Estimation on the Incidence of World Scale Food Shortage using the Interactive 3D Digital Globe

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Abstract:- For decades, D. L. Meadows and his colleages have been cautioning about a catastrophe, which would be triggered by the conflicts over food supplies, natural resources, and environmental issues. The author attempts to simulate how and under what conditions the catastrophe would come about by applying the simplest form of an Interactive 3D Digital Globe, as the continuation of the previous study presented at EEESD'06.
This Interactive 3D Digital Globe segmentalizes the surface of the Earth into 90 regions or meshes, each of which is consisted of four layers, namely, a layer of the undergraound non-renewable natural resources, that of the biosphere-atomosphere-ocean system, that of the man-made material production, and that of the man-made value system.
This literature looks closely into the subject of food supply-and-demand issue around the 2030's, under the conditions that surplus grain stock would have diminished to a greater extent, and that climatic aberration would have randomly triggered natural disasters over the world; and stimulates the probable circumstances that would lead to a world scale famine and confusion consequent upon food trade disturbances in that future time frame.

Keywords:- system dynamics, climatic aberration,interactive 3D digital globe (Aizu model)

1 Introduction

1.1 Point Model vs. Geographical Model

D. L. Meadows and his colleagues have been making significant contribution to resolving the world's environmental issues since 1972[1] and many researchers worldwide have followed in their footsteps. After the Kyoto Protocol was adopted in 1997, even more research literatures have been published and numerous comments have been made not only by academics in this field but also by laymen and government agencies.

D. L. Meadows's team has selected pupulation, food, natural resources, and environment as the parameters for simulating the world dynamics. However, the world dynamics is not suitable for analysis of the individual regions of the world. It was a point model that has made the analysis of the whole world. i.e., Meadows poses a question, "What will become of the world if people keep consuming the natural resources". In 2005, Katrina, the largest hurricane ever, hit the Mississippi Delta and inflicted heavy damage on that region. And yet, if we were to take the entire Uinted State as an individual entity, or a point, it had sufficient food supplies and a variety of logistics measures. Only when we examine this disaster using the geographical model, we could appreciate how this climatic phenomenon had escalated into a national disaster because the food supplies and aid did not reach the lower Mississippi regions from other parts of the United States.
At the IASME/WSEAS International Conference on ENERGY,ENVIRONMENT,ECOSYSTEMS, SUSTAINABLE DEVELOPMENT (EEESD'06) Athens, Greece, the author proposed "the Simplest Interactive 3D Digital Globe" hereinafter referred to as the "Aizu model". as a tool for stepping forward. The major characteristics of the Aizu model are follows:

- The Aizu Model segmentalizes the globe into 90 meshes or regions, by dividing the surface of the Earth by 9 latitudinal and 10 longitudinal lines.
- Each mesh is consisted of 4 major layers. They are;

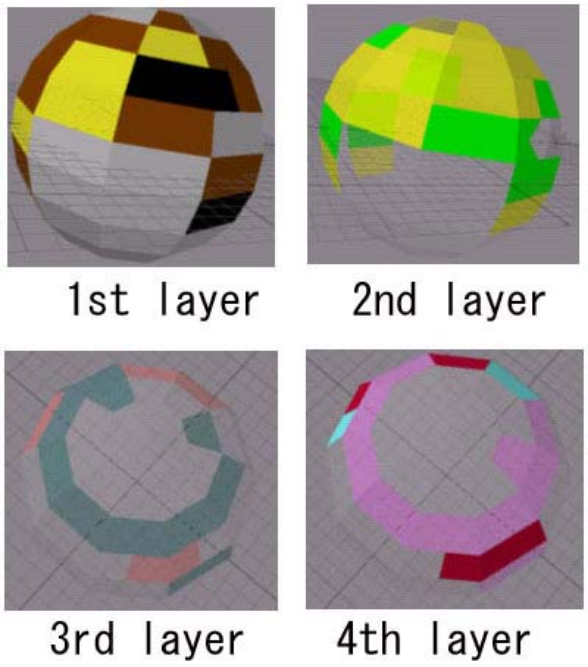

Figure 1: 90 meshes with 4 layers "Aizu model"

  - layer 1: A layer of underground mineral resouces, especially those that are non-renewable energy resources such as fossil oil and gases.
  - layer 2: A layer of the biosphere-atmosphere-ocean system including solar energy. This system has been nurturing mankind throughout the history. However, ever since the advent of Industrial Revolution, it has been seriously stressed out owing to farmful effect of the by-products of man-made material production
  - later 3: A layer of man-made material production, including the production of agriculture, forestry, fishery industry, the production of manufacturing industry, and the transportation of the material products, which is also referred to as a layer of the "atom".
  - layer 4: A layer of man-made value system including religion, political activities, financila activities, thechnological development, and the propagation of technology, which is also reffered to as a layer of "bit (or information)".

