programs. Such programs exist, and have existed for years, by continent, region, and also individual country, especially in the "Great Project" orientation associated with the jailed physical economist Lyndon LaRouche. Since the mid-1970s, when LaRouche first proposed his international credit reorganization in the name of the International Development Bank, he has sponsored the elaboration of 14 continental and subcontinental-level grand-scale packages for international development.

LaRouche's Great Project approach has thus far shared the fate of Dr. Sun Yat-sen's post-World War I policy for the development of China, and for the same reasons. The proposals Sun Yat-sen elaborated during the 1920s were not a program for China, in and of itself, but rather designs for the reorganization of the entire world economy, based on saving the industrial capabilities which had been built up to fight the war, for the higher purpose of developing the peace. The modernization of colonial nations such as China was the desired by-product of the world reorganization thus conceived. LaRouche's Great Project approach also requires overturning the global policy which insists that such concerns are not to be entertained, no matter what the cost in human life and suffering.

What we are looking for, out of the elaboration of the material to be presented in this series, is an aid to the construction of a physical function which will permit the assessment of what economic growth rates will have to be achieved in which regions of the world, and how, if the world economy as a whole is to be put on the path of real recovery, and then growth. The material to be presented won't provide any such a function, in and of itself, but in encouraging thought about the similarities, as well as the differences, between different regions of the world, and different levels of economic development, it will show up, as the publication of the series progresses, statistically, as an ordered array of step functions. Such an ordering ought to reflect the existence of the unifying pathway of transformation, along which mankind has moved itself forward and upward, against so-called "conditions" or "circumstances" which appear to be fixed and unchanging, except to the extent they get worse.

The requirements for such a physical function have been elaborated, over the course of many years, by Lyndon LaRouche, in his modern development of the tradition of physical economy associated with Gottfried Leibniz, Alexander Hamilton, and Friedrich List. He proved anew that man, set over the lower beasts, is not the subject of any fixed state of affairs, but through the self-improving power of creative reason is capable of emulating the divine. LaRouche proves the uniqueness of mankind from the history of the species, in its advance from the baboon-like potentials of the anthropologists' hunting and gathering mode of some 10 million people worldwide, to the roughly 5 billion souls who inhabit the planet today.

Ideas, transformed through technology into assimilated changes in the organization of human activity, consequently reducing the land area necessary to sustain human existence by increasing the power of human labor, are the driver of LaRouche's conception of human history as a self-ordered series of transformations resulting from willfully generated increases in mankind's potential relative population density. Such a function of increase, the product of the human mind's creative capacity for self-improvement, will not ever be developed out of statistical series. That would be to assume that the living somehow arises from the dead. At best, counting things, and ordering arrays of counted objects after they have become countable, can be indicative of the process by which such counted things came into existence, to the extent that the mind is encouraged to think about what is involved. In the same way, a pile of dead bodies would be effective indicators of the necessary existence of some preceding state of affairs, to a living being of investigative bent.

The data we are forced to use

This ought to function as a caution, and as an answer to those who will want to know, "How do we know your statistics are any good?" They aren't, because they can't be, but they can still be a useful tool. The data employed here have been collected from a variety of sources—international agencies such as the United Nations, International Energy Agency, International Road Federation, U.N. Food and Agriculture Organization, International Labor Organization, Unesco, among others; the national agencies of the countries

The LaRouche plan: 'great projects'

Over the past 20 years, economist Lyndon LaRouche has promoted a "great projects" development approach for national economic growth on all continents. Since 1976, when he first put himself forward as a candidate for President of the United States, LaRouche has stressed that the only way for the United States to make its way out of deepening economic depression, is to "build itself out"—to once again begin investing in great projects of infrastructure, both at home and abroad. LaRouche and his collaborators have devised infrastructure programs ranging from continent-wide networks of railroads, industrial centers run by nuclear power, and waterways, to the construction of new, modern canal links between the great oceans of the world.

The "great projects" approach is the most efficient way to improve and expand an economy, in many cases taking totally useless land and transforming it into productive territory, as was done by the irrigation of California's Imperial Valley.

These improvements are essential in order to maintain a world population of more than 6 billion persons, growing to 12 billion around the middle of the twenty-first century. They will serve as the basis for transforming and uplifting the economy, making it possible for a growing population to live at standards as high or higher than those in the United States during the decade that the Apollo Project to put man on the Moon was pumping wealth into the U.S. economy. The next step will be the colonization of the Moon, Mars, and beyond. Most important, the great projects will inject optimism and a vision of progress into a world now dominated by the cultural and scientific pessimism of the environmental hoaxsters.

The 'Oasis Plan'

An example of this approach is the "Oasis Plan" for developing the vast arid lands of the Middle East and North Africa, as indicated in an Aug. 21, 1990 policy paper by LaRouche, "A Peace Plan in the True Interest of Arabs and Israelis."

Speaking out in opposition to the Bush administration's drive for war against Iraq, LaRouche attacked the notion that "political settlements" of differences come first, and then maybe economic development will follow. "We have repeatedly said, and rightly so, that that line of argument is wrong, and even dangerously absurd. The simple reason is, that without a policy of economic development, the Arabs and Israelis have no common basis for political agreement; no common interest."

LaRouche stressed that a combination of "geographic engineering," such as running canals from the Mediterranean Sea and the Red Sea to the Dead Sea, could create water courses and be combined with nuclear-powered desalination, to provide water, power, and transport for industrial and agricultural growth. These projects, along with nuclear-powered desalination plants at other strategic sites in the arid North African-East Mediterranean region, could create man-made rivers and oases in the desert.

"We could define the proper approach to development of the Middle East, if no persons lived there presently, as if, for example, we were planning the settling of Mars: an uninhabited planet, by aid of artificial environment, and so forth." The provision and distribution of water and power must be organized to develop the average square kilometer of land to be productive at needed levels for different types of land use—pastoral, crop, residential, industrial, and commercial.

TABLE 1
Some indicators 1970

Country	U.S.	Germany	India	Japan	China
Population density	22	245	170	279	85
1,000 kwh per capita	3.7	2.1	0.06	2.5	0.013
Urban population	73.6%	81.3%	19.8%	71.2%	17.4%
Manufacturing operatives	14%	23%	12.5%	30%	8.2%
Agriculture labor force	4.1%	7.5%	74.9%	16.5%	80.8%
Tons food per capita	2.9	2.6	0.8	0.8	0.5
Life expectancy at birth	71.3	70.6	48.4	73.3	59.1
People per doctor	636	575	4,870	887	3,814
People per hospital bed	130	90	1,653	105	763
Pupils per teacher	21.8	19.2	36.5	21.9	37.6

included, other government departments, and private agencies, such as the Conference of Building Officials and Code Administrators—and have been supplemented in discussions with people from the countries included.

Fundamentally flawed, such data can also be corrupt, whether through error or design. Governments, like those the United States has had in recent years, like to make themselves look good, better even than their predecessors, if they can get away with it. The errors which corrupt the data are of two sorts, and misreporting is not the most significant of them. Here, we are dealing with relationships among population, land use, water management and supply, transportation facilities and use, power generation and disposition, employment, and selected categories of output: agricultural production and food, and outputs of various industries. These relations are subsumed by a causal ordering relative to the technological mode employed.

Such data are, more or less, collected by governments, and a stream of selected data is passed on to the international agencies, but with few exceptions, neither the collection, nor the pass-through, is coherent with any effort to compile indicators that would reflect any of the cause-and-effect relations which indicate what distinguishes mankind from the lower beasts.

Basic economic indicators

The basic sets of data thus provided include, among other things, population density—that is, numbers of people per square kilometer (km^2) of territorial surface, energy or electricity, percent of population urbanized, agricultural labor force as a percent of total labor, and food production per capita. **Table 1** sets out what such data looked like in 1970 for the countries which are the subject of this piece. Water availability and use, and transportation, are never included in such data. Nor is any attempt ever made to represent the output of society's productive activity—except in terms of monetary accounting measures, like the notoriously flawed Gross National Product indicator.

Differences between the three industrial countries and India and China are quite clear. Germany, with 2.1 thousand kilowatt-hours (kwh) per capita, has 35 times more than India and 161 times more than China does. The United States, employing one-eighteenth the agricultural labor India does, and one-twentieth that of China, produces respectively 3.6 and 5.8 times more food per person. The lower agricultural productivity is reflected in the different percentages of the total population which are supported in the cities. Food for the cities is produced on top of what the agricultural population itself consumes. As the life expectancy figures show, human life in these countries is not equal, and the differences in social investment reflect this. In 1970, an Indian lifetime, as opposed to a life, was 68% of the average American's; in China, the figure was 82%.

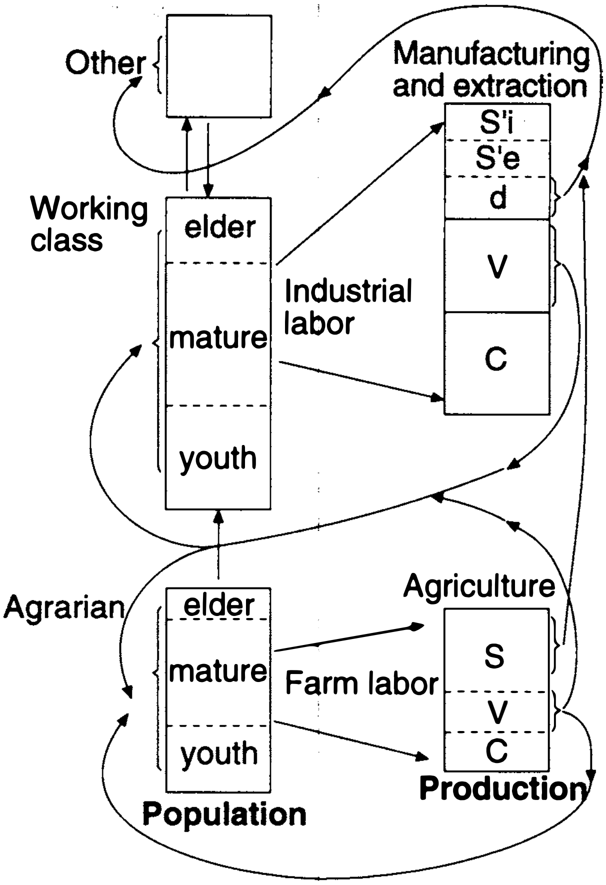
But, these types of series are also misleading for a variety of reasons. 1) Since lives are not equal with respect to lifetimes, population density as such, counting numbers of people, is not so useful; look instead at lifetimes per square kilometer. 2) People do not exist as discrete countable individuals, in the way the statisticians represent. Human life is organized through the household, which produces a new generation, supports those who work, and, in principle, also cares for the aged. People work and produce, more or less, sustenance for themselves, and the non-working population, as organized through the family household. 3) The land is not a uniform element. There are different classes of land, which are put to different uses. Some is not adequate for human habitation or cultivation at all—deserts, swamps, and mountains for example. The inhabited and cultivated portion of the land area is improved, in different ways, to be employed for different purposes. Therefore, one also has to take into account productivities per unit area, as well as per capita, or better, per household.

