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Lecture -15 & 16

**Resource use efficiency and optimization techniques,
Resource cycling and Flow of energy in different farming system farming system and environment**



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Efficiency

- Efficiency in any system is an expression of obtainable output with the addition of unit amount of input.
- The ratio of energy intake and energy of the produced biomass i.e. of input and output is called ecological efficiency. This can be studied at any trophic level.
- Resource use efficiency (fertilizer, water etc) is the output of any crop or any thing else per unit of the resource applied under a specified set of soil and climatic conditions.



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• Cultivated Land Utilization Index (CLUI):

- Cultivated land utilization Index (Chuang, 1973) is calculated by summing the products of land area to each crop, multiplied by the actual duration of that crop divided by the total cultivated land times 365 days.
- Where, n total number of crops; a_i area occupied by the i th crop, d_i , days that the i th crop occupied and A = total cultivated land area available for 365 days.

$$CLUI = \frac{\sum_{i=1}^n a_i d_i}{A \times 365}$$



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LUI can be expressed as a fraction or percentage. This gives an idea about how the land area has been put into use. If the index is 1 (100%), it shows that the land has been left fallow and more than 1, tells the specification of intercropping and relay cropping. limitation of CLUI is its inability to consider the land temporarily available to the farmer for cultivation.



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- FUE is the output of any crop per unit of the nutrient applied under a specified set of soil and climatic conditions.
- The NUE/FUE can be expressed in several ways.
- Mosier *et al.* (2004) described 4 agronomic indices to describe NUE: **partial factor productivity** (PFP, kg crop yield per kg input applied);
- **agronomic efficiency** (AE, kg crop yield increase per kg nutrient applied);



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- **apparent recovery efficiency** (RE, kg nutrient taken up per kg nutrient applied); and
- **physiological efficiency** (PE, kg yield increase per kg nutrient taken up).
- Crop removal efficiency (removal of nutrient in harvested crop as % of nutrient applied) is also commonly used to explain nutrient efficiency.



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- **Energy efficiencies**

- **Energy efficiency** = Energy output (MJ/ ha) / energy input (MJ/ ha)

- **Net energy (MJ/ ha)** = Energy output (MJ/ ha) - energy input (MJ/ ha)

- **Energy productivity (kg/MJ)** = output (grain + byproduct (kg/ha) / energy input (MJ/ ha)

- **Energy intensity** = energy (MJ/ ha) / output (grain + byproduct (kg/ha).



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Crop water use efficiency

- Crop water use efficiency is a ratio between marketable crop yield and water used by the crop in evapotranspiration.

Field water use efficiency

- Field water use efficiency is a ratio between marketable crop yield and field water supply which includes water used by the plant in metabolic activities, ET and deep percolation losses.



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Weed control efficiency

- $\frac{[\text{Weed count or dry weight in weedy} - \text{weed count or dry weight in a treatment}]}{\text{weed count or dry weight in weedy}}$

Resource use efficiency:

- Resource use efficiency in agriculture is defined to include the concepts of technical efficiency, allocative efficiency and environmental efficiency (Haque 2006).



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- **Technical efficiency** is the ability of a firm to produce a given level of output with minimum quantity of inputs under a given technology.
- **Allocative efficiency** is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of these inputs.



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- **Economic efficiency** is a product of technical and allocative efficiency.
- In one sense, the efficiency of a firm is its success in producing as large an amount of output as possible from given sets of inputs.
- **Maximum efficiency** of a firm is attained when it becomes impossible to reshuffle a given resource combination without decreasing the total output.

