# Geographical Relations Dynamics (2)
# - energy, GHG, and food with the world trade in 2030 -

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*Abstract:-* In the early 1970 's, D. L. Meadows and his colleagues have selected population, food, fuel (natural resources), and environment as the parameters to run their "the World Dynamics". The author attempts to present Geographical Relations Dynamics to study how various regions on Earth interact each other in time series. In this system, the world consists of 90 regions which have four layers, a layer of the underground non-renewable natural resources (represented by energy in Kcal unit), that of the biosphere-atmosphere-ocean system (the Nature, represented by green house gas emission), that of the man-made food production (the Civilization, by food production in Kcal), and that of the man-made value system with several digit binary indicators representing diet (vegetarian/non-vegetarian), national security (militarized/non-militarized) and environmental policies (regulatory/non-regulatory). Using this system, the author estimates the regionally unbalanced situation of population, GHS (CO2) emission, energy (production, consumption, and the world trade), food production, consumption, and the world trade) region by region around 1930 . To compensate the surplus and deficit in energy and food, the author proposed to operate the world trade matrix to estimate the interregional logistics. Then, some feasible solutions should be sought through international redistribution (trade) of food and fuel as well as through the modification of value system.

*Keywords:-* World Dynamics, Geographical Relations Dynamics, GHG (green house gas), international trade matrix

## 1 Introdction: Parameters in the World Dynamics

D. L. Meadows and his colleages selected four parameters such as rare metal chrommium representing non-renewable natural resource, environmental stress, food production, population who consumes resources, food and produces environmental stress. Meadows created a mathematical function that an environmental stress makes the man's average life shorter as a negatigve feedback.

## 2 Parameters in Geographical Relations Dynamics

Figure 1 is 24 land regions in 9 x 10 meshes on Earth. The author selects four parameters the following:

- population in each region based on UN population census. (Layer 3 in Fig.2)
- GHG (green house gas i.e., $CO_2$) emission based on UN statistics[1]. (Layer 2 in Fig.2)
- energy: In this paper, energy means the total energy which combines oil, coal, gas, and other energy sources together in unit of Kcal [2]. (Layer 1 in Fig.2)
- food: production and consumption in unit of Kcal based on FAO annual statistics (Layer 3 in Fig.2)

Basic approach is to estimate the sistuation of each parameters in 2030, by means of an extrapolation based on statistics in 1990 and 2000.

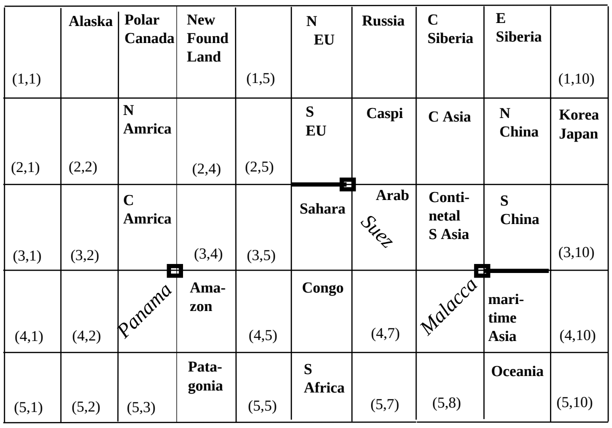


Figure 1: 9 x 10 regions

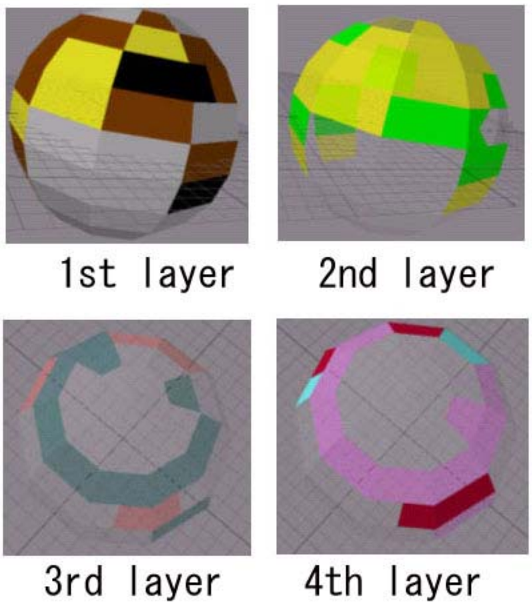


Figure 2: 4 layers in a region

# 3 Population

Among many socio-economic phenomena, the population dynamics is the most reliable and stable one when once it moves towards one direction of either increase or decrease. United Nations provides the world population census since the 1960's. Except the United State, all developed contries are experiencing lowering birth rate and incresing aged population. After so-called population bomb in developing contries, the world population is predicted to stabilize at 10 billion around 2100. The table 1 shows the regional populations around 2030.