The household, and the workplace, whether in industry or agriculture, are built on an area of land improved for the purpose, through provision of power supplies, water, drainage and sewerage facilities, and access to the transportation network which ties the immediate locale more or less tightly into the national and world economy, so that what has been produced in one place might be consumed somewhere else. It might be conceivable to think of such a schema as a kind of closed cycle, in which households produce labor, labor produces and distributes goods, and life appears to go on (**Figure 1**). Total output of such goods, at least those put into circulation, can be approximated by the country's reported total freight bill, and industrial output approximated by subtracting food and fuels from the total. The table can now be redone, bearing these qualifiers in mind (see **Table 2**).

The reproduction rate is the ratio of females who are born

FIGURE 1

The total economy



This schematic of the total economy shows population on the left and physical production on the right, with the connection shown in terms of the industrial and agriculture labor force "produced" by the households that in turn need to utilize output in order to continue to "produce" the labor force. .

The physical goods output of the economy, shown on the right, is analyzed as follows: Symbol V *refers to the total physical goods output required by households of operatives engaged in physical production. Symbol* C *refers to the capital goods consumed by production of physical goods, including the costs of basic economic infrastructure required. Symbol* d *is the total overhead expense. This includes consumer goods (of households associated with overhead expense categories of employment of the labor force), plus capital goods consumed by categories of overhead expense. Symbol* S′ *refers to the net operating profit or "free energy" of the economy. It is the result of* $S-d$*. (Subdivisions of* S′ *are shown by* i *and* e*.)*

The "Other" segment on the top left refers to physical product going to a component of the economy that is not involved directly in physical production, but which may be necessary—such as science and technology research and applications. Or it may be unnecessary and undesirable overhead expense that drags the economy down—bureacracy and "post-industrial" activity.

Some of the relationships thus indicated are: productivity: $S/C+V$*; capital intensivity:* C/V*; rate of profit:* $S'/C+V$*; expense ratio:* $D/C+V$.

Source: Basic Economics for Conservative Democrats, *by Lyndon H. LaRouche (1980).*

and survive to have children in their turn, to female births. Bearing in mind that life expectancy also increases, the ratio indicates whether or not the female population is reproducing itself. Compare the reported births per fertile female, with the values reported for output, and per worker productivities in this and the former table, and the conclusion is obvious. Higher birth rates and lower life expectancies go with lower output from industry and agriculture, and, as indicated by the data for electricity supply and transportation and area, with less improvements to the land.

Looking at improvements in land

The matter of improvements to the land is brought into sharper focus by considering the differences between the data reported for the United States, Germany, and Japan in the first table, and that in the second. The crude measure of population density changes significantly in respect to Japan, which uses less of its territory than either the United States or Germany. Where Germany and Japan were comparable with respect to the U.S. before, Germany remains with more than 10 times the population density of the United States, but Japan now has 26 times.

The electricity per capita figures showed the United States with 1.7 times the German figure and 1.5 times the Japanese. The per unit area figures show something different: Germany now has 4.4 times the U.S. level of use, and Japan 13 times more. Agricultural output per unit area is also interesting: With 1.8 times the labor force employed in agriculture, German farmers produce 6.2 times more per unit area than Americans, while Japanese farmers, with 4 times the proportion of labor so employed, produce 4.3 times the per area output.

Two related features deserve closer inspection. The first concerns the relationship between the per household values and the per area values. The second, since population, organized in households, is not distributed across the countryside in orderly statistical rows and columns, involves the physical and geographical parameters associated with the question of land use, and thus population settlement.

We noted that Germany uses one-tenth the land for the

Boost yields with new methods of agriculture

Fabulous plant yields are possible by use of energy-intensive agriculture in controlled environments. Non-soil-based methods include hydroponic systems, where the plants are grown in a liquid nutrient medium; and aeroponics, where the plant roots are in the open and periodically sprayed with a nutrient solution.

Variations of these non-soil-based technologies for use in space are sometimes called astroponics. Many improvements in technique have come about from scientists working on the problem of growing food in space, where the entire biosphere for plants will have to be created and controlled by man. NASA's research program into the controlled-environment life support systems is referred to as CELSS.

The accompanying table shows the comparative yields of wheat crops in controlled environments that were achieved by two NASA researchers in Utah, Frank B. Salisbury and Bruce G. Bugbee, in tests run during the 1980s. During one of their tests, they achieved the dramatic output of 4,760 grams per square meter of edible dry wheat biomass, in contrast to 500 grams per square meter, which is a good average yield for an open wheat field; or in contrast to the 1,053 to 1,450 grams per square meter achieved under other CELSS tests.

The results depend on the right combination of irradiance levels, number of hours of daylight, number of wheat plants per square meter, temperature, use of the right plant cultivar, ample water and carbon dioxide, and provision of all the basic elements that plants require, in the right relative quantities in a well-aerated nutrient solution. Under these conditions, a yield of about 50 grams per meter per day of wheat crop allows a "space farm" as small as 15 square meters per person.

High yields of wheat crops in controlled environments

Experiment	Days to harvest	Edible dry biomass g/m^2	Average growth rate (edible biomass) $g/m^2/day$
High average field	120	500	4.2
World record	140	1,450	10.4
CELSS:			
Soviet "Bios"*	60	1,314	21.9
Utah State University**	79	4,760	60.3

* Soviet simulated spaceship farm in Krasnoyarsk, Siberia
** Utah State University 1987 result by researchers Bugbee and Salisbury.
Source: *21st Century Science & Technology,* March-April, 1988.

Energy and water

CELSS research has found that light is the ultimate limiting factor for yield. Busbee and Salisbury reported in 1988, "Plants can't produce more chemical-bond energy in food than they absorb from the light that irradiates them—and, since they will never be 100% efficient, they will convert only some fraction of that absorbed energy to food." Their research shows that for maximum CELSS wheat yield, light input is required at an irradiance level of 2,000 micromoles/m^2/sec for a 20-hour period, for 79 days, with additional energy input required to maintain the crop plot at a 20°C/15°C day/night temperature.

Once the conditions are all met for the plant in question, Busbee and Salisbury stress that the "harvested end-products contain not only the mineral elements that were provided in the nutrient solutions, but also the carbohydrates, fats, proteins, and vitamins that are needed by the humans who will consume them. No plant grown in a rich, organic soil provides more nutrients required by humans than a plant grown hydroponically."

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same number of households as the United States does, and Japan one-twenty-sixth. Thus, Germany's household density is 10 times that of the United States, and Japan's 26 times. We also saw that Japan consumes approximately one-half the kilowatt-hours per household the U.S. does, but 13 times more in per area terms. This takes us further.

There is an inverse relationship between the per household and per area ways of treating data, which is a function of population density. Higher population densities permit a concentration of per area resources which offset lower per capita supplies.

This points to the idiocy of those who look simply at the per capita values put into circulation by the international agencies, or anyone else, to say, for example, "Look how much better the U.S. is doing than either Japan or Germany. We have a much higher per capita energy consumption." The reality is more complicated. The United States has a higher per capita consumption, precisely because its land area has not been subject to the same depth of improvements effected in the case of Germany over more than 1,000 years. The per unit area measure is one reflection of the level of infrastructural improvement to the land, which permits more people to be supported per unit area, at comparable standards of living, for lower costs per physical unit of capital improvement.

TABLE 2

1970 indicators re-stated

Country	U.S.	Germany	India	Japan	China
Lifetimes per unit area (km^2)	22	242.5	115	286	70
People per household	3.2	2.9	5.1	3.9	4.8
Used area/1,000 households	72.7	6.8	15.5	2.8	23.9
1,000 kwh/1,000 households	24,079	10,245	462	13,061	632
1,000 kwh/used area	355.7	1,562	30.4	4,631	26.3
Tons food/crop area	345	2,167	323	1,505	383
Freight tons/household	82	129	2.6	195	8.5
Output/operative (tons)	363	437	7.3	312	38.8
Million m^3 water/1,000 households	7.6	1.3	3.3	3.2	2.1
1,000 ton-km/1,000 households	47,380	10,058	1,768	13,279	2,513
Births/fertile female	0.06	0.05	0.16	0.07	0.15
Reproduction rate	0.9708	0.962	0.68	0.976	0.854

TABLE 3

Water availability and withdrawals

(million m^3/km^2)

Country	U.S.	Germany	India	Japan	China
Water available: total area	0.18	0.32	0.56	1.46	0.28
Water withdrawn: used area	0.11	0.19	0.22	1.07	0.11
Withdrawals: % water available	30.8%	37.3%	20.5%	15.1%	17.2%

This is emphasized by the different figures for agricultural yields in Germany and Japan, compared to the United States. Higher yields per unit area reflect a higher density of infrastructure, which cheapens the economic cost of both food production and distribution. You don't have to go so far from the city to bring the food to market; fresher produce and more seasonal variety are benefits that follow. The cost of delivering the manufactured products the farmer requires—machinery, fertilizer—is also less. The farmer can do more.

Pick up Henry Carey's essays "Past, Present, and Future," or Friedrich List's *The National System of Political Economy,* from more than 100 years ago, and you will see that the principles involved were quite clear then. In the meantime, they have been pushed aside, not because they are wrong, but because the neo-malthusians, and the butchers at the International Monetary Fund who opposed LaRouche's Great Projects approach, don't agree.

Such considerations serve as part of the proof that what was posited as a closed cycle above, is no such thing. Henry Carey might have called it instead his law of increasing returns. He posited correctly that if society is organized to restore to nature what it takes out through the work of farmers and miners and others, by improving the land—through clearances, drainage, building up the qualities of the soil, taming rivers for transport, building railroads—nature will return more than the labor invested in the form of the improvements, because the process of continual improvement is not simply additive in its cumulative effects. In LaRouche's more elaborated view, such a process of improvement is called the increasing negentropy of the system, and reflects the underlying coherence between the thinking processes which guide successful human practice, and the lawful ordering of the physical universe as a whole.

The supply of water, power, and transportation are technologically determined; so too are the educational and cultural skills of the work force and household.

Technological advance changes the characteristics associated with infrastructure, labor force, and households, to permit more efficient cultivation and usage of land, by more people, under improved conditions of life. The cycle of action is thus not closed, but open-ended, as a society, organized through the household, acts on itself, and the land it inhabits, to improve itself.

The role of climate and topography

Settlement patterns, and therefore also land use and improvement, are shaped by man intervening against a given topography and climate. The spread of man's activity, over centuries, has been channeled by river valleys and drainage basins, in one way, and by inhospitable mountain ranges, deserts, and swamps in another. Climate and the availability of water, including for transportation, have also played their part in channeling mankind's onward flow.

