Topic IV Land and Water Use – Study Notes/Test Practice

1. Agriculture

Feeding a growing population – before agriculture, our ancestors were hunters and gatherers; starvation was common, very few people received an adequate diet; despite advances in agricultural productivity many people still do not get adequate nutrition – as many as 24,000 people starve to death each day – 8.8 million people each year

Human nutritional requirements – an average person needs approximately 2,200 kilocalories per day (varies with gender, age, and weight); in children, undernutrition can lead to improper brain development and lower IQ

Undernutrition – (chronic hunger) means not consuming enough calories to be healthy

Malnourished – regardless of the number of calories consumed, a diet that lacks the correct balance of proteins, carbohydrates, vitamins, and minerals will lead to malnourishment

Food security – the condition in which people have access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life

Food insecurity – refers to the condition in which people do not have adequate access to food

Famine - a condition in which food insecurity is so extreme that large numbers of deaths occur in a given area over a relatively short period

Anemia – iron deficiency; the most widespread nutritional deficiency in the world

Over nutrition – the ingestion of too many calories and improper foods, causing a person to become overweight; another form of malnutrition

Industrial agriculture (agribusiness) – applies the techniques of the industrial revolution (mechanization and standardization) to the production of food

Energy subsidy – the energy input per calorie of food produced

Green Revolution – a shift in farming methods during the 20th century, from a system of small farms relying mainly on human labor and with relatively low fossil fuel inputs to a system of large industrial operations with few people and much more machinery; increased food production dramatically

Irrigation – has many benefits including a more efficient use of water in places where it is scarce; it can also have a number of negative consequences over time – it can deplete groundwater and draw down aquifers, in coastal areas it can promote saltwater intrusion into freshwater wells. It can also contribute to soil degradation through waterlogging and salinization.

Waterlogging – occurs when soil remains under water for prolonged periods, this impairs root growth because roots cannot get oxygen

Salinization – occurs when the small amounts of salts in irrigation water become highly concentrated on the soil surface through evaporation; these salts can eventually reach toxic levels and impede plant growth

Fertilizers – contain essential nutrients for plants (primarily nitrogen, phosphorous, and potassium) and they foster plant growth where one or more nutrients is missing; two types – organic and synthetic

Organic fertilizer – composed of organic material from plants and animals

Synthetic (inorganic) – fertilizers that are produced commercially; advantages – are highly concentrated and increase crop yields tremendously, easy application with nutrient content that can be targeted to the needs of a particular crop, plants can easily absorb them even in poor soil; disadvantages include adverse effects on the environment, manufacture uses fossil fuel energy and while readily available for plant uptake, they are also more likely to be carried by runoff into adjacent waterways and aquifers causing algae and other organisms to proliferate leading to a reduction in oxygen levels in the water

Monocropping – large plantings of a single species or variety; the dominant agricultural practice in the U.S.; wheat and cotton are frequently grown in monocrops of 405 hectares (1,000 acres) or more

Controlling pests – Monocropping encourages increased pest populations

Pesticides – substances, either natural or synthetic, that kill or control organisms that people consider pests. In the US, over 227 million kilograms (500 million pounds) of pesticides are applied to food crops

Types of pesticides: insecticides – target species of insects and other invertebrates that consume crops; herbicides – target plant species that compete with crops; broad spectrum pesticides – kill many different types of pests; selective pesticides – focus on a narrower range of organisms

Persistent pesticide – pesticide that remains in the environment for a long period of time (DDT)

Bioaccumulation – an increased concentration of a chemical within an organism over time

Non persistent pesticide – pesticide that breaks down relatively rapidly (weeks to months)

Resistant – when individuals are not as susceptible as others and survive an initial application of the pesticide (a disadvantage of pesticide use); in future generations, the number of resistant individuals in the population will increase

Pesticide treadmill – the cycle of pesticide development, followed by pest resistance, followed by new pesticide development and so on…. (an example of a positive feedback system)

Integrated pest management – (IPM) uses a variety of techniques designed to minimize pesticide inputs; include crop rotation and intercropping, the use of pest-resistant crop varieties, creating habitats for predators of pests, and limited use of pesticides

Genetic engineering – Benefits: increased crop yield and quality, reduced need for pesticides, increased profits; Concerns: safety for human consumption, effects on biodiversity, no current regulations of labeling genetically modified organisms (GMOs) in the US; applications for a number of genetically modified animals are currently under consideration by the Food and Drug Administration.