# 4 CO2 emission

There are many indicators on environmental stresses about water, air, and soil etc. However, since the Kyoto Protocol, statistics on Green House

Table 1: Regional population in 2030 (unit = million people)

| | | | | | |
|---|---|---|---|---|---|
| Polar Canada 3 | North EU 71 | E Rusia 101 | Cent. Siber. 5 | East Siber. 5 | |
| USA 432 | South EU 443 | Caspi an 143 | C Asia 99 | N China 686 | Korea Japan 181 |
| C Ame rica 359 | Sahara 454 | Arab 475 | India SEAs 2513 | S China 695 | |
| Ama zon 311 | Congo 1594 | | | | mari Asia 457 |
| Patago nia 107 | S Africa 154 | | | | Ocean-nia 47 |

Table 2: Regional CO2 emission in 2030 (unit = million tons )

| | | | | | |
|---|---|---|---|---|---|
| Polar Canada 1 | North EU 765 | E Rusia 922 | Cent. Siber. 51 | East Siber. 51 | |
| USA 8,351 | South EU 6,462 | Caspi an 1,981 | C Asia 229 | N China 4,153 | Korea Japan 1,800 |
| C Ame rica 1,413 | Sahara 701 | Arab 2,371 | India SEAs 3,284 | S China 5,943 | |
| Ama-zon 703 | Congo 181 | | | | mari Asia 1,265 |
| Patago nia 425 | S Africa 470 | | | | Ocean-nia 642 |

Gas has been well kept in good condition wordlwide basis[1]. Using the prepared statistics, it is easy to estimate the regional CO2 emission around 2030.

# 5 Energy

Compared to population and Green House Gas, estimation on regional energy production, consumption and the world trade matirx is difficult task because of data availability inconsistency. The units used to measure different enegy sources such as oil, gas, coal, and other energy sources are different. The author adopt "10 to the power of 12 Kcal" as the common measurement unit in this paper. Table 3 and table 4 are the sum of oil, gas, coal, and all other primary energy in each region.

As for population, the author only count the

Table 3: Regional Energy Production in 2030 (unit = 10 to the power of 12 Kcal )

| | | | | | |
|---|---|---|---|---|---|
| Polar Canada 355 | North EU 6,656 | E Rusia 7,261 | Cent. Siber. 403 | East Siber. 403 | |
| USA 26,386 | South EU 8,479 | Caspi an 1,150 | C Asia 2,516 | N China 3,758 | Korea Japan 2,369 |
| C Ame rica 9,724 | Sahara 4,234 | Arab 21,632 | India SEAs 7,653 | S China 3,758 | |
| Ama zon 2,503 | Congo 2,287 | | | | mari Asia 6,447 |
| Patago nia 2,279 | S Africa 4,061 | | | | Ocean-ia 6,447 |

Table 4: Regional Energy Consumption in 2030 (unit = 10 to the power of 12 Kcal )

| | | | | | |
|---|---|---|---|---|---|
| Polar Canada 76 | North EU 1,715 | E Rusia 1,287 | Cent. Siber. 72 | East Siber. 72 | |
| USA 35,629 | South EU 16,147 | Caspi an 1,568 | C Asia 247 | N China 4,711 | Korea Japan 10,618 |
| C Ame rica 3,083 | Sahara 1,913 | Arab 7,730 | India SEAs 10,119 | S China 4,985 | |
| Ama zon 2,503 | Congo 2,287 | | | | mari Asia 4,346 |
| Patago nia 1,659 | S Africa 3,036 | | | | Oceania 2,175 |

birth rate and the death rate in situ, neglecting the emigration from a region to another region. We can deal the CO2 emission in the same manner i.e., man's activity in situ is the major reason of the amount of CO2 emission in that region.