The maps accompanying this section identify the principal river basins, areas of crop production and human settlement, and water availability in each of the five countries.

Table 3 shows water availability: that is, the difference between what is precipitated in the form of rain or snow—and either evaporates back into the clouds, or runs off, ultimately, into the ocean—and overall withdrawals of water from that cycle. Withdrawals of water do not indicate that the water is "used," in the sense of evaporated. Most of the water withdrawn re-enters the cycle. In U.S. practice, 12 inches of rainfall annually, or 30 centimeters, is considered to be the cutoff point below which rain-fed agriculture is not viable. Germany, India, and Japan appear to have that level of water availability if the whole territory is considered; the United States does not, and China is on the borderline. But of course,

FIGURE 2

India: wide variation in water resources

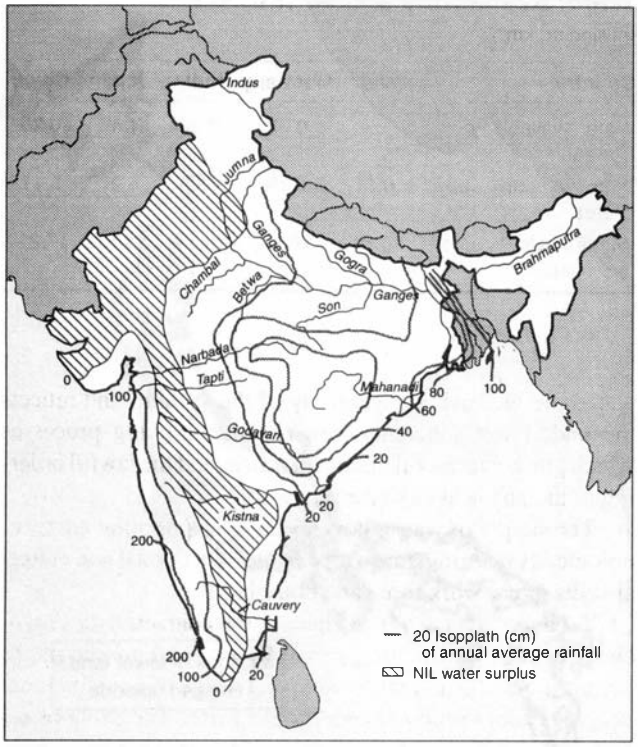
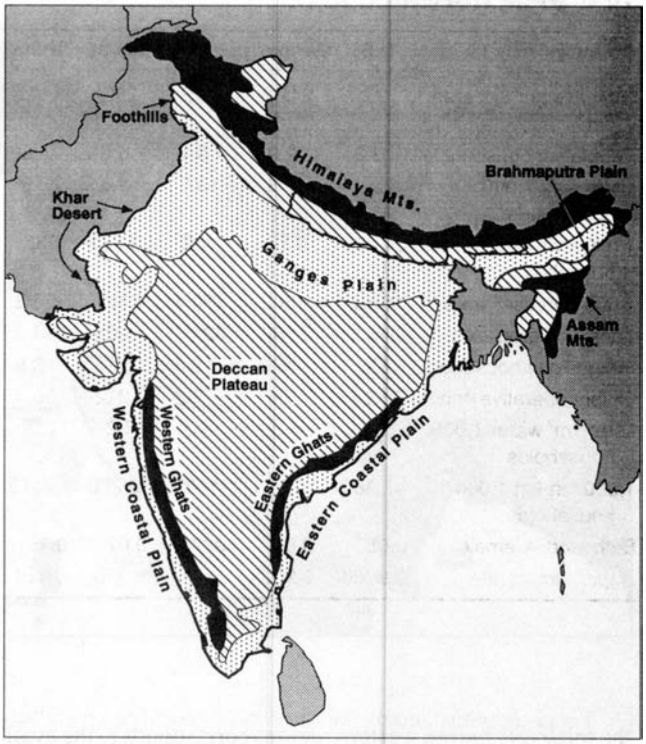


FIGURE 3

India's land forms



regional differences within the countries change the picture.

The difference between the availability of water and the reported withdrawals, shows that water might be available, but not at the right time or the right place, and not in a form in which it can be used for human activity.

India, with about one-third the area of the United States, roughly the area east of the Mississippi, is divided into three principal topographical regions (**Figures 2** and **3**): the mountainous Himalayan north; the Indo-Gangetic Plain, about 770,000 square kilometers in area, the largest alluvial plain in the world, with alluvium deposited to a depth of 6,000 feet; and south of the Narmada River and the Vindhya mountains, the Deccan Plateau, bounded by the Ghats Mountains, on east and west, inland of relatively narrow coastal strips. Population and cultivation are concentrated in the Ganges Plain, adjacent eastern areas, and on the coastal strips. There is an arid, drought-affected belt running from the Khar Desert in the northwest, down the entire length of the Deccan peninsula. The rivers of the Deccan primarily flow from their sources in the western mountains toward the ocean in the east.

With over half a million cubic meters (m^3) of water ostensibly available for each square kilometer of the country, i.e., 50 centimeters of water per square kilometer, India seems richly endowed with water resources. Yet, those of her rivers which flow from the Himalayas into the Gangetic Plain are snow-fed, and therefore seasonal. In the Deccan Plateau, the monsoonal climate ensures that 80% of the annual precipitation will fall during a mere four months, or less, of the year. For that brief period, dry river beds expand over the country to carry flood waters away to the oceans. Lands baked for three-quarters of the year do not absorb the runoff produced as the seasons change.

China, comparable in area to the United States, can be crudely divided into four areas (**Figure 4**). The western half of the country, which is made up of an arid northern quarter, with the Tibetan highlands to the south, contains about 10% of the total population. The eastern half, characterized by monsoon weather systems, is divided roughly along the line of the Huang He River into a northern and southern part. The eastern part of the country comprises 96% of the cultivated land, and produces 98% of the agricultural output. The eastern part is separated from the west by mountains, and the Ordos Desert. The area south of the Huang He accounts for about two-thirds of the cultivated area, and the area to the north for one-third. The area between the Huang He and the Chang Jiang (Yang-tze) sees the greatest concentration of all, for the Chang Jiang River basin is separated from the Pearl River (Si) basin of the south systems by a mountainous belt. In the south, the coastal strip is the most densely populated and cultivated.

The division between populated and cultivated east and

FIGURE 4
China: four major economic regions, and large rivers

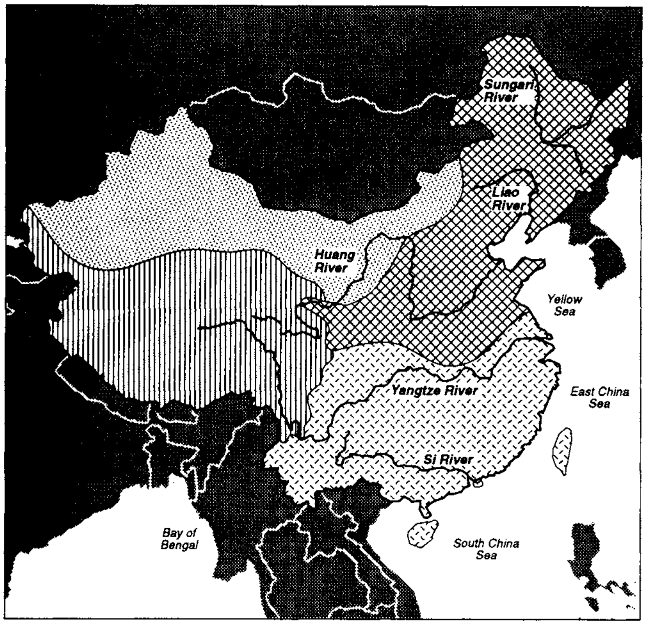
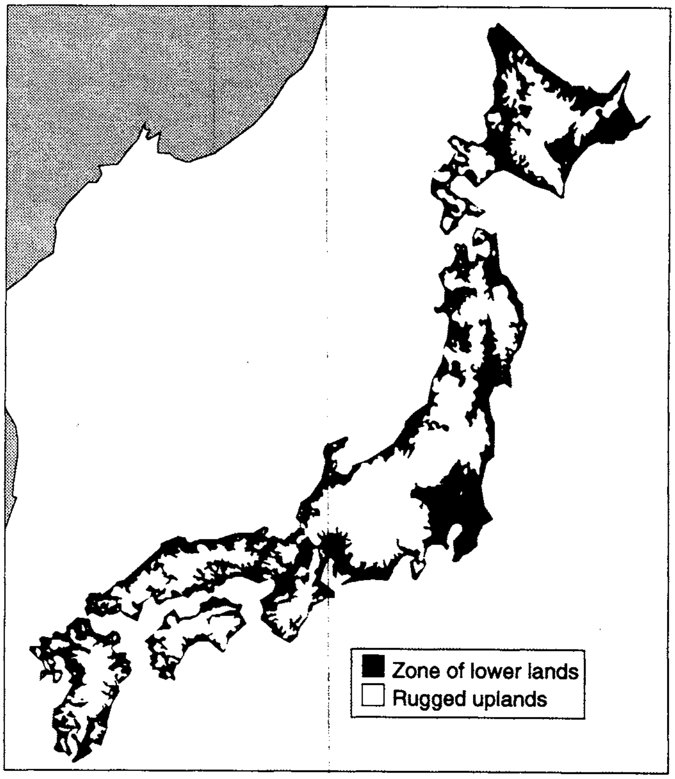


FIGURE 5
Japan's land forms



the relatively barren western regions corresponds to the availability of water. The sparsely populated, relatively uncultivated western half of the country has only 15% of the water available in the form of runoff, with the arid northern part of the west comprising 5% of the total, and the Tibetan highland region 10%. The monsoon seasonal east, draining into the Pacific Ocean, accounts for 85% of the runoff.

Japan, a mountainous archipelago (**Figure 5**), about 2,600 kilometers in length, and not much more than 200 km in width at its widest point, straddles the same latitudes as the eastern seaboard of the United States, from Maine's northern border with Canada down to Jacksonville, Florida. Only one-quarter of the largest island, Honshu, has a slope of less than 15°, and only half of this area is counted as lowland proper. Mountains restrict the spread of settlement inland, while the coasts exercise similar restraint. The coastal waters, Inland Sea, and the oceans are determining for Japan, so, for example, the Inland Sea functions as one of the country's principal routes for the internal transport of freight.

Germany (**Figure 6**) has about the same area as Pennsylvania or Oregon. Topographically, the country divides into three regions from the south to the north, a zone above 500 meters, of high uplands preceding the Alps mountains, a belt of low uplands between 200 and 500 meters above sea level, and below 200 meters, the lowland plain of northern Europe, bordered by the North Sea and the Baltic. Northwesterly trending rivers, like the Rhine, Weser, and Elbe, drain from the uplands, along with the southwesterly flowing Danube, shaping the spread of cultivation around the low uplands zone. Centers of population and cultivation are concentrated around the river-bordered low uplands.