Sustainable agriculture – fulfills the need for food and fiber while enhancing the quality of the soil, minimizing the use of nonrenewable resources, and allowing economic viability for the farmer; practices for sustainable agriculture include: intercropping – where two or more crop species are planted in the same field at the same time to promote a synergistic interaction between them. (For example: corn, which requires a great deal of nitrogen, can be planted along with peas, a nitrogen-fixing crop); crop rotation – achieves the same effect as intercropping by rotating the crop species in a field from season to season (For example, peas can be planted in an field for one year, leaving excess nitrogen in the soil to nourish the corn crop that is planted there in the following year); agroforestry – the practice of intercropping trees with vegetables, allows vegetation of different heights, including trees, to act as windbreaks and catch soil that might otherwise be blown away, reducing erosion; contour plowing – alternative methods of land preparation and use can also help conserve soil and prevent erosion

No-till agriculture – designed to avoid the soil degradation that comes with conventional agricultural techniques; farmers leave crop residues in the field between seasons – roots holds soil in place reducing wind and water erosion, and undisturbed soil is able to regenerate soil horizons; also reduces emissions of CO2 because the intact soil undergoes less oxidation; downside – in order for no-till to be successful, farmers often must apply herbicides to the fields so weeds do not compete with the crops

Organic agriculture – the production of crops without the use of synthetic pesticides or fertilizers

High-density animal farming – concentrated animal feeding operations (CAFOs), large indoor or outdoor structures designed for maximum output (beef cattle, dairy cows, hogs, poultry); minimizes land costs, improves feeding efficiency, and increase the fraction of food energy that goes into the production of animal body mass, animals given antibiotics and nutrient supplements to reduce risk of adverse health effects and diseases; consequences: evidence that antibiotics given to confined animals are contributing to an increase in antibiotic-resistant strains of microorganisms that can affect humans, waste disposal is also a serious problem, an average CFAO produces over 2,000 tons of manure annually, can be used as fertilizer but over application can lead to the same nutrient runoff problems as synthetic fertilizer. The US Environmental Protection Agency (EPA) has concluded that chicken, hog, and cattle waste has caused pollution along 56,000 km (35,000 miles) of rivers in 22 states and has caused some degree of groundwater contamination in 17 states

*Free-range* meat, if properly produced, is more likely to be sustainable than meat produced in CAFOs; downside – free-range operations use more land than CAFOs and cost of meat produced using these techniques is usually significantly higher

Test Practice: Preparing for the Exam…..Multiple Choice Questions

1. Which of the following does *not* explain the rise of the modern farming system?
   1. The cost of labor varies from country to country.
   2. Small farms are usually more profitable than large farms.
   3. Irrigation contributes to greater crop yields.
   4. Fertilizers improve crop yields and are easy to apply.
   5. Mechanization facilitates monocropping and improves profits.
2. Irrigation can result in which of the following environmental problems?
3. Reduction of evaporation rates
4. Accumulation of salts in soil
5. Waterlogging of soil and plant roots
   1. I only
   2. II only
   3. III only
   4. I and II
   5. II and III
6. The use of synthetic fertilizers increases crop yield, but also
   1. destroys the nitrifying bacteria in the soil
   2. increases fish populations in nearby streams
   3. decreases phosphorous concentrations in the atmosphere
   4. increases nutrient runoff into bordering surface waters
   5. slows the release of organic nutrients from compost
7. Which of the following statements *best* describes the pesticide treadmill?
   1. Broad-spectrum pesticides degrade into selective pesticides, thereby killing a wide range of insect pests over a long period.
   2. Pesticides accumulate in the fatty tissues of consumers and increase in concentration as they move up the food chain.
   3. Some pest populations evolve resistance to pesticides, which become less effective over time, so that new pesticides must be developed.
   4. Beneficial insects and natural predators are killed at a faster rate than the pest insects.
   5. Testing of the toxicity of pesticides to humans cannot keep pace with the discovery and production of new pesticides.
8. In which of the following ways did the Green Revolution increase food production?
9. The development of disease-resistant and high-yielding crop plants
10. Monocropping and the widespread use of machinery
11. The application of fertilizers and the use of irrigation techniques
    1. I only
    2. II only
    3. III only
    4. I and III
    5. I, II, and III
12. Which of the following is *not* a traditional farming technique that is used in sustainable agriculture?
    1. Nomadic herding
    2. Intercropping
    3. Crop rotation
    4. Agroforestry
    5. Contour plowing
13. Which of the following is an environmental advantage of no-till agriculture?
    1. The use of herbicides improves the stability of the soil.
    2. Migratory bird populations are reduced.
    3. The undisturbed soil is less susceptible to erosion.
    4. The crop residues reduce the soil profile.
    5. The concentration of CO2 in the fields is increased.
14. Which of the following practices is not a part of integrated pest management?
    1. Crop rotation
    2. Elimination of pesticides
    3. Use of pest-resistant crops
    4. Introduction of predators
    5. Frequent inspection of crops
15. Farmers who practice organic agriculture have less of an impact on the environment than farmers who practice industrial agriculture because they
    1. Use no-till agriculture exclusively
    2. Import soil to maintain soil fertility
    3. Maintain large farms with a single crop
    4. Avoid pesticides and synthetic fertilizers
    5. Have lower labor costs
16. Critics of using genetically modified organisms as food crops warn of which of the following dangers?
17. Introduction of new allergens into the food supply
18. Loss of genetic diversity in food crops
19. Decreases in food production worldwide
    1. I only
    2. II only
    3. III only
    4. I and II
    5. I and III
20. Concentrated animal feeding operations (CAFOs) can *best* be described as
    1. Facilities where a large number of animals are housed and fed in a confined space.
    2. A method of producing more meat at a higher cost.
    3. A means of producing great quantities of manure to fertilize fields organically.
    4. An experimental plan to test the effectiveness of antibiotics.
    5. The storing and compacting of grain for use as a nutrient supplement for cattle.
21. Which of the following is *not* an environmental or health problem that has been associated with CAFOs?
    1. The increase of antibiotic-resistant bacteria potentially harmful to humans.
    2. The overgrazing of large tracts of land.
    3. The runoff of animal wastes into natural waters.
    4. The production of huge quantities of manure, creating a waste disposal problem.
    5. The use of grain as feed, reducing the food supply available to humans.