However, energy and food are the objects of the world logistics. This is why we need "Geographical Relations Dymanics" which can deal with region to region interactions. Figure 3 is the world wide trade matrix among 24 land regions.

Figure 4 shows that there are only 14 major energy exportes and 9 major energy importes in the world energy trade matrix. The major problem of this matrix is that it based on statistics between 1990 and 2000 so that any new phenomenon after 2000 are not taken into the consideration. According to China Custom (2006) statistics, China was used to be an energy exporter till 2000 but it is snowballing oil import from 6 thousands ton in 2001 to 12 thousands ton in 2005. Everyone gets afraid of China's gulping oil causing the worldwide energy crisis soon.

| | Alaska | P Canada | G Land | N Amrica | C Amrica | Amazon | SSAmrica | N EU | S EU | Sahara | Congo | S Africa | Russia | C Siberia | E Siberia | Caspi | Arab | C Asia | N China | S China | India | mar Asia | Oceania | K-Japan |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alaska | x | | | | | | | | | | | | | | | | | | | | | | | |
| P Canada | | x | | | | | | | | | | | | | | | | | | | | | | |
| G Land | | | x | | | | | | | | | | | | | | | | | | | | | |
| N Amrica | | | | x | | | | | | | | | | | | | | | | | | | | |
| C Amrica | | | | | x | | | | | | | | | | | | | | | | | | | |
| Amazon | | | | | | x | | | | | | | | | | | | | | | | | | |
| SSAmrica | | | | | | | x | | | | | | | | | | | | | | | | | |
| N EU | | | | | | | | x | | | | | | | | | | | | | | | | |
| S EU | | | | | | | | | x | | | | | | | | | | | | | | | |
| Sahara | | | | | | | | | | x | | | | | | | | | | | | | | |
| Congo | | | | | | | | | | | x | | | | | | | | | | | | | |
| S Africa | | | | | | | | | | | | x | | | | | | | | | | | | |
| Russia | | | | | | | | | | | | | x | | | | | | | | | | | |
| C Siberia | | | | | | | | | | | | | | x | | | | | | | | | | |
| E Siberia | | | | | | | | | | | | | | | x | | | | | | | | | |
| Caspi | | | | | | | | | | | | | | | | x | | | | | | | | |
| Arab | | | | | | | | | | | | | | | | | x | | | | | | | |
| C Asia | | | | | | | | | | | | | | | | | | x | | | | | | |
| N China | | | | | | | | | | | | | | | | | | | x | | | | | |
| S China | | | | | | | | | | | | | | | | | | | | x | | | | |
| India | | | | | | | | | | | | | | | | | | | | | x | | | |
| mar Asia | | | | | | | | | | | | | | | | | | | | | | x | | |
| Oceania | | | | | | | | | | | | | | | | | | | | | | | x | |
| K-Japan | | | | | | | | | | | | | | | | | | | | | | | | x |

Figure 3: the world trade matrix in 24 regions

| Import \ Export | N Amrica | C Amrica | Amazon | N EU | S EU | Sahara | Congo | S Africa | Russia | Caspi | Arab | N China | mar Asia | Oceania |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAmerica | 6050 | 1793 | 2439 | | 807 | 491 | 546 | 11 | 48 | 1670 | 1917 | | | 11 |
| CAmerica | | | 44 | | | | | 25 | | | | | | |
| Amazon | 23 | | | | | | | | | | | 37 | 10 | 113 |
| N EU | 16 | | | 202 | 36 | | | | | | | | | |
| S EU | 1088 | 18 | 619 | 3844 | 1761 | 747 | 307 | 877 | 4394 | 267 | 1066 | 70 | 249 | 439 |
| Caspian | 2 | | | | | 235 | | 30 | 150 | 101 | 64 | | | |
| IndiaSEA | | 16 | | | | | 145 | 87 | | 385 | 2568 | | 99 | 197 |
| maritime Asia | | | | | | | | | | 131 | 222 | | 96 | 4 |
| K-Japan | 59 | | 22 | 27 | | | 46 | | | 925 | 4156 | 1339 | 1578 | 2247 |

Figure 4: estimation of the world energy trade in 2030 (unit = 10to the power of 12 Kcal)