The United States (**Figures 7-9**) is divided into six main topographical regions, each running in a north-south direction. From east to west, they are: 1) the Atlantic coastal plain, from the coast to the fall-line of the eastern rivers; Montgomery, Macon, Columbia, Raleigh, Richmond, Baltimore, Trenton, and Hartford are the inland border of this zone; 2) the Appalachian Mountains, 480,000 square kilometers; 3) the middle plains and Great Lakes, basically the drainage basin of the Ohio and Mississippi rivers, which run from western Appalachia to the 100th meridian; 4) the arid high plains; 5) the Rocky Mountains, water-rich in the north, arid in the south; and 6) the Pacific Slope. Major centers of population are concentrated along the northern part of the eastern seaboard, and along the Great Lakes and Ohio River Valley, where water is abundant and the climate temperate.

The maps should be consulted with reference to **Tables 4** and **5**, which quantify land usage by type in two different ways. In Table 4, land use, by type, is presented per 1,000 households. Table 5 expresses land use by type as a ratio to urban residential land use. The first thus shows different areas reportedly used to support 1,000 families; the second

FIGURE 6

Germany: topography and rivers

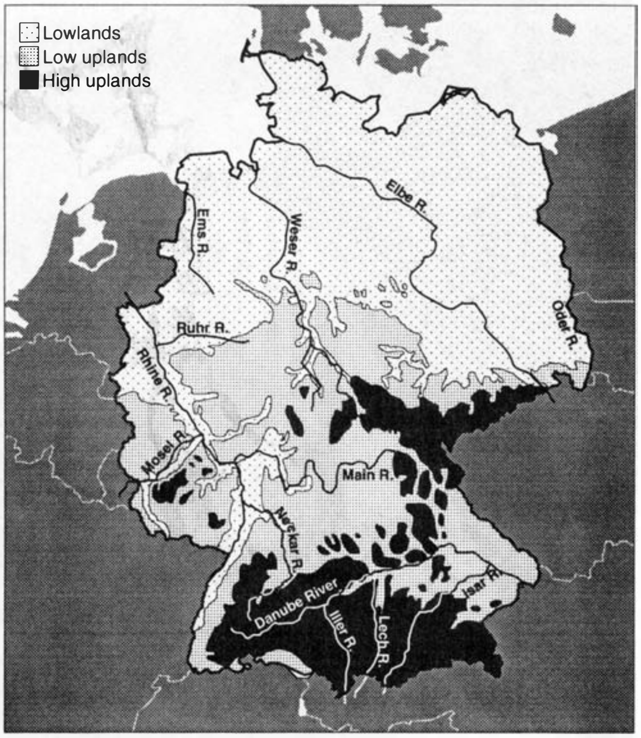
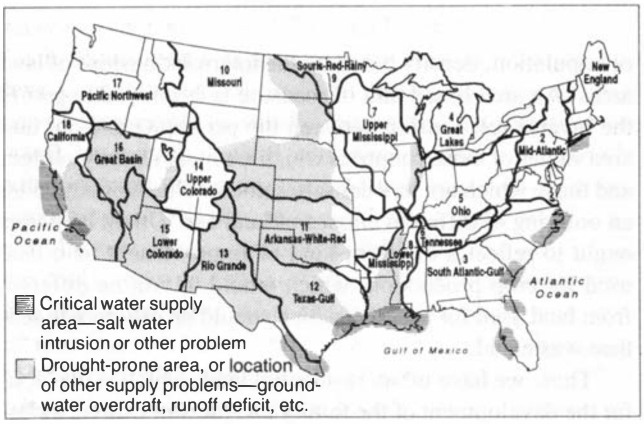


FIGURE 7

United States: 18 hydrologic regions, and areas of water supply problems



restates the same data from the standpoint of relations among the land uses themselves. Forest resources constitute the major use not included here. Forest resources are used, do have roads or trails, but it has not been possible to develop that kind of profile. The total U.S. forest area was 46 square kilometers per 1,000 households in 1970.

For purposes of comparison, **Table 6** shows area esti-

FIGURE 8

United States: annual precipitation

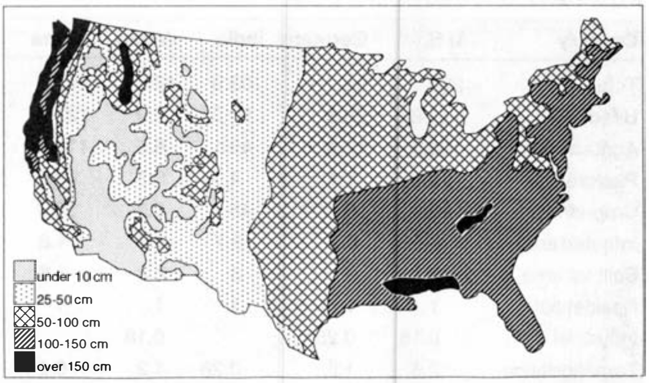


FIGURE 9

United States: major urban residential areas

TABLE 4

Land area per 1,000 households

(km²)

Country	U.S.	Germany	India	Japan	China
Total	147	11.2	30.1	13.6	54.3
Used	72.7	6.75	15.5	2.8	23.9
Agricultural	68.5	5.6	14.1	2.1	23
Pasture	38.5	2.2	1.1	0.1	16.1
Crop-land	30	3.4	13	2	6.9
Irrigated area	3.9	0.1	2.6	1.24	2.9
Built-up area	2	1	0.88	0.75	0.65
Residential	0.6	0.32	0.29	0.33	0.19
Industrial	0.09	0.08		0.06	
Transportation	1.6	0.47	0.06	0.38	0.04

TABLE 5

Area per km^2 urban residential land

Country	U.S.	Germany	India	Japan	China
Total	229	34	103.9	42.8	277.9
Used	112.8	20.5	52.5	8.9	122.9
Agricultural	106.3	17.3	49.1	6.5	118.5
Pasture	59.7	7.1	4.1	0.3	82.9
Crop-land	46.6	10.2	45	6.2	35.6
Irrigated area	6.0	0.3	8.7	3.8	14.8
Built-up area	3.1	3	3	2.2	3.6
Residential	1	1	1	1	1
Industrial	0.16	0.25		0.18	
Transportation	2.6	1.5	0.26	1.2	0.2

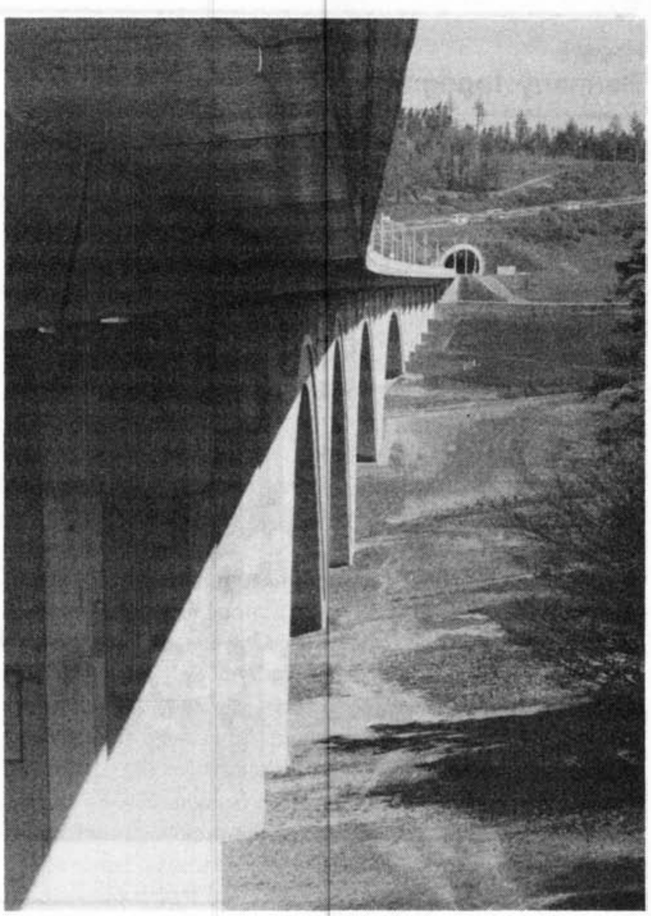
TABLE 6

Some U.S. comparisons: builders' and planners' estimates

(per km^2 residential area)

	Km^2 residential area/1,000 households	House-holds	People	Km^2 industrial area
RAND Corp.	0.764	1,307	4,184	0.58
Lancaster, Pa.	1.166	857	2,743	
Conf. of Building Officials	1.29	771	2,469	2.5
Bartholomew central city	0.114	8,752	27,433	0.49
Bartholomew satellite	0.155	6,429	20,875	0.57
Bartholomew "urban" area	0.18	5,511	17,635	0.6

mates employed by U.S. planning agencies and building associations in the 1950s and '60s. The RAND Corp. estimates were employed by that agency in the early 1960s. The entries for Lancaster, Pennsylvania were used in planning the city's expansion in the 1960s. The entry marked Conference of Building Officials shows the guidelines employed by the agency which coordinates Building Officials and Code Administrators, around 1970. The entries marked "Bartholomew" are from a study of land-use patterns in U.S. cities produced by Harland Bartholomew and published in 1955. The last three reflect an earlier state of affairs, when American cities were real cities, and not bombed-out focal points for escaping suburban sprawl.



High-speed railroad under construction between the German cities of Hanover and Würzburg. Rail transport is the best mode for rapid movement of goods.

There is a reason for adopting a measure of household, or population, density based on the interrelationships of land areas. An area-based unit of measure is employed to permit the inverse relationship between the per capita and per unit area values of those countries which are more densely settled, and those which are less densely settled, to be unified, under an ordering of different classes of land use. Urban land uses ought to reflect a different kind of improvement than land used for crop production, which would in turn be different from land used for pasture, which should be different in turn than wasteland.

Thus, we have urban residential land, which is the locus for the development of the family and the work force; industrial areas, apportioned to each square kilometer of residential land; crop and pasture land, out of which the agricultural population produces food for the urban population; and land for transportation uses, which represents the network for the movement of goods and people which unifies the whole.