Test Practice: Preparing for the Exam - Free Response Questions

1. Maintaining dairy cattle in a CAFO requires large quantities of water and produces vast quantities of wastewater and manure. The increasing number of CAFO dairies in eastern New Mexico and West Texas is contributing to significant groundwater contamination and the depletion of the Ogallala aquifer. Consider a CAFO with 1,000 dairy cows and answer the following questions.
   1. According to the U.S. Department of Agriculture, the average dairy cow can consume up to 200 L of water daily. An additional 120 L per cow per day is required to wash the milking equipment and milking area. How many liters of water are required to operate this dairy daily? (2 points)
   2. According to the U.S. Environmental Protection Agency, the average dairy cow produces 55 kg of wet manure daily. How many metric tons would this dairy produce each day (1,000 kg = 1 metric ton)? (2 points)
   3. The recommended maximum manure application rate for a farm site with low runoff potential is approximately 275 kg per hectare. What size farm would be required to apply all of the manure produced by this dairy each day? (2 points)
   4. Identify one environmental problem that could be caused if the rate of runoff of nitrogen from the manure into natural waters became excessively high. Describe one way to prevent this problem. (2 points)
   5. If this same dairy herd was raised in a free-range operation, identify and explain one environmental problem, other than water pollution, that would be minimized or eliminated. (2points)
2. The following results of a survey of 113 people conducted in Trinidad, West Indies, appeared in a 2006 edition of the *British Food Journal*:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Questions | Very likely | Somewhat likely | Not too likely | Not at all likely |
| Would you be willing to purchase these foods (corn oil, potatoes, tomatoes, rice) which are bought regularly if they were genetically modified? | 15.9% | 31.9% | 38.9% | 7.1% |
| Would you purchase GM foods if they were considered healthier than conventionally produced foods? | 30.1% | 34.5% | 25.6% | 9.7% |
| Would you be willing to purchase GM foods if they were safe? | 15.9% | 31.9% | 38.9% | 7.1% |

* 1. Considering the “very” and “somewhat” responses as one group and the “not too” and “not at all” responses as another group, what percentage of the survey respondents would probably purchase GM foods? What percentage would not? (1 point)
  2. Referring to the second survey question, identify and explain two possible benefits of the inclusion of GM foods in the diet that might convince people to purchase these products. (4 points)
  3. Referring to the third survey question, identify and explain two possible dangers of the use of GM foods that might convince people not to purchase these products. (4 points)
  4. Identify one U.S. federal agency that is responsible for the regulation of GMOs. (1 point)

Do the Math…….. Feeding the World (ALWAYS show your work)

*We have seen that raising beef requires more resources than growing corn….calculate some actual numbers.*

1. On farms in the Midwestern United States, a hectare of land yields roughly 370 bushels of corn (equivalent to 150 bushels per acre). A *bushel* consists of 1,250 ears of corn, and each ear typically contains 80 kilocalories. Assume that a person eats only corn and requires 2,000 kilocalories per day.
2. How much land would it take to feed that person for one year?
3. What if that person ate only beef? It takes 20 kg of grain to produce 1 kg of beef, so it would take about 0.4 hectares (1 acre) of land to feed a person who ate only beef. Globally…… the Earth has about 1.5 billion hectares (37 billion acres) of land suitable for growing food.
   1. Is there sufficient land on Earth to feed all 6.8 billion inhabitants of the planet if they all ate a diet of only beef?
   2. If no, how many people eating a beef-only diet could Earth support?
4. If a person only eats apples and each apple contains 53 kilocalories,
   1. How many apples will the person need to eat to get all the kilocalories (2,200) they require per day?
   2. Month? (assume a 30-day month)
   3. Year?
5. If there are 6.8 billion people on the planet, how many apples would be needed per day to meet all the kilocalorie demands for the world?