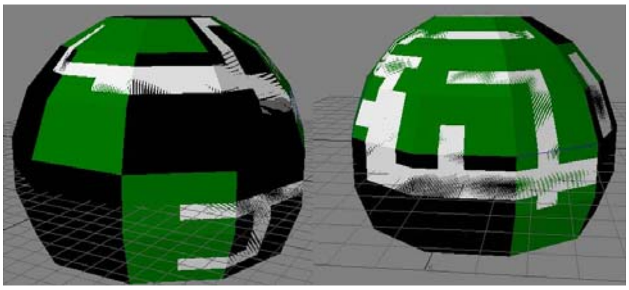

Figure 5: 3D visualization of the world energy trade left: Americans, right: Eurasia

# 6 Correlation between CO2 emission and energy consumption

Figure 6 is a bivariate plot of regional CO2 emmision (1,000 tons)[Y-axis] and regional total energy consumption[x-axis]. It indicates a relatively good correlationship between environmental stress and resouces consumption.

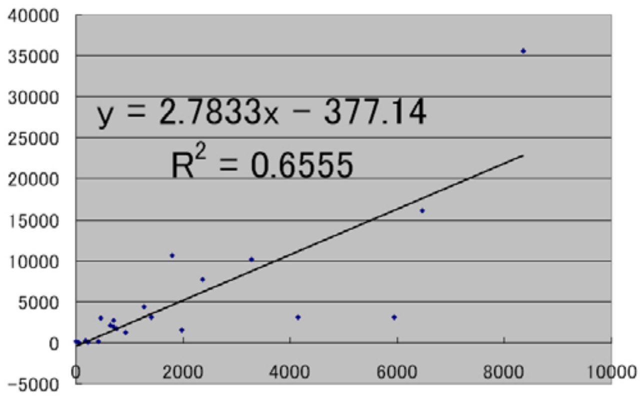


Figure 6: CO2 emission and energy consumption

# 7 Food

The problem is how much those population rich regions demand food in 2030. It depend on the stage of economic development of that region. There is a approximate correlationship between per capita GDP with diet habit. To survive merely, man needs about 1,700 Kcal per day (ca. 200 Kg grain per capita per year). However, the richest region such as North America, people eat a lot of beef so that an average American consumes about 10,000 ton of grain. 80 percent of 10,000 ton means to feed animals. To produce 1 Kg of beef, we need 16 Kg of feed grain, mostly corn. As for pork and broiler, we have to feed them 6 Kg and 3 Kg respectively.

Table 5: Regional annual food production in 2030 (unit = 10 to the power of 12 Kcal per year)

| | | | | | |
|---|---|---|---|---|---|
| Polar Canada 22.0 | North EU 156.0 | Rusia 211.6 | Cent. Siber. 11.4 | East Siber. 11.4 | |
| USA 1,545 | South EU 1,064.7 | Caspi an 221.9 | C Asia 95.6 | N China 679.5 | Korea Japan 87.0 |
| C Ame rica 173.2 | Sahar 180.9 | Arab 116.1 | India SEAs 1,799 | S China 678.7 | |
| Ama zon 390.8 | Congo 441.3 | | | marin Asia 328.7 | |
| Patago nia 224.8 | S Africa 82.2 | | | Ocean-ia 198.8 | |

Table 6: Regional annual food consumption in 2030 (unit = 10 to the power of 12 Kcal per year)

| | | | | | |
|---|---|---|---|---|---|
| Polar Canada 6.9 | North EU 191.6 | Rusia 165.0 | Cent. Siber. 9.1 | East Siber. 9.1 | |
| USA 985.5 | South EU 1,150 | Caspi an 98.9 | C Asia 126.3 | N China 980.4 | Korea Japan 271.9 |
| C Ame rica 227.8 | Sahara 261.0 | Arab 263.9 | India SEAs 1,561.5 | S China 992.1 | |
| Ama zon 198.6 | Congo 858.8 | | | marin Asia 294.2 | |
| Patago nia 67.0 | S Africa 96.4 | | | Ocean ia 59.1 | |

The annual food requirement of mesh (i,j) is estimated
a diet habit factor
(from 2,000 Kcal/day/man to 7,000 Kcal/day/man)
times the population of mesh(i,j) in 2030.

We extraporate the food production obtained by FAO statistics, which reports the world food production since 1990 on the country basis (Table 5). In the same manner, table 6 is the regional annual food consumption in 2030.