The reported classes of areas are grossly defined, such that the use identified could be considered the major use. "Residential" areas include other uses besides living arrange-

TABLE 7

People, households, and urban residential area, 1970

Country	U.S.	Germany	India	Japan	China
People per household	3.2	2.7	5.1	3.9	4.8
Households/km^2	1,549.6	3,019.8	3,384.7	3,078.9	5,119.2
People/km^2	5,011.6	8,337.2	17,532.7	11,962.7	23,650.7
Lifetimes	5,011.6	8,253.4	11,829.5	12,299.1	19,909.6
Births/km^2	81.4	100.3	690.9	229.7	819.7
Deaths/km^2	47.3	100.9	288.9	78.9	252.3

ments as such—schools, shopping areas, and community facilities among them. It is the same with "industrial" areas, where figures are available. Built-up area is not the sum of residential, industrial, and transportation uses. The transportation uses reflect inter-city networks as well as urban roads and railways. Built-up area includes parks, lakes, and water surface, and land which is not in use, or waste. The generality reflects the fact that data is not collected for the purpose of identifying specific such uses with precision.

Thus, the areas so defined do not precisely conform to the areas on which water, electricity, and fuel are used, or output produced. Water, electricity, and fuel for household use are, for the most part, used in the house. The residential area will be larger than the area over which the electricity, water, and fuel are concentrated. Reported industrial electricity and power usage includes consumption for lighting and space conditioning, as well as for manufacturing processes. In the same way, the area on which a farm and adjacent buildings, which use power and electricity, sit, is very different than the crop area farmed.

Transportation, shown as an area measure, will be considered below in terms of network length in relation to different area usages. When built, after all, a road or railway is an area of land which is taken from a prior use, such as crop or pasture land, and transformed for highway or railroad usage. For these purposes, the American Railroad Association considers that the freight capacity of one double-tracked railroad line is the equivalent of sixteen 12-foot-wide highway lanes. The railroad requires a right-of-way of 50 feet or 15.2 meters, the highway 400 feet or 122 meters.

The number of people who occupy households on each of the reported square kilometers of urban residential land is shown in **Table 7.**

We can now begin to correlate population density and land use with the different aspects of basic economic infrastructure—water supply and distribution, transportation, and power supply.

TABLE 8

U.S. water usage standards

(million m^3/year)

	Per person	Per 1,000 households	Per urban residential km^2 public use*
Public use: municipal*		0.54	0.86
Residential: single	0.0001	0.32	0.50116
Residential: multi	0.00008		
Public use**	0.000039	0.124	0.195
Schools	0.00009	0.068	0.113
Hospitals/bed	0.0008	0.018	0.031
Factories: sanitary	0.00002	0.0035	0.0058
Manufacturing/employee	0.005	0.879	1.465
Agriculture: irrigation/km^2	0.69	2.7	4.5
Commercial/hectare	0.0016	0.012	0.02
Electrical generation/kwh	0.00015	3.6	6
Total		7.78	12.8

*The sum of residential, public use, schools, hospitals and commercial.
**For street cleaning, fire department services, and so forth.

Water usage standards

Table 8 is a tabulation of standards for water consumption applied in the United States during the early 1970s. With the exception of agriculture and electricity generation, they were taken from guidelines issued by the U.S. Conference of Building Officials and Code Administrators, an agency which coordinates zoning requirements and construction codes across the country, and the publications of the Urban Land Institute, and reviewed in light of reports from the U.S. Geological Survey and the U.S. Department of Agriculture. They are converted from U.S. gallons per day to a metric measure on an annual basis.

These kinds of standards ought to be used with some caution in assessing what is reported below about comparable water use in the other countries. One reason for such caution is that the standards do not precisely correspond with reported use. Another is the preponderance of single-family homes in the United States, with relatively large lot sizes, because significantly less water is required to provide for multi-family dwellings, such as apartment buildings.

The water for electricity generation cooling is calculated from an engineering estimate employed by both the U.S. Geological Survey and Babcock and Wilcox company, of 50 kilowatt-hours (kwh) per liter of water evaporated in the cooling cycle. In 1970, the United States used the "once-through" cooling system for about 75% of its generating capacity. This is where cooling water is sucked out of a river or some other flowing body of water, put through the system, and then discharged back again. It is favored where water is in plentiful supply. Closed-cycle systems, involving wet or dry cooling towers, cooling ponds, lakes, or spray ponds, use 2-4% of the water employed in an open cycle "once-through" system. Or, they may not even use water at all. The water-based closed-cycle systems require more land than do the once-through systems, even though they use less water.

Agricultural requirements are simply what was used—water per irrigated area—in the United States. Use will depend on crops grown. California fruits and vegetables, and western cotton, are obviously very different than paddy rice production.

The industrial guideline is based on 3,000 gallons per day per manufacturing employee, the late 1960s construction standard for new manufacturing facilities. This, again, is a ballpark estimate. Water is used in industry for cooling thermal processes, for steam generation, as well as for processing, washing, and other sanitary purposes. Different types of products require different volumes of water, and different processes of making the same product require different volumes of water. A study sponsored by the American Waterworks Association prepared in the mid-1970s put the volume of water required per manufacturing employee at 12,600 gallons per day, more than four times the construction standard of the late-1960s. In the United States, Germany, and Japan, the chemical and iron and steel industries account for roughly half of industrial water consumption.

Lastly, the U.S. guidelines involve a 15-25% margin for system leaks and losses. The core water and sanitation systems of America's larger cities date from the end of the nineteenth century. That provision says something about the quality of a system which is approximately 100 years old (see **Tables 9** and **10**).

The overall situation is less complicated than all the provisos might make it appear. In India and China, 93% and 86%, respectively, of the water accounted for as withdrawn is used in irrigation for agriculture. Water use per irrigated

Energy and water for the future: the MHTGR

High-temperature gas-cooled reactors (HTGR) are an advanced form of nuclear fission reactor that originated as a spinoff of NASA's search for a nuclear propulsion system for manned missions to Mars in the 1960s, and prototype reactors have been operating for years at Fort St. Vrain, Colorado, and in the Federal Republic of Germany.

Modular reactors (MHTGRs) derive from the program of G.A. Technologies of San Diego, which has developed a standardized design for an HTGR module, able to produce 350 megawatts of thermal energy, which can be converted to about 140 MW of electricity. The General Atomics MHTGR has also been designed with a view to mass-producing the units, so that design, engineering, manufacturing, construction, and certification costs can be spread out over many units, making them much cheaper than previous nuclear power plants, which were each custom-designed and built from the ground up. This saving in capital costs, combined with the savings in fuel cost means, according to General Atomics estimates, that MHTGRs will be able to deliver electric power below the cost of a coal-fired power plant.

The MHTGR uses helium gas as a coolant, instead of water. Since helium gas is inert, and has very low neutron absorption charaterics, the MHTGR is top of the line in design safety. Pipes, valves, and other metal reactor parts will not react with helium, virtually eliminating corrosion. The inability of helium to absorb neutrons means it cannot become radioactive, so problems with embrittlement and possible fatigue-failure of metal parts are also eliminated. Moreover, since helium remains as a gas throughout the reactor cycle, there is no chance that the coolant will boil away; this also allows for visual television inspection of the inside of the reactor while in operation—something not possible during the steam phases of a water-cooled reactor.

MHTGRs for desalination

A unique advantage of high-temperature gas-cooled reactors is that their energy can be used as process heat or steam. Seventy percent of industry's energy needs are of this type. The advantage of MHTGRs, as the word modular implies, is their flexibility in siting. They can be placed where the heat energy or steam is to be used; designed not only for mass production, but also for ease of shipment.

For a thirsty world, MHTGRs could provide the thermal energy required for certain desalination processes. A study by the U.S. Department of Energy and the Metropolitan Water District of Southern California found that one single desalination plant, consisting of four 350 MW MHTGRs, could produce 106 million gallons of water per day, or 38.6 billion gallons per year. Thus, four such plants could meet the projected new water needs of Southern California, and provide 466 MW of electric power each as well.

As the study also pointed out, the only obstacle to immediately initiating a program of building desalination plants based on MHTGRs, is public acceptance of nuclear power waste disposal.

TABLE 9

Water availability and supply per 1,000 households

(million m^3/year)

Country	U.S.	Germany	India	Japan	China
Available	20.1	3.5	15.66	20.7	14.7
Withdrawn	7.6	1.3	3.3	3.2	2.1
Agriculture	2.7		3.1	1.8	1.8
Public use: municipal	0.5	0.13	0.11	0.17	0.13
Industrial	0.95	0.47	0.03	0.5	0.05
Electrical generation cooling	3.4	0.74	0.08	0.71	0.1

TABLE 10

Water availabilty and supply per km^2 urban residential land

(million m^3/year)

Country	U.S.	Germany	India	Japan	China
Available	33.5	10.8	54.1	62.7	77.7
Withdrawn	12.6	4	11.5	9.5	11.1
Agriculture	4.5		10.7	5.5	9.6
Public use: municipal	0.9	0.42	0.38	0.5	0.66
Industrial	1.6	1.5	0.11	1.5	0.24
Electrical generation cooling	5.7	2.3	0.3	2.2	0.54

area among the four countries which report it, was much closer than for electricity use or agricultural employment. For the United States, 0.75 million cubic meters per square kilometer; for India, 1.2; for Japan, 1.5; and for China, 0.65. For the latter two countries, that usage is untouchable. Without it, food production would collapse dramatically.

Water use and food production per 1,000 households on irrigated land would look as shown in **Table 11.**

TABLE 11

Water use and food production, per 1,000 households, on irrigated land

Country	U.S.	Germany	India	Japan	China
Irrigated crop	2,505	—	1,684	1,956	1,669
Tons/million m^3 water	927.7	—	543	1,086	927
Million m^3 water/tons	0.001	—	0.002	0.001	0.001
Million M^3 water/area	0.69	—	1.19	1.45	0.62

That leaves 7% and 14%, respectively, of withdrawals for all other uses in India and China. That is, there is absolutely no margin for improvement or expansion without dramatically increasing the ratio between water withdrawn and water available, reducing the volume of water deployed into agriculture, or employing some means of creating fresh water, such as employing the modular high-temperature gas-cooled nuclear reactor, which has been available since 1970 (see box on MHTGR and desalinization).

The "public use: municipal" figures which look, at first glance, quite close to Germany and Japan, are not so at all, given the different numbers of people involved. Expressed in U.S. gallons per day per person, we have 77 gallons for the Americans, 36 for the Germans, 15.6 for the Indians, 30 for the Japanese, and 20 for the Chinese. The U.S. figure is for all the uses catalogued above under "public use: municipal." Germany and Japan correspond to residential uses per se. China and India to the broader figure.

Usage estimates, based on those used in the old-style wars against poverty in the United States, were that an electrified house, not apartment, would require 60 gallons per person per day; a house without electricity or running water would generally have 10 gallons per person available. It used to be thought that each person would require one gallon per day for cooking and drinking, 19 gallons per day for hand and face washing and toilet flushing, and 15 gallons per day for one three-minute shower. Below 20 gallons per person per day then, is below the sanitary minimum.

