Chapter 4
SIPS: A Measure for Land Use

It took Britain half the resources of the planet to achieve its prosperity; how many planets will a country like India require?
Mahatma Ghandi in response to the question whether India will achieve the British standard of living after independence[1].

Surface area, solar energy and coffee beans

In MIPS the criteria mass and energy are taken into account. We have argued that this permits a preliminary and rugged--but certainly still rough--estimate of the environmental compatibility of all processes, goods, infrastructures and services. We have also indicated that the consumption--or demand for--areas for civilizational and economic activities has undeniable ecological ramifications. After all, the earth's surface is all that humans have to live on. The absolutely minute amount of land that has so far been reclaimed from the oceans with the help of enormous amounts of material and energy (under "high MIPS" conditions) does not amount to much on a global scale. The Dutch obviously, and rightfully, see this a bit differently.

In the first part of this chapter we will try to develop a feeling for the importance of surface area as a resource for humans. We will introduce a few examples to illustrate this.

The two nuclear power plants in Neckarwestheim in Southern Germany take up about fifty hectares, including all the supply facilities, but excluding the waste disposal. On this surface they generate 2,200 Megawatts (million watts) of electrical power, day and night, assuming they are not switched off. Were one to have solar panels set up on the same area, about 50 MW of power could be generated, assuming the sun is shining. This is about one fourtieth, or 2.3%, of the first figure.

From an ecological perspective many good reasons speak for using the sun's energy directly, and few can be found for nuclear energy. But this is not our issue at the moment. This example is supposed to illustrate the tremendous difference in surface demands between the two forms of generating electricity. Most renewable energy sources have more or less the same disadvantage: their energy flows slowly, and not always when we want it to. Regardless of how much electricity an ecologically transformed society of the future might still demand, it will require a fair amount of surface area to generate a kilowatt if it is to be done exclusively with solar energy. We also know that parts of Northern Germany are not ecologically equivalent to parts of the Sahara. Therefore, geographically independent comparisons are of little use. This is the difference between the surface-use intensity of a service and its material and energy intensity. Material and energy intensity are independent of the location at which they are measured.

On the other hand, Germany has vast roof surfaces which are unused, and which could be used for generating electricity or hot water; or they could be planted with a "roof" cover. Table 2 indicates that the area taken by buildings in former West Germany adds up to to 15,000 square kilometers. Nitsch and Luther[2] have determined that 2,850 square kilometers of that is roof area. As only roof area with a southward exposure is useful for solar energy capture, they figure that 650 square kilometers are left which could be covered with solar hot water collectors or photovoltaic arrangements. With further careful qualifications, they come to the conclusion that the solar heating from rooftop collectors alone could save ten to thirteen million **SKE**, (or anthracite units) of primary energy (oil, coal and gas). This is equivalent to between seven and ten percent of all the primary energy which Germany's electrical utilities require per year.

The value of this number game is not to show that Germany can get pretty far with solar energy. These numbers are instead supposed to point out alternatives that may become relevant in the future, especially in light of the need--and the technical possibility, as we will argue later on-- for Germany to achieve a dematerialization of about ninety percent over the course of the next century. The familiar injunction that solar energy is presently not economical is of little ecological relevance as long as we do not have access to an objective comparison of the environmental burden of all technically feasible energy supply systems over their entire life, including all rucksacks of the requisite materials. Especially in the field of energy, the prices fail to reflect the "ecological truth." One of the main goals of this book is to advance our ability to assess the environmental compatibility of systems.

Our initial comparison of energy facilities is therefore absolutely inadequate. The surface demands of the finished power plant per kilowatt cannot be the sole criterion for deciding for or against solar energy. A MIPS comparison should precede any such assessments. One thing was made clear by this imperfect example, however: surface demand is an environmentally relevant factor that must be taken into account along with material and energy intensity, toxicity, and possibly others, if ecological mistakes are to be avoided.

Large areas of densely populated countries like Germany are already "sealed off" (see Table 2). While one may not consider the entire built up area (the areas taken up by highways, buildings and commercial use) to be sealed off, the numbers for the Ruhrgebiet show that roughly two-thirds of this number is *in fact* sealed off.