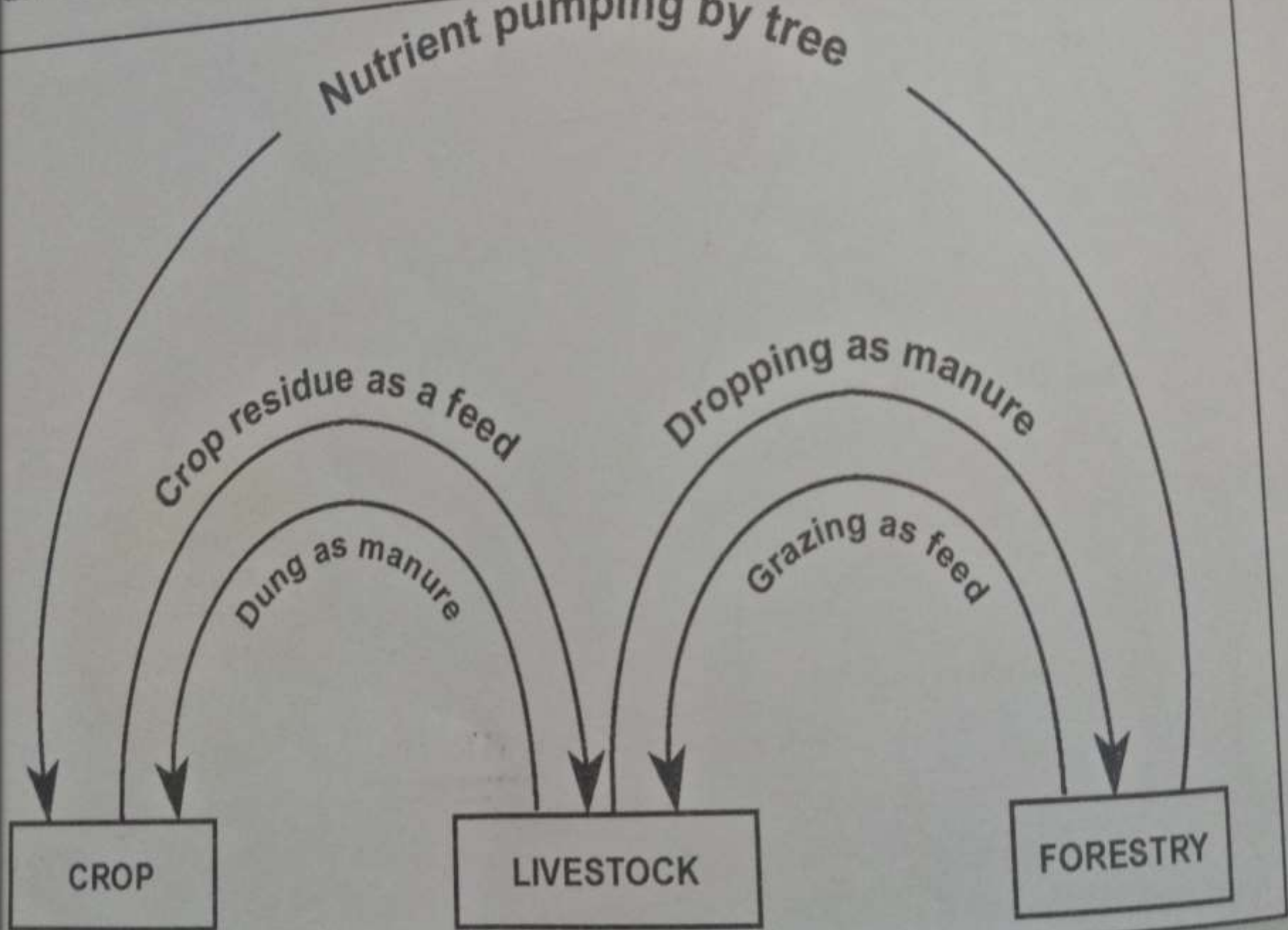


FIG 3.4. Resource flow model for crop-livestock-forestry farming system.