Running water and sewer systems go together. If 20 gallons per person per day indicates absence of running water distribution systems overall, then it also indicates absence of sewer systems. If it indicates a water distribution system which cannot handle more than 20 gallons per person per day, then it also indicates a sewer system which cannot handle the effluent produced. Apart from the water used in the household, U.S. building code standards considered the output of 50-100 gallons of water per person to be necessary to make an urban sewerage system work.

Clean water and sanitation

What this means has been known for more than 100 years. Without provision of sufficient clean, fresh water and adequate sanitation, cities become breeding grounds for epidemic diseases, like cholera. Across Third World countries, half of the infant mortality can be attributed to diseases spread through contaminated water supplies or parasites, which would not exist if water and sewage treatment were adequate. Leaving aside the reservations about the U.S. building code standards, to have provided water for the 1970 urban population, at those standards, India's total withdrawals would have been 20% greater, and China's 29% greater. The "public use: municipal" category of withdrawal would have been 6.8

TABLE 12

Water at U.S. building code standards

(millions m^3/km^2 urban residential land)

Country	India	China
Public use: municipal	2.6	3.9
Residential	1.7	2.4
Public use	0.68	0.92
Schools	0.2	0.34
Hospitals	0.008	0.248

TABLE 13

Industrial water use: output and area

Country	U.S.	Germany	India	Japan	China
Tons output/ operative	363	437	7.3	312	38.8
Tons/million m^3 water	72,600	218,500	73,000	312,000	129,300
Million m^3 water/ton	0.00001	0.000005	0.00001	0.000003	0.00001
Million m^3/area	10	6	—	8.3	—

TABLE 14

Water use and electrical generation/1,000 households

Country	U.S.	Germany	India	Japan	China
Thermal: % capacity	0.82	0.88	0.54	0.8	0.66
Thermal: kwh	19,744	9,016	249	10,880	417
Kwh/million m^3 water	5,807	12,183	3,113	15,324	4,170
Million m^3 water/ kwh	0.00017	0.00008	0.0003	0.00007	0.0002

TABLE 15

Power supply: electrical

(000s kw and kwh/1,000 households)

Country	U.S.	Germany	India	Japan	China
Generating capacity	5,283	2,088	148	4,062	133
Kwh: total	24,079	10,245	462	13,601	632
Agriculture	688	250.8	4.4	4.5	84.6
Residences	7,275.6	2,139.2	36.9	3,076.6	32.2
Industry	11,013.6	5,723.6	323.1	9,990.8	491
Railroads	74.3	393.3	14.6	490.7	6.9
Other	5,028.7	1,740	83	40.5	17.3

TABLE 16

Power supply

(000s kw and kwh/km^2 urban residential land)

Country	U.S.	Germany	India	Japan	China
Generating capacity	8,806	6,528.8	513.8	12,312.7	700.3
Kwh: total	40,132	32,018.8	1,594.2	41,217.7	3,235.4
Agriculture	1,146.7	783.9	15.5	13.8	445.3
Residences	12,126.9	6,685.8	127.3	9,323	169
Industry	18,356.3	17,886.2	1,114.2	30,275.2	2,584
Railroads	123.9	1,229.1	50.4	1,487.2	36.3
Other	8,378.2	5,433.8	286.8	118.5	0.4

times greater for India and 5.9 times for China. The results are shown in **Table 12.**

The U.S. standard for water supplied for manufacturing purposes is defined per worker. The reported volumes available, per manufacturing operative, in millions of cubic meters per year, are: United States, 0.005; Germany, 0.002; India, 0.0001; Japan, 0.001; China, 0.0003. Per square kilometer of industrially used land, the volumes are: United States, 10; Germany, 6; and Japan, 8.3 million cubic meters. Industrial water use, output, and area are shown in **Table 13.**

For electricity generation, the question is one of the cooling system adopted. The U.S. engineering standard provided for 0.00015 cubic meters of water per kwh. Cooling water is employed in thermal and nuclear generation of electricity, as shown in **Table 14.**

We take power supply in terms of the sources of power supplied, whether electrical or fuel sources for combustion, and in terms of the consumption and production of such power sources. Using current thermal combustion-dominated modes, the two are united in electricity generation, which accounts for over 30% of the tons of oil equivalent fuel consumption of four of the five countries. The exception being China, where 17.5% of the fuel consumed is so used. For the other four countries, the ratios are: United States, 35%; Germany, 35%; India, 33%; and Japan, 32%.

Tables 15 and **16** show how the electrical power so produced was consumed, and how much generating capacity was employed in its production. (The tables can be read in conjunction with **Tables 18** and **19,** which break out fuel consumption, in tons of oil equivalent, in the same form.)

Wasteful tradeoffs

The non-thermal generating capacity indicated in Table 14 was, in 1970, primarily hydropower, which has been pushed by the World Bank and others, as a cheap, cost-effective way for Third World countries to add generating capacity. Cited in support of this assessment are the immense power potentials of the water resources of countries like India and China. China is estimated to have a hydropower potential of 680 million kilowatts, India of 41.5 million. At 60% capacity utilization, this would yield 3,574 million kwh in the case of China, and 216 million kwh in the case of India. The numbers sound impressive.

But compare the power capacity in 1970 per household terms with the generating capacities which then existed in the United States, Germany, and Japan. China's 3,800 megawatts per 1,000 households would be comparable to Japan more than Germany, and 70% of U.S. capacity. India's 2,016 megawatts would be comparable with Germany's 1970 total, half of Japan's, and two-fifths that of the United States. Since the potential is relatively fixed, it declines per household, as the number of households increase.

Add to this what we saw above about the water requirements of these countries, and what could be implied about dam, reservoir, and other land and water management needed to free up some of the available water supply for hydropower, and it becomes clear that the World Bank-recommended hydropower investments for such countries are among the cruelest of hoaxes. Hydropower has functioned in low population-density countries which are not hard-pressed for either land, water, or transportation needs—Norway, Sweden, Switzerland, and the Pacific Northwest of the United States, come to mind. But where power, land, and water are all in short supply, it won't provide a solution.

Thermal generation of electricity and, since the oil hoaxes of the 1970s, coal-fired systems, have been enforced as the only other option, since nuclear power was effectively banned for Third World countries by Jimmy Carter in 1978 when he insisted that West Germany's agreements with Brazil be canned. It is amazing that this is all done in the name of threats to the environment, given what the coal-fired alternative actually represents, and what the proponents of "greenhouse effect" and "global warming" hoaxes never discuss.

Environmental competence: the nuclear issue

Assuming, on the basis of the U.S. fuel ratios, a 1,000 megawatt plant operating at 60% capacity, the fuel requirement will be 3,200 oil equivalent tons per day (see **Table 17**). The volume of coal as such would be about 5,600 tons per day. Some 1,800 tons of typical steam coal cover an acre of land to a depth of one foot. Therefore, three acre-feet of land, plus over-burden, must be cleared per coal-fired megawatt per day. Underground mining has a yield of 50-60%. There is then the environmental damage from the transportation and cleaning of the coal, and the emissions produced from burning it.

TABLE 17

Fuel and electrical generation

(oil equivalent tons)

Country	U.S.	Germany	India	Japan	China
Fuel/1,000 kwh	0.39	0.39	0.71	0.29	0.55
1,000 kwh/ton	4.5	4.8	3.1	3.3	1.79

TABLE 18

Power supply: fuel per 1,000 households

(oil equivalent tons)

Country	U.S.	Germany	India	Japan	China
Total	21,906	10,134	541	9,905	1,292
Agriculture	522	40	3.6	53.9	60.724
Residences	3,360	2,456	52.2	381	219.64
Industry	5,174	2,945	183.5	4,063.9	609.824
Transportation	4,570	1,195	127.2	1,174	62.724
Truck	4,229	1,034	45.5	840	12.92
Rail	188	81	75.9	90.3	25.84
Water	79	41	2.8	121	2
Electrical generation	7,759	3,533	177	3,210	226.1
Other	600	5	0.3	1,142	114.988

A 1,000 megawatt nuclear plant, on the other hand, contains about 100 tons of 3% enriched uranium. The plant's containment vessel is opened once a year, and one-third of the fuel replaced. Roughly 500 tons of unenriched ore is required to produce 100 tons enriched fuel. The ore which is to be enriched makes up 0.7% of the natural uranium mined. Thus, a mere 70,000 tons of natural uranium have to be mined to provide a one-year fuel supply for a 1,000 megawatt plant. The coal-fired plant will require about 2 million tons of coal, four hundred 5,000 ton-unit trainloads, representing more than 1,100 acre-feet of land (see Tables 18 and 19).

Electricity and fuel were otherwise used as follows.

In U.S. residential applications, the major specific use is home heating. In 1970, before the first oil shock, approximately 70% of the fuel consumed by households was accounted for by heating, about 6% for cooking, and other uses include water heating and so on. So, 2.3 tons of the 3.3 tons fuel consumed per household was for home heat, and 0.2 tons employed for cooking. The figures do not include so-called biomass fuels—like cow dung, which predominates

TABLE 19

Power supply: fuel per residential unit area

(oil equivalent tons)

Country	U.S.	Germany	India	Japan	China
Total	36,511.7	31,667.3	1,867.5	30,015.3	6,802.3
Agriculture	870.9	125	12.6	163.5	319
Residences	5,601	7,676.3	180.4	1,157.7	1,155.8
Industry	8,624.9	9,204.3	632.9	12,315.7	3,209.5
Transportation	7,485.9	3,607.7	429.1	3,192.5	330
Truck	7,049	3,231.2	157.1	2,546.3	67.8
Rail	314.6	254.3	262.6	273.7	135.7
Water	122.5	122.3	9.4	372.6	10.5
Electrical generation	12,932.8	11,043.4	612.3	9,729.4	1,190
Other	997	10.6	0.2	3,456.5	597.7

in India—so one could assume the Chinese figure of 0.2 tons per household is roughly equivalent to cooking requirements only, and that the Indian figure of 0.05 tons is the minor portion of consumption which is for the most part made up of cow dung patties.

Fuel for heating, as a guideline, would vary with the floor space or volume of the residence to be heated, and with the number of days such heat is required during a year. Typical U.S. floor space was around 1,500 square feet; German, about 1,000; and Japanese, about 700. Some 29% of the electricity supplied to U.S. residences was used for space heating, about 17% for water heating, 13% for lighting, another 6% for electrically powered cooking equipment, and 7% for a category called "other," cited here because it includes power for televisions, radios, and smaller appliances. The remaining 28% was used for larger appliances, like refrigerators, washers, driers, and freezers.

In agriculture, where the United States is concerned, the major part of the electricity applied, except for irrigation pumps, is for indoor uses in dairying, crop drying, and so on. Fuel use is primarily to power machinery, such as tractors, harvesters, and farm trucks. The reported ratios between fuel use and output in the five countries are shown in **Table 20.**

The Chinese numbers could be discounted for reasons discussed earlier. It ought to be noted that Germany applies 5.9 times more fuel per crop area than does the United States, to produce a crop yield which is about 6.3 times greater per crop area than that produced in the United States. The food produced per ton of fuel, and the fuel consumed to produce a ton of food, are roughly the same for the two countries.