Table 2 Land-use in the former West Germany, 1985[3]

	Fläche (km²)	Anteil
Verkehr	12430,35	5,0%
Gebäude- und Freifläche	15414,38	6,2%
Betriebsfläche	1491,71	0,6%
Landwirtschaft	135000,12	54,2%
Wald	74088,46	29,8%
Wasser	4475,14	1,8%
Erholungsfläche	1740,33	0,7%
Fläche anderer Nutzung	4226,52	1,7%
Summe	248867,01	100%

It is fairly intuitive that the surface area is limited, and cannot be increased in any measurable way. Statistically speaking, each person requires a certain amount of land for his or her food production, for living, working, transportation, recreation and other things. For food production alone, sources indicate a per capita requirement of between 0.19 hectare (subsistence) and 0.38 hectare[4]. At 0.3 ha per capita in West Germany, the area needed to grow enough food would be 180,000 km^2. This is roughly equivalent to seventy percent of the area of former West Germany. Table 2 indicates that only 135,000 km^2 are available for agricultural purposes, apparently not enough for self-sufficiency at today's standard of consumption.

In an international comparison, West Germans demand considerably more than the average. Sascha Kranendonk of the Wuppertal Institute has calculated that to meet the Germans' demand for orange juice, the entire agricultural area of one of Germany's states (Saarland) would have to be planted in orange trees (see example at the end of this chapter). To grow enough coffee to supply the German market, 12,000 km^2 are needed in the tropics, an area equal to the total surface taken up by German highways, also equal to ninety percent of the area taken up by buildings in former West Germany. Drive your car or drink coffee? For climatic reasons neither oranges nor coffee can be grown in Germany, so the Germans occupy large parts of the Third World--in exchange for cash payments. This is also true for the supply of soybeans (which the Germans feed to their hogs), geologic raw materials and innumerable other things. Altogether one can assume that satisfying the Germans' material demands requires roughly twice the area of their country[5].

Germany would have to be several times larger than it is to produce all of the things which the Germans consume. As it is, they simply occupy the land of other countries.

As the world population grows, the pressure on the available areas will continue to rise. The pressure will rise especially in those situations where the rich countries today are occupying large areas in other countries for their own consumption. Because it seems fair to assume that we cannot, and do not, wish to deny the rest of humanity access to material resources comparable to our own, our material consumption cannot continue in its present form, either in terms of its quantity or at such low prices.

In market economies the price of land is a function of the economic use to which one can put it. But the same injunction is true for the price of land that we mentioned earlier in the context of raw material prices: they do not tell the ecological truth.

Ecologically intact nature has no market price, at least none that would give it a chance in competition for use as industial or residential areas.

Therefore society must step in and protect nature by removing it from such competition--which is in fact happening through the many forms of nature conservation laws and regulations. The success of such procedures always remain limited, however. The Germans occupy twice the amount of area for growing coffee worldwide as they afford themselves in national parks. (The national parks total 5,700 km^2. Nature preserves add another 4,600 km^2, and conservation areas are equal to one quarter of the area of former West Germany). This form of conservation is apparently a kind of "luxury" that a rich nature-loving society can afford. From an ecological perspective something can be said for this type of "luxury," though, as the national parks and nature preserves are the only areas in which the original species diversity is still (more or less) present. If the economy turns sour, or if a conflict can be resolved by renouncing our interests in such a tract of land, then the luxury items become bargaining chips. And luxuries of this sort are not afforded at all in poor countries, especially not when area is in as catastrophically short supply as it is, for example, in Bangladesh.

In Bangladesh each person is statistically associated with 1,200 square meters. About fifteen percent of this surface would suffice to grow the coffee West Germans consume. Statistically speaking, a family of six is entitled to the equivalent of one soccer field. This area must afford all the necessary services for these six people: housing, food production, energy provision, the production of industrial goods, the private sector, transportation, and the removal of all waste. This is obviously not possible. Bangladesh imports food, just as Germany does. It should not surprise us, though, that in such a country even the most ecologically sensitive areas are "used" in some way. The rate of population increase in Bangladesh is exacerbating this situation in an unparalleled manner.

Each of the roughly eighty million Germans has about one half a soccer field (4,470 m^2) to himself--so, considerably more, even though virtually every nook and cranny is already being used in some way. We have already seen that this is not enough for the Germans. Each Frenchman and woman has about twice that amount, and each citizen of the U.S. has as much as four soccer fields, or 36,500 square meters.

The value that is placed on surface-use intensity in a national Life Cycle Analysis depends to a considerable extent on the prevailing conditions of that country. The fact that national borders change from time to time has been brought to our attention quite vividly in the very recent past. Besides, in the interest of the biosphere, it is not wise to adjust the value of a particular area according to the population density. Rather the consumption of resources should be keyed to the individual. Much political rhetoric is also directed toward the idea that all humans should be permitted equal access to resources.

