

Introduction to Natural Resource Economics in Agriculture

Key concepts, analytical tools, and policy implications

Aspect	Description
Definition	The branch of economics that studies how society allocates scarce natural resources (land, water, soil, biodiversity, climate) over time.
Goal	Achieve efficient, sustainable, and equitable use of resources while maximizing welfare.
Relevance to Agriculture	Farming directly depends on land, water, nutrients, and ecosystem services; decisions about cropping, input use, and technology affect resource stocks and future productivity.

Principle	Agricultural Example
Scarcity	Limited arable land and freshwater in many regions.
Opportunity Cost	Choosing to grow wheat on a plot foregoes the potential profit from growing soybeans.
Marginal Analysis	Farmers compare the marginal revenue from an extra unit of fertilizer with its marginal cost.
Externalities	Pesticide drift that harms neighboring farms is a negative externality; pollination by wild bees is a positive externality.
Intertemporal Trade-offs	Intensive tillage may boost current yields but degrade soil health for future seasons.

Resource	Economic Characteristics	Management Issues
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Land (soil)	Fixed supply, heterogeneous quality, subject to degradation and improvement.	Soil erosion, compaction, nutrient depletion, land-use conversion.
Water	Often renewable (rainfall, groundwater) but can be over-extracted; spatially variable.	Irrigation efficiency, allocation among users, drought risk.
Biological Resources (pollinators, microbes)	Public good, non-excludable, non-rival.	Habitat loss, pesticide impacts, biodiversity decline.
Climate & Air	Global commons; agriculture contributes to greenhouse gas (GHG) emissions and is vulnerable to climate change.	Carbon sequestration, adaptation to temperature/precipitation shifts.
Energy	Input for machinery, fertilizers, processing.	Fossil-fuel dependence, price volatility.

4. Analytical Tools

4.1. Production Functions

- **Typical form:** $(Y = f(L, K, N, W, T))$
 Y = output; L = land; K = capital (machinery); N = labor; W = water; T = technology.
- Allows estimation of **marginal products** and **elasticities** (e.g., how output responds to an extra mm of irrigation).

4.2. Cost-Benefit & Net Present Value (NPV)

- **NPV** = $(\sum_{t=0}^T \frac{B_t - C_t}{(1+r)^t})$
 B = benefits, C = costs, r = discount rate, T = planning horizon.
- Used to compare long-term practices (e.g., conservation tillage vs. conventional tillage).

4.3. Bio-Physical Modeling Integrated with Economics

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- **Crop models** (e.g., DSSAT, APSIM) generate yields under different resource scenarios.
- Coupled with **price and cost data** to evaluate profitability and resource footprints.

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4.4. Game Theory & Institutional Analysis

- Models strategic interactions among farmers (e.g., water sharing, pest control).