Based on table 5 and table 6, we can calculate the difference between the production and the consumption at each region mesh (i,j). Table 7 shows the difference in the unit of 10x12 Kcal. Minus means that the area mesh(i,j) can not support itself. This result indicates that the world can not support itself in 2030 otherwise we would not have some food stock

Table 7: Regionl food surplus vs shortage in 2030 (unit = 10 to the power of 12 Kcal per year)

| | | | | | |
|---|---|---|---|---|---|
| Polar<br>Canada<br>15.1 | North<br>EU<br>-35.6 | Rusia<br><br>46.6 | Cent.<br>Siber.<br>2.3 | East<br>Siber.<br>2.3 | |
| USA<br><br>559.5 | South<br>EU<br>-85.3 | Caspi<br>an<br>123 | C<br>Asia<br>-30.7 | N<br>China<br>-300.9 | Korea<br>Japan<br>-184.9 |
| C Ame<br>rica<br>-54.6 | Sahar<br><br>-26.1 | Arab<br><br>-147.8 | India<br>SEAs<br>237.5 | S<br>China<br>-313.4 | |
| Ama<br>zon<br>199.2 | Congo<br><br>-180.3 | | | marin<br>Asia<br>34.5 | |
| Patago<br>nia<br>157.8 | S<br>Africa<br>-14.2 | | | Ocean-<br>ia<br>139.7 | |

over years. This study has not yet take the relation between annual flow and stocks world wide basis as an international trade.

larger exporter ⟷ smaller

larger importer ⟷ smaller

| food export / import | N Amrica | Amazon | SS America | India SEAsia | Oceania | Caspian | Russia | maritime Asia |
|---|---|---|---|---|---|---|---|---|
| S China | 24 | 52 | 75 | 23 | 15 | 30 | 33 | 15 |
| N China | 24 | 56 | 75 | 25 | 23 | 25 | 25 | 23 |
| C Asia | 32 | 60 | 80 | 28 | 31 | 17 | 17 | 30 |
| Korea Japan | 20 | 48 | 70 | 38 | 30 | 35 | 30 | 23 |
| Congo | 30 | 15 | 22 | 25 | 30 | 38 | 34 | 23 |
| Arab | 24 | 38 | 37 | 8 | 30 | 8 | 17 | 23 |
| S EU | 20 | 30 | 38 | 23 | 45 | 8 | 14 | 37 |
| C America | 8 | 8 | 23 | 56 | 60 | 38 | 45 | 38 |
| N EU | 20 | 30 | 38 | 25 | 48 | 15 | 8 | 42 |

Figure 7: Food export and import matrix (unit = days for delivery )

# 8 Relation between energy consumption and food production

Table 4 is how much energy (Kcal) a region would consume in 2030 and table 5 is how much food (Kcal) a region would produce. We want to know how much percentage of the total energy consumption would

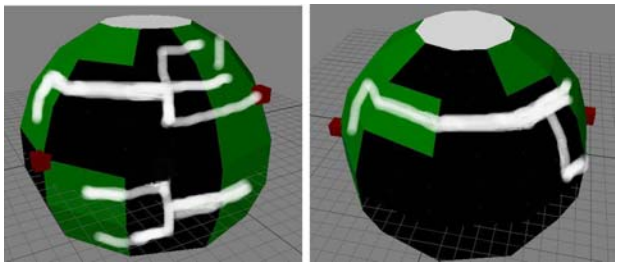

Figure 8: 3D visualization of the world food trade left: Atlantic, right: Pacific

be used for food production in a specific region. We would like to group agricultural practice into two major calsses. In developed contries, it is a commen practice to use large amount of chemical products (i.e.,fertilize and pesticide) and machinary use. On the other hand, farmers in developing countries such as todays equatrial Africa (”Congo” in this paper) can not afford those modern input.

E.Ishikawa made a trial calculation as of energy input output of rice farming based on data provide by Science and Technology Agency, Japan[3]. His calculation is the following:

1. an organic farming case; only human labor is the necessary input. We can get 1 Kcal of rice output against 0.07 Kcal of human labor.

2. a modern agriculture case; human labor, chemical products, and machinary (including deprediation and running) are inout. To get 1 Kcal of rice output, we have to input about 0.68 Kcal of energy.