- Database function: It allows you to input and update a variety of worldwide statistical data via the visualized 3D globe. The globe browser depicted by Java3D interfaces with the to Microsoft ACCESS database software.

- Visualization Function: It allows you to visualize the simulated image of the database created by 3D CG globe browser.

N.Negroponte at MIT Media Lab has proposed a new approach appropriate in teh age of the Internet, to differentiate human activities into the atom or material-realted and the bit or information- and the value system-related activities[2]. The bit or information travels around the world at the speed of light; Whereas the atom or materials, moves at speeds of 500 to 1,000 Km/h at the maximum, if some products are to be transported by air. The atom can exist by itself (such as a sheet of paper), whereas the bit must have some type of media for its existence, such as one doller bill.

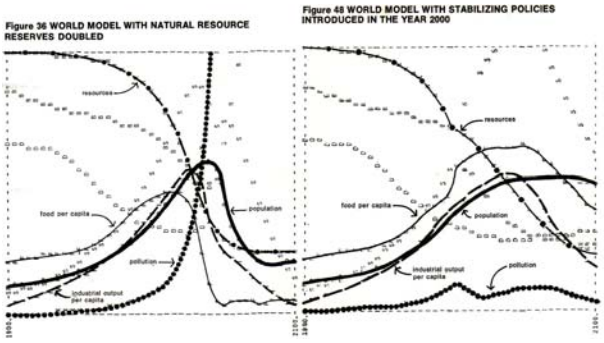

Figure 2: Two simulations results by Meadows' team (after Fig.36 and Fig 46 in "Limit to Growth")

1.2 Casualties of Natural and Man-made Disasters

Figure 2 is the quatations of simulation results presented in "Limit to Growth" . As we well know that the left side figure indicates the feasible catastrophe and the right side figure is what Meadows' recommend mankind to select for the survive through a prudent way of living. If we understand the scales and figures in the leftside figure literally, the death toll from 2040 to 2080 would be ca. 4.5 billion then the world population would stabilize at the low level of ca. 3.5 billion.

Mankind has suffered various natural and man-made disasters throughout in history. If a nuclear war had broken out during the cold war, it is estimated that the death toll would have been in the order of billion at that time the world population was three billion. And the death toll of the World War II is estimated to total over 20 million when the world population was two billion.
In 2004, the tsunami off the coast of northern Sumatra killed more than 120,000 in Indonesia, Thailand, and Sri Lanka.
So-called Little Ice Age brought down a frigid climate and devastated agriculture all over the world, and as

Table 1: death toll due to various disasters

desastrous event	death toll (the world population 8 billion base)
nuclear war	3 billion
World War	0.08 billion
potate famine	1.5 billion
Indonesia tidal wave	0.4 million
pollution	2000

the result, 1.5 million people out of total population of 8 million starved to death during the potato famine of 1840's in Ireland. Some researchers attribute the grave magnitude of this famine to the inability to implement the emergency measures to import food supplies from abroad even though sailing vessels were available at that time.

From 1960's to 80's, hundreds of people became the victims of environmenta; pollution in Japan. Over a hundred people died of mercury and cadmium poisning, and another hundred died of severe asthma induced by air pollutants. The population of Japan was 120 million at that time. The Japanese government as well as private industrial firms paid little attention to the well being of its people and instead, put a high value to economic growth much like the current policy of the Chinese government.

Table 1 shows the fatality of each disaster if the world population was extrapolated to 8 billion in the year 2030.

Many environmentalists have predicted that the environmental deterioration would bring about the disasters of a great magnitude[3]. However, Table 1 shows otherwise, and indicates that the fatality induced by the deterioration of environment is much less compared to other types of disater. The death toll, for instance, from starvation would be expected to rise much higher. In cases where the international trade of food supplies should fail to function, food shortage would trigger a disaster of grave consequences[4]. Thus the author attempts to verify the possibility of a large-scale famine being the primary factor for triggering a world-scale catastrophe.

2 Simulation strategy

Basic assumption: The surplus food stock in the United State and EU decreases significantly diminished.

- " The non-renewable fossil underground water in the United State would have been depleted by the year 2020 due to the overuse of the irrigation system, greatly reducing the agricultural yield.
- According to the projection made by "the Earth Simulator" in Japan, global warming would continue to escalate, the amount of annual precipitation in the United State and Europe would gradually decrease over the next one hundred years.[6].
- As the result, the agriculture in Europe would have dwindle. In other words, the elasticity of the food markets worldwide would be reduced. Simultaneously, rapid economic growths in China and India would have generate a tremendous demand of food.

Out of 90 meshes in the "Aizu model", 24 meshes represent land areas. (Other meshes for the oceans.)