Ratios between electricity and fuel consumed in industry, per unit of industrial output, and output per unit fuel and electricity consumed, are shown in **Table 21.**

TABLE 20

Fuel use in agriculture

Country	U.S.	Germany	India	Japan	China
Food produced/ ton of fuel	8.4	8.8	293	218	5.8
Fuel consumed/ ton of food	0.11	0.11	0.003	0.005	0.17
Fuel/crop area	41	244	1.1	6.9	66

TABLE 21

Fuel and electricity use in industry

Country	U.S.	Germany	India	Japan	China
Tons/kwh	5.7	20.7	6.1	18.1	12.1
Kwh/ton	0.17	0.048	0.17	0.055	0.08
Tons/ton of fuel	12.3	40.5	10.4	44.6	9.9
Tons of fuel/ton	0.08	0.025	0.09	0.02	0.1
Kwh/area	203,995	223,575	—	504,583	—
Tons of fuel/area	53,900	36,816	—	68,416	—

TABLE 22

Ton-kilometers, % modal share per 1,000 households

Country	U.S.	Germany	India	Japan	China
Total ton-km	47,380	10,058	1,768	13,279	2,513
Truck	18.6%	34%	34%	38%	3%
Rail	34.8%	37%	65%	18.2%	76.5%
Water	26.9%	21.3%	—	43%	20%

The food and the fuel discussed represents the following portions of the total goods moved on the freight transportation network of the five countries: United States, 24%; Germany, 9%; India, 30%; Japan, 12.3%; and China, 29%.

The total ton-kilometers (ton-km) are divided among the three principal modes of transportation of freight as shown in **Table 22.**

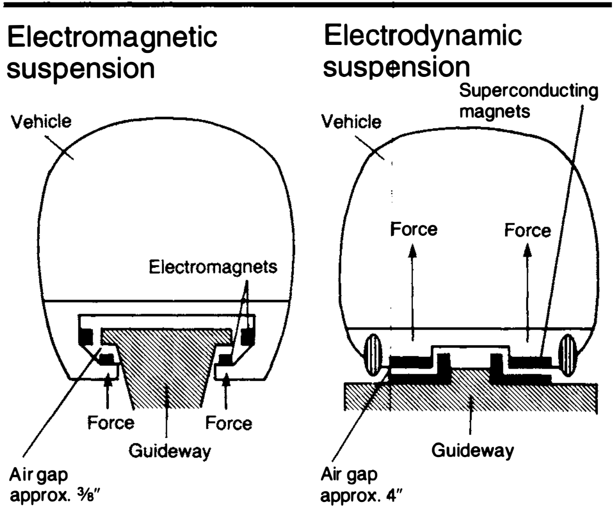
The fuel bill, in thousand ton-kilometers per ton, and tons per thousand ton-kilometers, for each of the modes, is shown in **Table 23.**

The fuel bill can be compared with estimates of the freight carrying capacity of each of these three modes, expressed in ton-kilometers moved per hour. These estimates are based on those the U.S. Army Corps of Engineers employed in a review of the U.S. transportation system commissioned under the Carter administration, and suppressed from publication by the Reagan administration. The following assumes a freight train carrying 2,000 short tons (1,814 metric tons)—about standard for the United States but heavier than most other systems—a standard 20 metric ton truck, and a standard jumbo barge of 1,500 tons organized in a 12-barge train.

The control systems are the signaling methods employed to regulate train movements, and together with numbers of tracks, determine line capacity. Manual or automatic block signaling assumes that the track is divided into blocks of a certain length relative to the headway of the trains, and that a train does not enter a given block until its predecessor has left it. Controls for stopping the train are onboard. Under central traffic control, the train, say for emergencies, can be stopped by orders issued from the central control. Central handling of movement permits better coordination and increases capacity. These comparisons apply to vehicles under way, and do not consider stopping and starting (see **Table 24**).

It requires 299 trucks to transport the same volume of ton-kilometers in an hour as 3.3 trains, or 4.5 barge trains, but they will only cover 7 kilometers each. With current U.S. speed limits, the trucks wouldn't actually travel at 127 kilometers per hour. And diesel-fueled trains, the freight-carrying workhorse in the United States, cannot technically exceed 125 miles per hour (200 km/hr). Other modes can be compared to this outline, for example those shown

Magnetic levitation transport systems



Magnetic levitation (maglev) transport systems can revolutionize passenger and freight transportation by early in the next century. Moreover, the spinoffs which will follow the development of advanced maglev systems, such as giving impetus to high-temperature superconductor research, will have even more profound effects.

Maglev systems feature two basic types of propulsion and guidance systems: those in which the levitation magnets are onboard the vehicles and are superconducting, such as Japan's HSST models, and those which are propelled and controlled from the track on which the vehicles run, known as the guideway. Both the German TR-07 and the Japanese MLU-002 models make use of what are called passive systems. However, the German and Japanese programs make use of different electromagnetic principles to provide the suspension, propulsion, and guidance of their vehicles (see diagram).

The German Transrapid is based on the attractive power of permanent magnets, a system called Electromagnetic Suspension. The vehicle's underframe "wraps around" the guideway and pushes the vehicle up and off its rails. The Japanese make use of repulsive forces, a system called Electrodynamic Suspension, to lift the vehicle away from the guideway. These systems must employ an undercarriage-like landing-gear, for lift-off and landing, because the vehicles only levitate at speeds in excess of 25 mph.

Maglev technology is already developed to meet an array of transportation functions, from short-distance but relatively high-speed urban commutes (Japan's HSST can function at between 60 and 250 mph), to inter-city travel at speeds in excess of 310 mph.

The Transrapid TR-07 is capable of carrying up to 200 passengers at speeds of 310 mph. With a one-minute headway between units, Germany's TR-07 can transport 10-20,000 people per hour. Japan's commercial design maglev train will consist of 14 cars capable of carrying 900 passengers, and is intended to move 75-100,000 people per day between Tokyo and Osaka, some 320 miles.

A maglev transport system compares favorably to aircraft in effective travel time for distances from 200 to 900 miles, and a maglev system can carry twice the number of passengers at half the cost of a Boeing 737. It uses electrical energy, rather than petrochemical fuels.

The maglev system is cheaper than the movement of passengers on today's railroad system. The best estimate of maglev operating and maintenance costs per passenger-mile is 5.2¢ in 1988 dollars. Today's U.S. Amtrak Metroliner service costs 16.2-36¢ per passenger-mile, depending on the bookkeeping methods used.

TABLE 23
Transportation fuel bill

Country	U.S.	Germany	India	Japan	China
1,000 ton-kms/ton fuel:					
Truck	2.08	3.3	13.2	6.1	5.8
Rail	87.6	67.8	29.7	10.7	88.8
Water	173	55	—	46.5	256.8
1,000 tons fuel/ton-km:					
Truck	0.47	0.29	0.08	0.16	0.16
Rail	0.01	0.01	0.03	0.009	0.01
Water	0.006	0.02	—	0.02	0.004

TABLE 24
Transport density: mode*
(ton-km/hour)

Control system	Trains/hr	Km/hr	1,000 Ton-km/hr	No. of trucks	No. of barge trains
2-track, manual/auto block	2.5-3.3	94.9	568	299	4.5
2-track central traffic	6.6-8.3	127.1	1,912	1,000	15.1
4-track central traffic	12.5-15	127.1	3,455	1,820	27.4

*Freight train: 1,814 million tons; truck: 20 million tons; barge: 1,500 million tons in 12-barge train.

TABLE 25
Other variants of transportation

	Speed (km/hr)	Load (million tons)	Ton-km/hr	Rail equivalent
Junk or country-boat	2-4	1-20	2-80	7,100
1 Animal-drawn cart	1.7-2	0.3-0.4	0.5-0.8	710,000
1-Man hand-cart	1.7-2	0.18	0.3-0.36	1,577,777
Human carrier	1.7-2	0.05-0.07	0.085-0.14	4,057,142

TABLE 26
Length of haul by mode
(kms)

Country	U.S.	Germany	India	Japan	China
Truck	362	36.7	—	29.4	24
Rail	789	219.9	644	250	513
Water	916	203.4	—	400	365

in **Table 25.**

Germany considers 70,000 vehicles per day traversing a highway stretch to be the level at which it is necessary to start planning to construct a new stretch. That's about 3,000 vehicles per hour. U.S. capacity considerations are similar. The truck equivalent of 3.3 trains per hour would be the only variant considered here, which would, perhaps, not cause highway congestion.

Planning transportation needs

The combination of the three transportation parameters we have seen so far, ton-kilometers per hour, fuel per ton-kilometer, and ton-kilometers per ton of fuel, together with the land use requirements, which distinguish rail traffic from highway transit, would permit these three different modes to be ranked according to function: slow-moving water freight, cheapest for movement of bulk goods for which there is no delivery time pressure; rail, which ought to be best for rapid movement of goods where time does become a consideration; and trucking, whose function ought to be the shorter-haul delivery of goods to the other modes or to the final user of the goods.

This functional arrangement would only work, however, if marshaling and break-bulk facilities were adequate. Philadelphia and New York City are 90 miles apart, 1.5 hours traveling at 60 miles per hour. U.S. railroads were never able to manage the overnight delivery of goods from Philadelphia to New York because of the intermediate-stage handling arrangements.

The economics which underlies the differences between the three different modes is reflected in the average hauls which are obtained by dividing ton-kilometers by tons (see **Table 26**).

The longer hauls in the United States, compared to Germany and Japan, reflect the larger area and the lower population densities. This can be seen further in comparing the densities of the networks of the different transportation modes relative to different land uses, in light of what we saw above about areas of land used for different purposes, per household. The grid densities are compared over the entire area, and per 1,000 households, and relative to agricultural and urban areas (see **Table 27**).

We find the same inverse relationship we saw with electricity use per household and per used area. With 10 times greater population density than the United States, relative to total area, Germany and Japan have 2.3 and 3.5 times,

Shipping on the Rhine, with Mainz, Germany in the background. Climate and the availability of water, including for transportation, have played their part in channeling mankind's development.

respectively, the density of transport grid to total area, but the United States has 4.8 times the per household network that Germany does and 2.5 times that of Japan. The overall figures reflect the depth, or lack of it, of the road network. Note Germany's combined densities of railroad and waterway networks in relation to total area. The Japanese water network is calculated on the basis of coastline, since their water-borne freight is coastal freight, and population is based on the coast.

Transportation network densities were calculated by identifying major crop producing areas of the countries, where 50% or more of production was located, and then cross-gridding the transport networks of those areas against their total areas and the crop production areas. This was not possible for Germany because it was not possible to find the railroad network broken down at the state level. The numbers for Germany are simply transportation network and total area repeated.