Lets’ apply this assumption to ”Congo”. To output 411.3 x 10 to the power of 12 Kcal of food, 28.8 x 10 to the power of 12 Kcal is necessary. If 2,287 x 10 to the power of 12 Kcal is probable energy consumption, input energy for food production is only 0.01 percent.

Let’s apply this assumption on Korea and Japan region in 2030. As food, 87.0 x 10 to the power of 12 Kcal should produce there. To produce this amout of output, the necessary input energy is 59.2 x 10 to the power of 12 Kcal. At the same time, the expecting total energy consumption in this region is 10618 x 10 to the power of 12 Kcal. To cut a long story short, the necessary energy input for food production is negligible (0.0006 percent).

This simple calculation tells that total energy consumption and the necessary energy input for food production have almost nothing to do each other. Energy crisis and food shortage crisis do not have much correlationship.

# 9 Conclusion and a feasible scenario

We examine the interelations of energy, CO2 emission, and food in 2030 based on statistics prepared by various international organizations.

- CO2 emission and energy consumption has close correraltion. We have to device feasible measures to decrease energy consumption as soon as possible.
- so-called food crisis might be less anyhing to do with other parameters (energy and CO2). We have to look closely at the inner mechanizsm of food production.

As for food problem, the author proposed three feasible solutions There would be three feasible measures at 4th WSEAS Int. Contf. on Environement, ECOSYSTEMS and DeVELOPMENT in Venice 2006[4]. They were (1)increase the total agricultural production, (2) manipulate the worldwide food transportation logistics, (3) an advancement of another diet habit such as vegetarian diet in a modern form.

The upper figure in Figure 9 tells that the increasing feed is the major contributor in food supply problem. Recently, synthesizing bio-methanol out of sugar cane and corn makes the 3 playeres trade-off game more difficult. To cope with this dilemma, the lower figure in Figure 9 is how much we can get animal protein as a result of feedings.

In average, grain has about 6 percent of protein in it so that, as of 2007, we can have 133 million ton of vegetable protein out of grain. In th same manner, out of beans, potatos, and vegetables, we can get more than 70 million tons of vegetable protein. Today, worldwide basis, about 40 percent of total grain and beans are used for feeding. As a result, we obtain 40 million tons of animal protein altogether. Based upon this calculation, if we give up 1 Kg of animal protein, we can save 13 Kg of vegetable prorein. Growing up youngsters need some amino acid only available from animals but adults do not need so much animal origine protein. The sum of pupulation of China and India makes up almost half of the world population. It is a good fortune that both Chinese and Indians have had historical tradition of vegetable protein diet. If we could develop new types of instant food as same as cup noodles, it might save the world food crisis in the future.

## Acknowledgements

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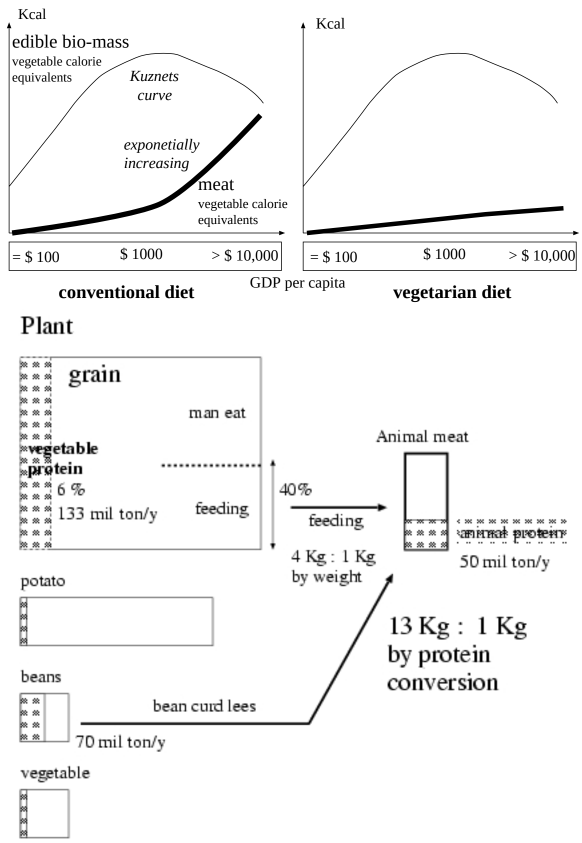


Figure 9: vegetable protein and animal protein

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