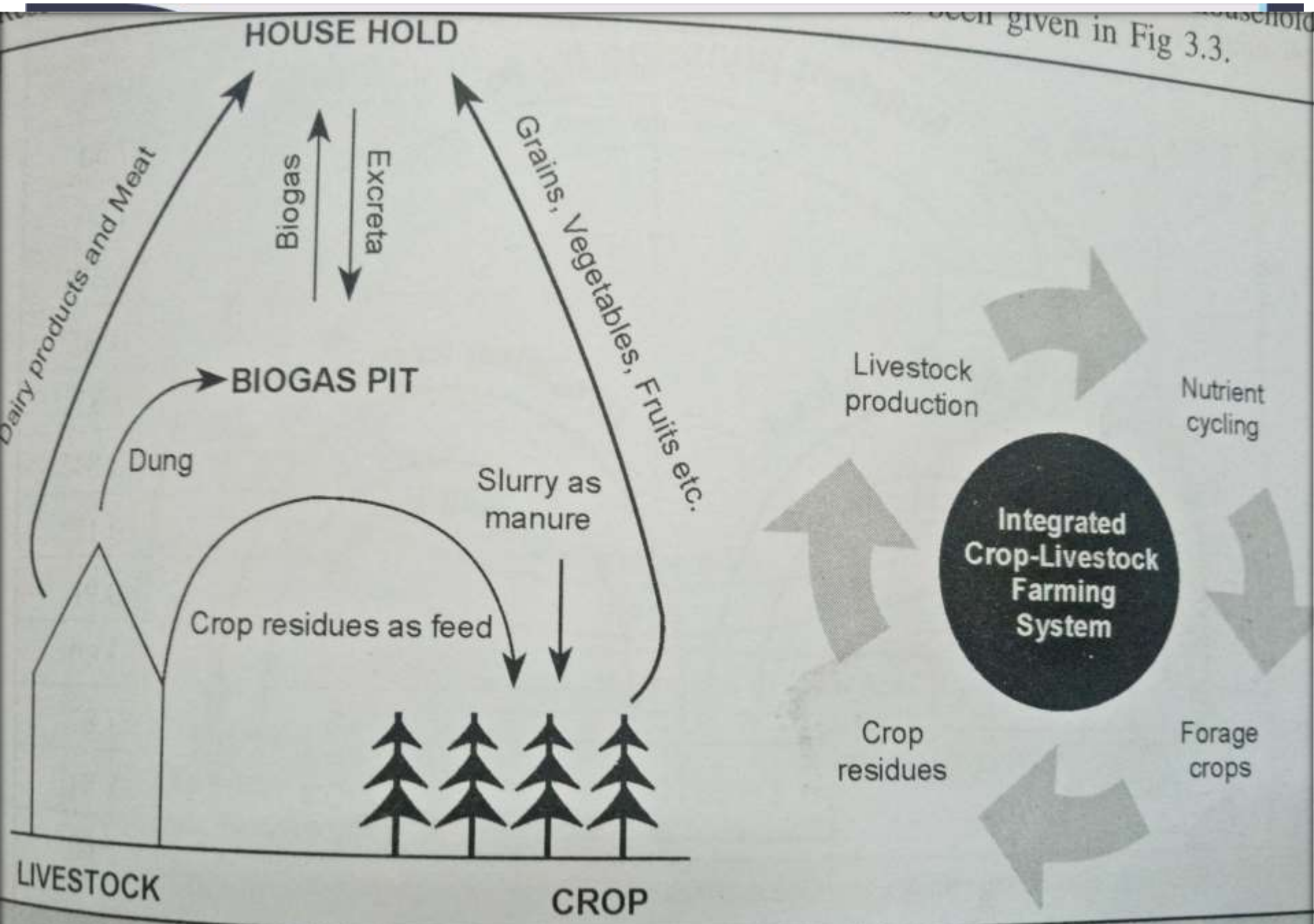


FIG 3.3. Resource flow model for crop-livestock farming system.

