

GEOS 24705 / ENST 24705
Problem set #3
Due: Th. April 5

The slides shown in class (and posted here) show the arable land available for different countries, and the efficiency of food and biomass production. Use this information in the following problems.

Answer at least one of problems 1 and 2 (optional do both, and 2.4 is optional no matter what)

Problem 1: Food in crowded countries

Of all the countries you were shown, Bangladesh is the most crowded and has the lowest arable land available to each resident. Also in Bangladesh the staple crop is rice, not corn, with lower photosynthetic efficiency. But Bangladesh is not a rich country and likely not capable of importing much food, so they must be sustaining themselves. Check if this is possible.

Questions

- 1) What are the W in the form of food that can be captured per Bangladesh resident, by local farming?
- 2) Does this seem enough to sustain life as a relatively active farmer?
- 3) Is there room for meat production, population growth, or wastage?
- 4) Do your numbers agree with the implications about Bangladeshi arable land use from the last slides?

Problem 2: Food in the wealthy U.S.

The U.S. has much more arable land than Bangladesh. We also eat a fair amount of animal protein, with 1/3 of the typical U.S. diet deriving from animals. As a rough estimate you can assume that you must feed an animal 10 units of grain to produce one unit of meat / milk, etc., i.e. that to produce a given amount of calories as animal food you need 10 x the land that you would if you were a vegan. (If this does not make sense, draw a diagram and think about it). You can for estimation's sake assume that the average American still uses 100 W in food, but you might want to add a factor for food wastage in processing (your choice). You can assume that corn is a reasonable representative staple grain, and that animals are fed from farm-raised corn only. (The errors in those assumptions likely cancel).

Questions

- 1) How much land does each American need to produce the grain/vegetable part of the American diet?
- 2) How much land does each American need for the meat portion of his/her diet?
- 3) Does the U.S. have sufficient per capita arable land to feed its citizens this diet, or must we be importing food?
- 4) (*Optional*) The per capita use of fertilizer represents 100 W. If Americans were eating vegan this would imply that you needed 1 W of fertilizer to produce 1 W of plant food in the modern agricultural system. That high fertilizer rate would make you very wary of the difficulties of going organic. But it turns out a lot of our fertilizer use goes to raise grain to feed animals, so we are producing more plant food than your 100 W implies. Using what you know about the U.S. diet, what is the ratio of energy used in fertilizer manufacturing to chemical energy in plant food produced?

Problem 3: Vertical farms part 1.

Imagine that you are a vegan, enamored of vertical farms, and you decide to grow all your food indoors under artificial lights. To power those lights you'll grow biomass outdoors. For now, let's pretend that you have magical hydroponic lights that convert the chemical energy of your biomass into radiation energy with perfect efficiency— you need only produce as much biomass as the power requirement of your indoor farm.

Questions *Answer 1), then answer at least one of 3) or 4)*

- 1) What is the total power (in W) that you need to shine on your indoor farm to feed yourself with 100 W?
- 2) What is the area of your outdoor farm that makes the biomass that powers your grow lights? Does the U.S. have enough arable land?
- 3) You give up on biomass and decide to just buy electricity instead for your (perfectly efficient) lights. Typical household electricity usage is ~ 1 KW (lights, hot water heater, appliances). The retail rate for electricity in Illinois is ~ 10 cents per kWh. (1 kWh is the number of Joules converted if you use 1 KW of power for one hour). What was your monthly electric bill before you decided to grow your food inside? What is your bill after you plug in the hydroponic lights?