1. food consumption at each mesh in 2030.
   Based on the statistical data, which have been made available by the United Nations, the total population for each land mesh in the year 2030 is extrapolated. And by estimating the economic growth level of that region, we could obtain the total amount of food intake required within the mesh by multiplying the number of population by an individual's daily food intake. e.g. the minimum daily calorie demand per capta is ca. 2,000 Kcal in the poor area, while USA people consume almost 7,000 Kcal daily, because they eat a lot of beef and other meat.

2. food production at each mesh in 2030
   Based on the FAO statistical data, the total africultural yield in each land mesh in the year 2030 is estimated.

3. food export and import matrix in 2030 Based on estimations of item 1 and 2, the surplus and shortage of food supplies in each mesh is estimated.

4. Using the mathematical approach of random function, climatic aberration is artificially creat over 24 meshes. These simulated results indicate that the cimatic aberration would bring about severe shortage in food production in the affected areas. In order to compensate for the shortage, food supplies would have to be transported through international trading. However, if the affected area were randomly dispersed over the globe, the food supplies (the atom) would have to take a great length of time being transported into the areas by seas or by land, and in some cases long delays in transporting much needed food supplies and aid would be unavoidable.

Table 2: 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	Caspian 143	C Asia 99	N China 686	Korea Japan 181
C America 359	Sahar 454	Arab 475	India SEAs 2513	S China 695	marin Asia 457
Amaz 311	Congo 1594				Ocean-ia 47
South S America 107	S Africa 154				

Table 3: Regional annual food consumption in 2030 (unit = 10x12 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	Caspian 98.9	C Asia 126.3	N China 980.4	Korea Japan 271.9
C Americ 227.8	Sahar 261.0	Arab 263.9	India SEAs 1,561.5	S China 992.1	
Amaz 198.6	Congo 858.8			marin Asia 294.2	
SouthS Americ 67.0	S Africa 96.4			Ocean ia 59.1	

3 Simulation

3.1 food demand

Based on United Nation statistics, Table 2 is the calculation how huch population each mesh will have in 2030. For the simplicity sake, numbers are rounded at million.

As we understand well, the population of North Europe, Russia & Siber., and Korea&Japan will decrease significantly through out this century. On the other hand, India & SE Asia, North & South China, Congo(equatorial Africa) make two-third of the world population (ca. 5.5 billion).Because of compulsory birth control policy by the Chinese goverment, the population of China will not increase significantly.

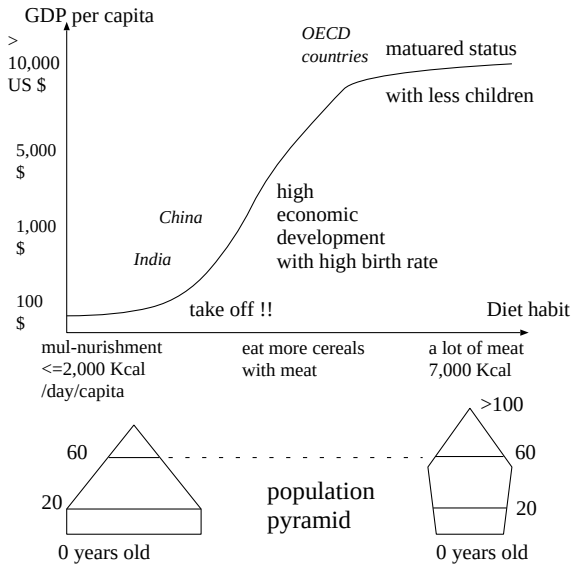

Figure 3: Economic growth and diet habit

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 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 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.

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.

3.2 food production per mesh(i,j)

We extraporate the food production obtained by FAO statistics, which reports the world food production since 1990 on the country basis (Table 4).

3.3 food surplus vs shortage at mesh(i,j)

Based on table 3 and table 4, we can calculate the difference between the production and the consumption at each region mesh (i,j). Table 5 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 over years. This study has not yet take the relation bewteen annual flow and stocks world wide basis as a international trade.

Table 4: Regional annual food production in 2030 (unit = 10x12 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	Caspian 221.9	C Asia 95.6	N China 679.5	Korea Japan 87.0
C Americ 173.2	Sahar 180.9	Arab 116.1	India SEAs 1,799	S China 678.7	
Amaz 390.8	Congo 441.3			marin Asia 328.7	
SouthS Americ 224.8	S Africa 82.2			Oceania 198.8	

Table 5: Regionl food surplus vs shortage in 2030 (unit = 10x12 Kcal per year)

Polar Canada 15.1	North EU -35.6	Rusia 46.6	Cent. Siber. 2.3	East Siber. 2.3	
USA 559.5	South EU -85.3	Caspian 123	C Asia -30.7	N China -300.9	Korea Japan -184.9
C Americ -54.6	Sahar -26.1	Arab -147.8	India SEAs 237.5	S China -313.4	
Amaz 199.2	Congo -180.3			marin Asia 34.5	
SouthS Americ 157.8	S Africa -14.2			Oceania 139.7	

4 Discussion

The estimation foresee a feasible incidence of world scale food shortage. Different from the point model created by D. L. Meadows and his colleages, Aizu model has to concern the regional unevenness. The author would like to propose three scenarios.