The comparison is seen best between **Tables 28** and **29,** for the ratio of transport route to crop area is unrealistic given that there are other uses in agricultural area. For China, there is a significant increase in density, which reflects the fact that the relatively unpopulated western part of the country is not included. Japan is reduced below the national total, because of the large area of Hokkaido, and India and the United States are about the same as the overall density figures.

The food-producing areas included: for the United States, Ohio, Indiana, Illinois, Iowa, Missouri, Minnesota, North Dakota, South Dakota, Nebraska, and Kansas; for India, the states of Andhra Pradesh, Bihar, Madhya Pradesh, Uttar Pradesh, Maharashtra, Punjab, and West Bengal; for Japan, the prefectures of Hokkaido, Nigata, Akita, Miyagi, Yamagata, Fukushima, Aomori, Ibaraki, Iwate, Tochigi, and Chiba; and for China, Heilongjiang, Liaoning, Jilin, Shandong, Hebei, Henan, Zhejiang, Jiangsu, Anhui, and Sichuan.

TABLE 27

Density of transportation grid

(km/1,000 km^2)

Country	U.S.	Germany	India	Japan	China
Total network	837.3	1,920.4	237.9	2,960.7	83.3
Roads	798	1,773.2	215	2,815.9	64.1
Railroads	37.3	143.9	18.5	62.4	3.7
Waterways	2	17.9	4.4	82.3	15.4

TABLE 28

Density of transportation grid

(kms/1,000 households)

Country	U.S.	Germany	India	Japan	China
Total network	104.9	21.8	7.29	40.97	4.51
Roads	100	20	0.56	39	3.48
Railroads	4.6	1.6	6.6	0.87	0.2
Waterways	0.3	0.2	0.13	1.1	0.83

It is a different matter when it comes to transportation networks in urban areas. Here again, the numbers represent

TABLE 29

Transport network density and agriculture

(kms/1,000 km^2 agricultural area)

Country	U.S.	Germany	India	Japan	China
Total area:					
Total network	949.3	1,920.4	346.9	2,138.8	183.5
Roads	896.9	1,773.2	321.9	2,058.5	145.2
Rails	48.6	143.9	20.1	24.2	14.7
Waterways	3.7	17.9	4.9	56.1	23.6
Crop area:					
Total network	1,851.5	3,516.6	664.9	13,450.8	702.3
Roads	1,749.4	3,247.2	616.9	12,945.2	555.6
Rails	94.9	236.6	38.6	152.1	56.2
Waterways	7.2	32.8	9.4	353.5	90.4

TABLE 30

Transport network density and urban areas

(kms/1,000 km^2)

Country	U.S.	Germany	India	Japan	China
Built area:					
Roads	6,925.9	10,627.2	1,203.6	13,935.6	343
Bus routes	1,391.4	3,877.8	10.6	397.7	375
Trolley routes	6.9	201.1		70.1	
Rails		1,590		1,152.8	40.7
Rail routes	25.7	115.2	248	601.5	

TABLE 31

U.S. comparisons: builders' and planners' estimates

(km/1,000 km^2)

	Streets	Rails
RAND Corp.	5,735	—
Lancaster, Pa.	2,850	—
Conf. of Building Officials	8,264	—
Bartholemew central city	10,927	1,897
Bartholemew satellite	10,160	1,693
Bartholemew "urban" area	7,578	1,700

TABLE 32

Transport grid: maximum distance from any part of grid

(km)

Country	U.S.	Germany	India	Japan	China
Total:					
Area	1.19	0.52	4.2	0.33	12
Agricultural area	1	0.5	2.8	0.46	5.46
Crop area	0.52	0.27	1.47	0.07	1.4
Built-up area	0.14	0.09	0.8	0.07	
Rail:					
Area	28.75	6.9	54	15.6	269
Agricultural area	19.7	6.9	48	40.9	71
Crop area	10.2	4	25.6	6.2	17.5
Built-up area	38	0.12	3.8	0.8	

different things. For the United States, they are national numbers for 1970. For Germany, the ratio of road to built area is based on the Rhine-Ruhr area, and the cities of Hamburg, Bremen, and former West Berlin; and ratio of railroad to built area is based on the cities of Hamburg, Bremen, and former West Berlin. For India, the road-to-built-area ratio is national. The ratio of bus route to area is based on the cities of Ahmadabad, Bombay, Calcutta, and Madras, and the rail-route ratio on Bombay and Calcutta. The Japanese ratios in each case are based on the cities of Tokyo, Osaka, and Nagoya. And China's is simply the city of Shanghai (see **Table 30**).

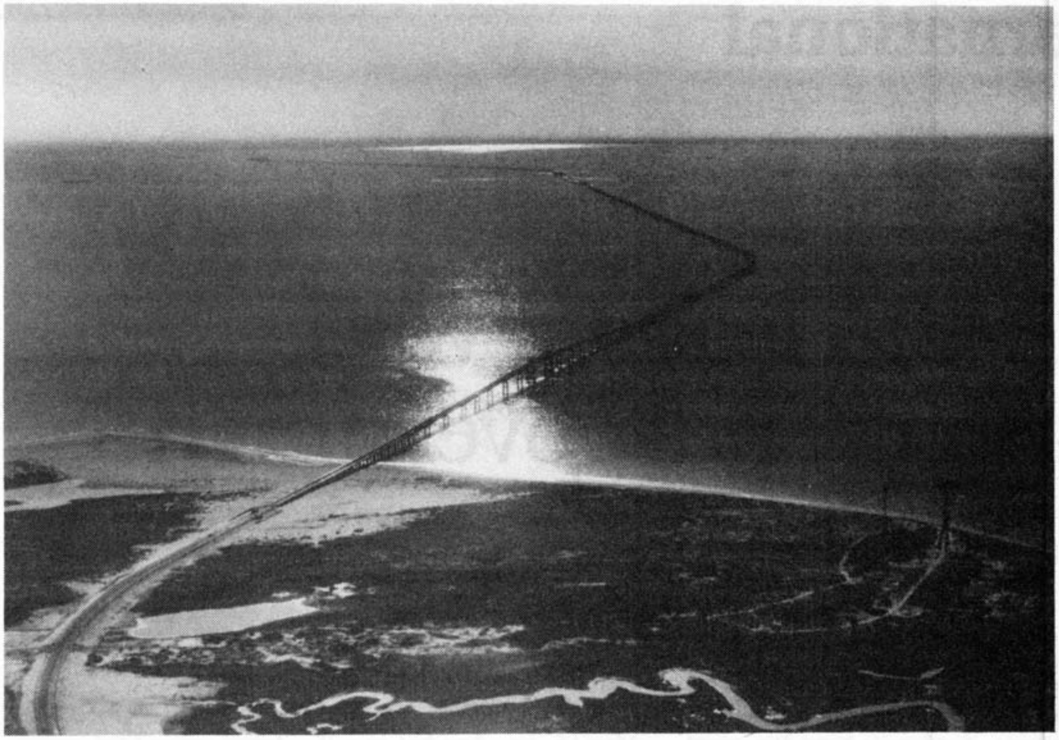
The ratios employed by the framers of the U.S. construction estimates we saw above can be converted into the same terms of reference as shown in **Table 31.**

Such grids can also be reformulated to show the maximum distance from any part of the transportation grid in a given area, of, say, 10 kilometers by 10 kilometers (**Table 32**).

In Tables 1 and 2 we reported gross profiles of the labor force, the percentage in agriculture and the percentage in manufacturing, and we showed estimates of labor productivity in terms of agricultural and industrial output. We also reported the ratios of population to teachers, doctors, and hospital beds. The discrepancies between the advanced sector countries and India and China were obvious.

The number of workers per 1,000 households is: United States, 1,338; Germany, 1,219; India, 2,074; Japan, 1,899; and China, 1,949.

Earlier, we saw how those workers were organized, roughly; now, a different point. We saw that lower life expectancy and higher birth rates go together with lower productivity and less-developed infrastructure. The combination creates a necessity for the young to be incorporated into the labor force, however that labor force is defined, as rapidly as possible. If we look at the officially reported age composi-



The Chesapeake Bay Bridge-Tunnel, at Virginia Beach, Virginia.

tion of the labor forces of the five countries, we find that the percentage of the labor force under 20 years of age is: United States, 9.5%; Germany, 10.2%; India, 26.2%; Japan, 6.5%; and China, 25.3%.

Education and health care

Compare this with the school-age population of the five countries. We assume 20 years of age as the upper limit on school age. The school-age population, expressed in terms of the number of people under 20 years of age per 1,000 households, and the percentage of enrollment, is: United States, 841 and 90%; Germany, 574 and 90%; India, 1,921 and 37.4%; Japan, 992 and 70%; and China, 1,792 and 40%.

The under-20-year-old part of the Indian and Chinese labor forces are also almost 30% of the population of youth under 20 years of age. Some 85% of India's 1970 school enrollment was at the primary level, and 91% of China's. To assume 15 pupils per teacher, and also assume that the entire school-age population would be the basis for calculating the target number of teachers that has to be trained, would be a move in the right direction. Compare this with the pupil-teacher ratios reported in the first table. Then, of course, there is the matter of how and what the teachers are going to teach.

The education of youth is of a piece with the matter of water supply. Without clean, fresh water for the population, the rates of infant mortality will burgeon. Accepting the increased infant mortality, as is done increasingly now in the United States, is also to assert by implication that there is no value in the child's future existence, and therefore no need for investment in his or her education, including the quality of the education. The child is, after all, doomed to the fields or the streets, or perhaps McDonalds.

The results of this view then become the source of the biggest health problems any nation could face, and make the discussion of the provision of health care academic. If you don't have clean water and functioning sewage systems, it doesn't really matter how many doctors, nurses, and hospital beds you have, at least to the extent that what is needed to stop the dying, especially among the children, is clean water and fresh, healthy food.

Standards for hospital care were laid down for the U.S. population in the Hill-Burton Act of 1946. These standards provided for at least 12 hospital beds for every 1,000 people, or 83 people per hospital bed. At that time, it was thought that, out of the 12 beds, 4.5-5.5 basic hospital beds were needed, 5 mental patient beds, and 2 chronic disease beds. The chronic disease which was then being fought was tuberculosis. In 1970, the ratio of people to hospital beds in the United States was 57% below the Hill-Burton Act recommendations. In certain of the more prosperous regions of the United States, those standards are met, and exceeded. In others, it is much worse. In areas where the hospital bed standards are met, the ratio of people to doctors is in the realm of 1 doctor for every 250 people. That ratio could become a reference point for judging the significance of the people-doctor ratios reported in Table 1.

Subsequent articles in this series will take up these questions in regard to other countries in the world.