At the start of the book we noted the contradictions inherent in the traditional economic policy focus of increasing national wealth alongside an awareness of the conditions necessary for preserving global ecological stability. We argued that the global loss of political credibility and the likelihood of sudden changes in the sociopolitical landscape will rise if this conflict is not dealt with. Bangladesh is among those countries that will in all probability suffer most from the climatic changes induced--for the most part--by the behavior of members of the OECD countries (to which it does not belong). We do not have that much time to solve this dilemma, and it is up to the rich to take the lead.

SIPS

In order to estimate the environmental stress intensity of goods and services, we related the associated material and energy flows to the service rendered. We will proceed in similar fashion with surface area. The reasons are again the same: it is necessary to define ecological indicators in such a way that economic activity and ecological necessity can be linked.

We are defining the surface-related environmental indicator, for the time being very generally, as Surface Input Per Service unit, or SIPS.

Once an area has been allotted to a particular use or activity, this generally excludes the possibility of simultaneously using it for another economic purpose. In economic parlance the "sealing off" or use of natural areas for civilizational or economic purposes translates into an opportunity cost for the biosphere. This means that through such human appropriation the biosphere loses evolutionary balance and stability. This loss can be partially compensated through planting such areas with grass, shrubs or trees.

Our task is to find simple, scientifically defensible and easily measurable indicators that are able to reflect the complex ecological changes (losses) due to this appropriation of surface area. The same conditions apply in this case as were mentioned in Chapter 3:

1. Although these indicators should be simple, they should reflect significant influences on the environment.
2. They should be based on characteristics that are common to all processes, goods and services.
3. The chosen characteristics must be easily measurable and subject to quantification.
4. Their application should be cost-effective.
5. The measures should permit the transparent and reproducible estimation of environmental stress potentials of all conceivable plans, processes, goods and services from the cradle to the cradle.
6. Their use should always lead to directionally stable results.
7. The measures should form a bridge to market activities.
8. They should be usable on all levels: locally, regionally and globally.

What we are going to suggest in the following paragraphs is of a provisional nature and is intended to stimulate further contemplations. These are thought fragments--no more--but they might be part of a future solution.

Surface area analysis of an economic trading area

Surface area is limited in the same way that matter is. The use of an area cannot be solely understood as a value-neutral "occupation," but must also be appreciated as a "using-up or wearing out" of the area. The soil erosion that follows in the wake of intensive agricultural practices found on the cocoa plantations of the Ivory Coast, for instance, or the changes in soil composition such as salinization following prolonged irrigation characterize such qualitative changes.

In order for an economic trading area to flourish, a certain minimum area seems to be necessary. Among other aspects, production facility requirements, consumption habits and recreational behavior all shape the extent of such an area. It therefore seems fair to relate the demand for surface area to the prevailing needs and expectations. As no presently available statistics permit such a relationship, we must rely on sufficiently detailed land-use data with which to compile our own statistics. We wish to show this in an exemplary way for the Ruhrgebiet. We thank Helmut Schütz of the Wuppertal Institute for the data.

Table 3 shows that seventeen percent of the total available area of 4,433 square kilometers is used for housing. Included in this figure are not only residential structures, but also public installations such as post offices, hospitals, administrative buildings etc. Almost one-third of the area is used for the production of food. A further eighteen percent are maintained for forest products. Traffic installations, highways, streets, parking lots and car lots take up ten percent, or about 450 square kilometers. Two percent or 90 km^2 are used for recreational facilities such as miniature golf, horseback riding and amusement parks.

Altogether almost nine-tenths of the area are subject to some technical use, of which about one third is "sealed off." Only about ten percent of the area even begins to look natural or undisturbed: forests, wetlands and other such areas. From an ecological perspective these "natural" areas can be appreciated in light of their ability to counterbalance the environmental pollutants emitted from the other ninety percent of the area (their ability to absorb CO_2 and other more noxious substances).

Table 3 Flächenbilanz des Wirtschaftsraumes Ruhrgebiet. Als Gesamtfläche ist die Katasterfläche angegeben. Sie weicht aus methodischen Gründen von der Summe der Einzelposten leicht ab.

Bedarf	Fläche in km²	Fläche in % Gesamtfläche	Fläche in m² pro Kopf
Wohnen	754	17	108
Ernährung	1330	30	192
Ressourcenanbau	798	18	111
Ressourcenabbau	45	1	7
Produktion	266	6	36
Energiegewinnung	11	0,25	2
Entsorgung	44	1	7
Verkehr	443	10	65
Freizeit	89	2	11
Natur	576	13	80
Ungenutzt	89	2	12
Gesamt	4433	100	631

We can also see in Table 3 that each citizen of the Ruhrgebiet has only 190 square meters with which to meet his or her nutritional needs. Although this part of Germany should not be seen in isolation from the rest of the country without qualifications, we can nevertheless point out that these residents of the Ruhrgebiet appropriate 200 square meters per capita in other countries for the consumption of soybeans which they then feed to their hogs. Another 150 square meters go for growing the coffee they drink, and 82 square meters to grow the chocolate they consume. In total, these areas, which all lie outside the borders of the Ruhrgebiet and Germany, add up to more than 1,400 m^2 per capita, or seven times what is available within the borders of the Ruhrgebiet.