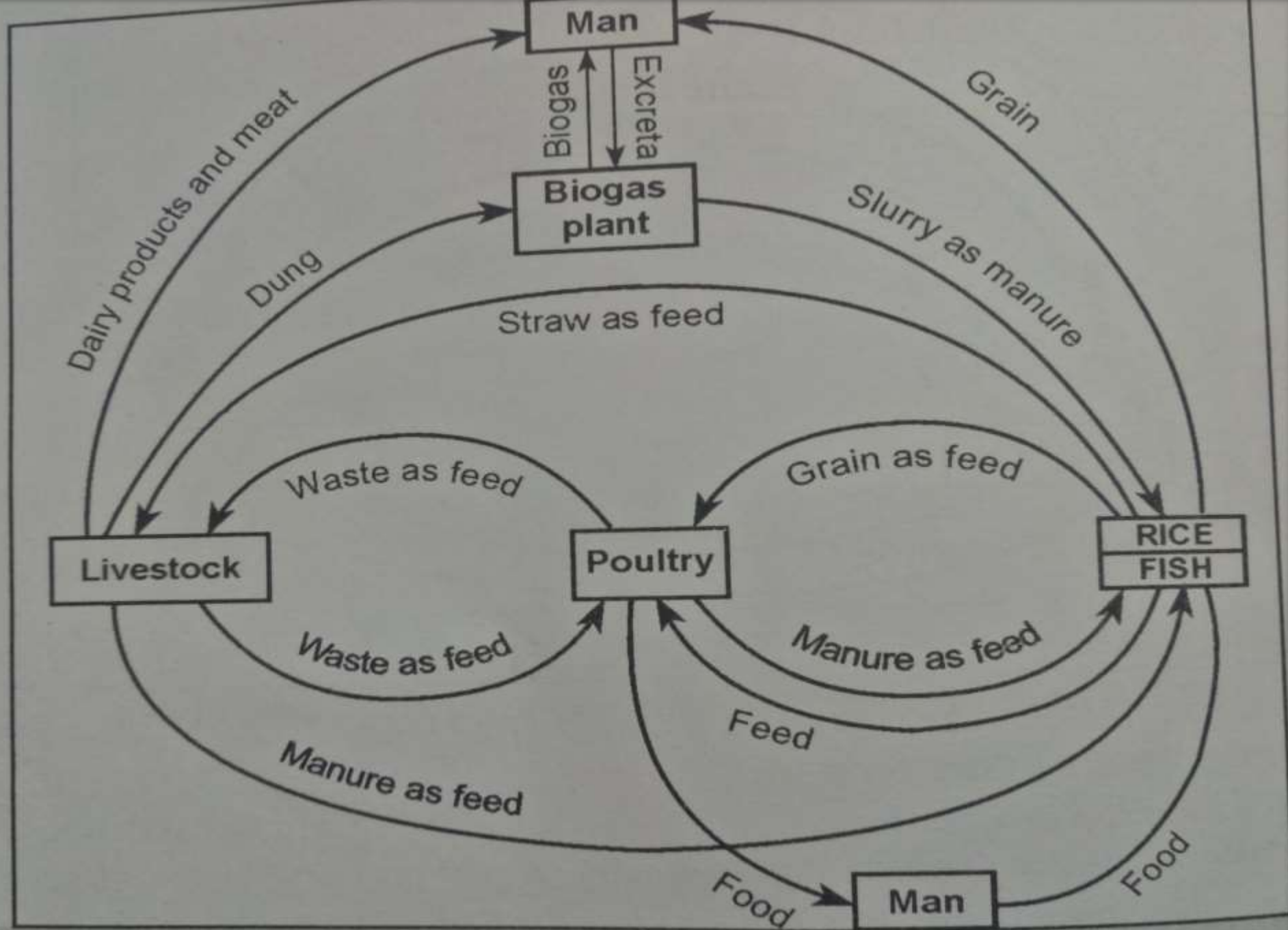


FIG 3.6 Resource flow model for crop-livestock-poultry-fish system.