Scenario 1: a Future of Conventional Diet

In the 1960's when D. L. Meadow made the simulation, the major problem was the absolute shortage of daily grain intake per capita. In the 2030's, the problem comes from the diet habit change that more people prefer the protain rich diet so that larger part of total edible bio-mass is used to feed stock. An feasible solution would be to increase bio-mass. However, since 1990, there is no major agricultural technology advancement as same as "the Green Revolution".

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 4: Food export and import matrix (unit = days for delivery

Scenario 2: Manage Worldwide Logistics

Table 5 shows in which mesh M(i,j) has food surpluses and shortages around 2030. Figure 4 is the result of rearrangement among the possible exporters and possible importers in a single matrix chart. Along the uppermost line, North America mesh loctes at the leftmost cell and other exporters locate according their capabilities. On the top cell along the leftmost row, North China mesh locates the largest importer. Then after, South China mesh, Central China mesh, Korea and Japan mesh follow.

The custom office of Tokyo Port, Japan provides a rough estimation as for delivery time both on sea and on land. To transport 1 ton of grain on bulk cargo ship, its average sailing speed is about 15 knot. For

example, it takes 19 days and 18 hours from LA port to Shanghai, South China. On land, 4 ton truck run at an average speed 20 km/hour. Most of roads in the world are not so well maintained as those in the developed countries. The figure shows rough estimation how many days for delivery from one region to another region in the world.

Judging from the delivery time estimation, it is strongly recommended that we should select the logistics routes as short as possible. The most serious reion are north and south China. Only North America has the capabilty to rescue the Chinese people.

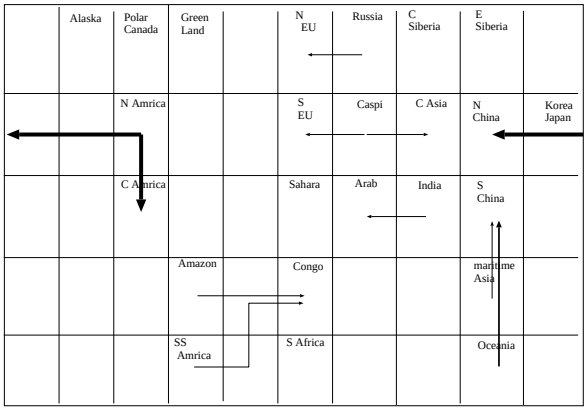

Figure 5: The Shortest Logistics Passes

Scenario 3: Promote a Vegetarian Diet

The quick economic advancement in China and India might create an incidence of world scale food shortage. Because the Chinese and the Indian would prefer more proteins as their life style become richer. However, we could remind that both the Chinese and the Indian have had a long history of vegetarian diet originating from their traditional religions. Especially, Zen buddism had developed a cuisine of vegetarian dishes consisiting of rich protein ingredients which are delicious and visually appetizing. Growing youngsters need specific amino acid which only animal meat can provide. However, adult people need less animal origin protein. The problem of Asian vegetarian dishes are cooked by specialty restaurants ususally locating next to the temples. As a feasible measure, we better think of industrialization of Asian vegetarian diet.

This strategy would decreases the competition between edible bio-mass vs. feed bio-mass. It is better than strategy of demanding patience and sparing.

5 Conlusion and Future Study

This paper deals with the imblance of food supply in the year 2030. There would be three feasible measures. First, increase the total agricultural production. Secondly, we manipulate the worldwide food tarnsfer logistics. Thirdly, an advancement of another diet habit in the meshes where the large population are economically developing quickly.

As future study, the author will examine the feasibility of the second scenario and the third scenario.

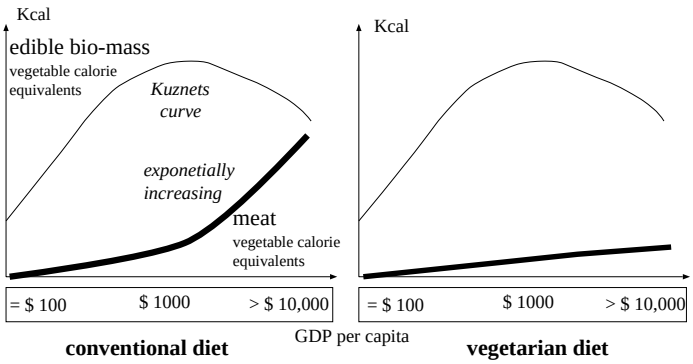

Figure 6: The conventional diet vs vegitarian diet

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