We have so far not included in these calculations the effects these consumption patterns have on the exporting countries--in other words, with how much soil erosion, fertilizers, pesticides, water and CO_2 the ecological rucksacks are filled. It would also be pertinent to ask what effects such trade flows have on the people involved--especially the producers themselves. Let us recall the collapse of the international *Coffee Agreements* that brought us reduced prices and increased consumption, but that also ruined many a small producer in the Third World. Perhaps we should think about the fact that the greater part of the Ivory Coast's agricultural area was lost in order to provide us with our chocolate desserts, and that the rising population of that country is now encountering shortages of food. In light of rising population and sinking agricultural yields world-wide, the question of a more just distribution of area, as well as of matter, as preconditions for a sustainable development will not go away. The results of the "Green Revolution" should have made it clear that the problem has no technical solution.

The ecological ramifications of banking on renewable resources as replacements for, say, fossil fuels or other mineral raw materials are not at all certain.

[1.1] quoted in Robert Goodland, The case that the world has reached limits. In R. Goodland et al. (eds.): Environmentally Sustainable Economic Development: Building on Brundtland, UNESCO, 1991.

[2.2] Joachim Nitsch and Joachim Luther, Energieversorgung der Zukunft. Berlin, Heidelberg, New York, 1990.

[3.3] Umweltbundesamt, Daten zur Umwelt. 1988/89.

[4.4] "Sustainable Netherlands," Friends of the Earth discussion papers, 2 September 1993; and Meadows et al., Beyond the Limits; and Norman Myers, ed., GAIA-An Atlas of Planet Management. London: GAIA Books Ltd., 1984.

[5.5] M. Buitenkamp, H. Venner and T. Wams, Actieplan Nederland Duurzaam. Amsterdam, April 1992.

The price of quenching the Germans' thirst

With respect to drinking orange juice, which here includes the categories of 'drink,' 'juice,' and 'nectar,' the Germans are world champions. Twenty-one liters of orange juice per person per year is an astounding number for a country that contributes so little to growing oranges.

Sascha Kranendonk of the Wuppertal Institute has taken a closer look at the environmental consequences of this thirst for vitamins*. Her work helps answer the questions of how material intensive and how surface intensive the average German lives. Could the whole world afford the same?

Eighty percent of the orange juice which the Europeans drink is grown in Brazil, mostly around São Paolo. After being harvested, the juice is concentrated, frozen and subsequently transported 12,000 km to Europe, almost a third of the way around the globe.

How much material has been translocated before the glass of juice appears on the breakfast table? How large is the ecological rucksack of orange juice? It turns out that each kilogram of orange juice, or every liter, requires 25 kg of "environment." Just the amount of water necessary is staggering. By the time the oranges have been washed, concentrated to eight percent of their original mass using steam, and then diluted with water again in Germany, twenty-two glasses of water have been used for one glass of juice. Additionally, almost one-tenth of a liter of fuel has been burned in the agricultural machinery for just one liter of juice.

But this rucksack is light when compared with the rucksack for the same product in the United States: in Brazil, orange orchards are only rarely irrigated; the orchards do not need to be heated if a frost threatens and are generally not harvested with machinery, but by hand. In Florida things are very different: there, two liters of fuel are burned for each liter of juice, twenty times the amount in Brazil; and the amount of water used is not twenty, but 1,000 liters for a single liter of orange juice. The ecological rucksack in Florida is thus forty times as heavy as it is in Brazil. This comparison illustrates very vividly how much environmental protection can be achieved just through more adaptive agricultural practices, which should include the notion of growing things where conditions are favorable. (Here too, the transport effort must still be taken into consideration.)

The surface-use is also enormous. To quench a single German's thirst for juice, twenty-four square meters of land must be planted in orange trees. This may not sound like very much, but it adds up to 150,000 hectares--three times the total arable land in the eastern part of Germany.

* . * Sascha Kranendonk and Stefan Bringezu, Major material flows associated with orange juice consumption in Germany. in: *Fresenius Environmental Bulletin*, 2(8), August 1993.