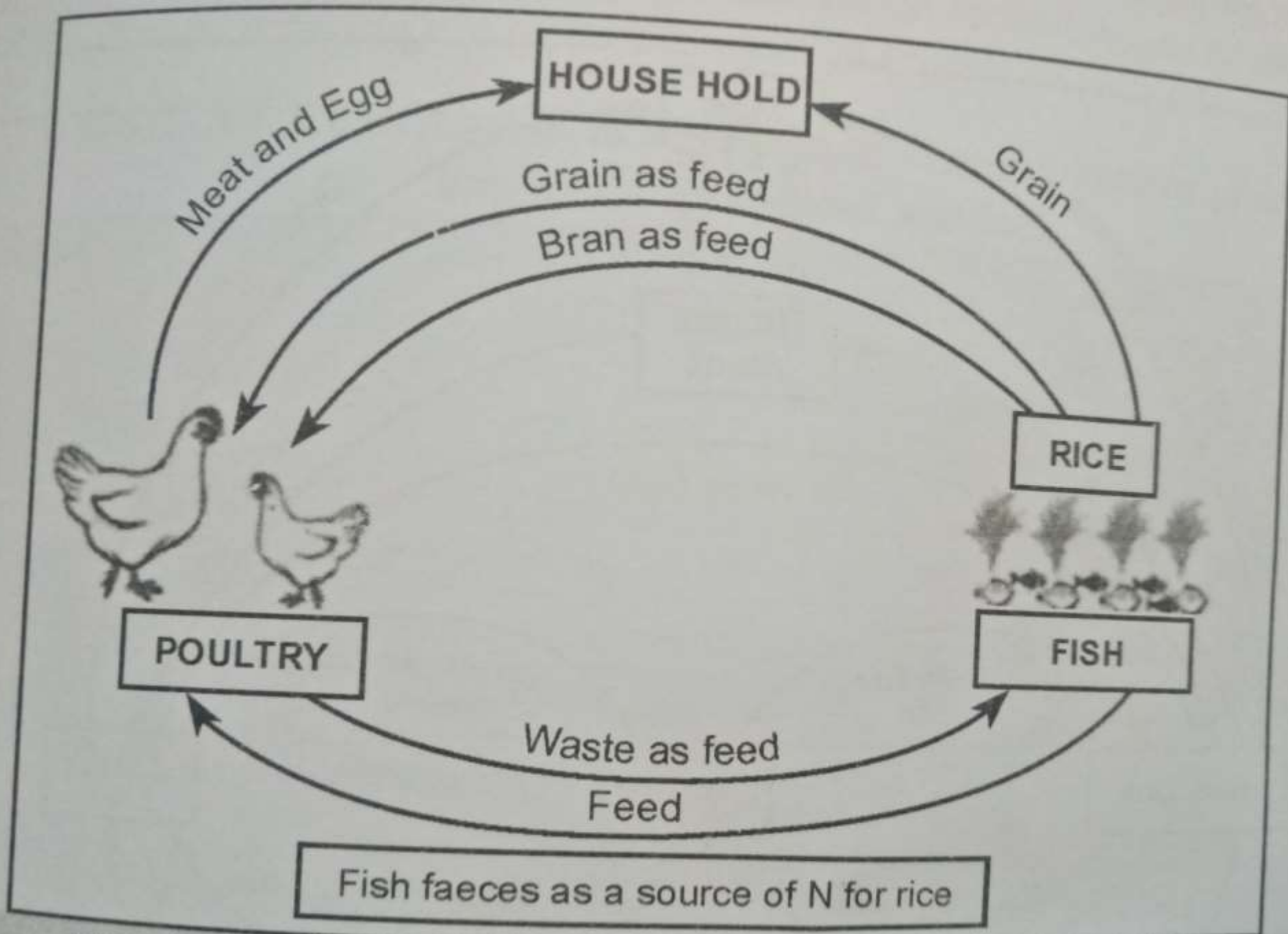


FIG 3.5 Resource flow model for crop-livestock-forestry system.



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- **Assumptions of Linear Programming**
- **Linearity:** It describes the relationship among two or more variables which are directly proportional.
- **Additivity:** Total input required is the sum of the resources used by each activity. Total product is sum of the production from each activity.
- **Divisibility:** Resources can be used in fractional amounts. Similarly, the output can be produced in fractions.
- **Non negativity:** Resources and activities cannot take negative values. That means the level of activities or resources cannot be less than zero.



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Advantages of Linear Programming :

- Allocation problems are solved.
- Provides possible and practical solutions..
- Improves the quality of decisions.
- Highlights the constraints in the production.
- Helps in optimum use of resources.
- Provides information on marginal value products (shadow prices).



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Limitations of Linear programming

- Does not consider the effect of time and uncertainty
- No guarantee of integer solutions
- Single valued expectations.
- Linearity
- Consider only one objective for optimization.



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Thank You