NET & SET Economics: Environmental Economics and Demography

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1. Environment as a Public Good

- The environment performs four functions: supplies **resources** (renewable and non-renewable), acts as a **sink** for wastes, provides **amenities** (aesthetic, recreational) and **life-support** services (climate regulation, biodiversity).
- **Materials balance approach (Kneese, Ayres and d'Arge, 1970):** matter is neither created nor destroyed (first law of thermodynamics), so all materials extracted eventually return to the environment as waste.
- Many environmental goods — clean air, ozone layer, climate stability, biodiversity — are **non-rival and non-excludable** (pure public goods); others like fisheries, forests and groundwater are **common-pool resources** (rival but non-excludable).
- Consequences: **free-riding**, under-provision of environmental quality and over-exploitation (**tragedy of the commons**, Garrett Hardin, 1968).
- Global public goods (climate) need international cooperation — Kyoto Protocol (1997), **Paris Agreement (2015)**: Nationally Determined Contributions, limit warming to well below 2°C, pursue 1.5°C. India's updated NDC (2022): reduce emissions intensity of GDP by 45% from 2005 levels by 2030; 50% installed power capacity from non-fossil sources by 2030; net zero by 2070.
- **Elinor Ostrom (Nobel 2009):** communities can manage commons successfully through local institutions.
- **Environmental Kuznets Curve (Grossman and Krueger, 1991):** pollution first rises then falls with per capita income (inverted U).
- **Weak sustainability** (natural capital substitutable by man-made capital; Hartwick rule — invest resource rents) vs **strong sustainability** (critical natural capital must be preserved).
- **Hotelling's rule (1931):** for an exhaustible resource, net price (scarcity rent) rises at the rate of interest.

Exam pointers: public good vs common-pool resource; tragedy of the commons; EKC; Hotelling's rule; Hartwick rule; Paris Agreement.

2. Market Failure

Environmental problems arise because markets fail to price environmental services.

Causes

- **Externalities:** pollution imposes costs on third parties; marginal social cost (MSC) = marginal private cost (MPC) + marginal external cost (MEC). Free markets produce where MPC = price, so output and pollution exceed the social optimum.

- **Public goods and common property:** absence of property rights → over-use.
- **Incomplete information and uncertainty** about environmental damage.
- **Short-sightedness / high discount rates** undervalue future damage.
- **Policy failure:** subsidies on fertilisers, electricity, fuel encourage overuse.

Optimal pollution

- Efficient level of pollution is not zero: it is where **marginal abatement cost (MAC) = marginal damage cost (MDC)**.

Policy instruments

Instrument	Type	Features
Pigouvian tax / emission charge	Market-based (price)	Tax per unit = MEC at optimum; cost-effective; revenue raised; "polluter pays principle" (OECD, 1972)
Subsidy for abatement	Market-based	May encourage entry of polluters in the long run
Tradable permits (cap-and-trade)	Market-based (quantity) — Dales (1968), Montgomery (1972)	Fixes total emissions; trading equalises MAC across firms; EU ETS, India's Carbon Credit Trading Scheme (2023), PAT scheme
Command and control	Regulation	Emission standards, technology mandates; certain but often costly
Deposit–refund systems, liability rules, eco-labelling	Others	

- **Weitzman (1974) — prices vs quantities:** taxes preferable when MAC is steeper than marginal damage; quantity controls when marginal damage is steeper.
- **Double dividend hypothesis:** green taxes improve environment and allow cutting distortionary taxes.

Exam pointers: MSC = MPC + MEC; optimal pollution MAC = MDC; Pigouvian tax vs permits; Weitzman's rule; polluter pays principle.

3. Coase Theorem

- **Ronald Coase, "The Problem of Social Cost" (1960)**; Nobel 1991. Name given by George Stigler.
- **Statement:** if property rights are well defined and transaction costs are zero, private bargaining between the polluter and the affected party leads to an **efficient** allocation, regardless of who initially holds the rights. The initial assignment affects only distribution (who pays whom).
- Example: factory smoke harming a laundry — if the laundry has the right, the factory pays compensation or abates; if the factory has the right, the laundry pays it to abate. In both cases pollution settles where marginal benefit of polluting = marginal damage.
- **Reciprocal nature of externalities:** harm is caused jointly by both parties.

Limitations

- Transaction costs (negotiation, monitoring, enforcement) are high when many parties are involved.
- Free-rider and hold-out problems with large groups.
- Asymmetric information and strategic behaviour.
- **Income/wealth effects:** if willingness-to-pay differs from willingness-to-accept, the outcome depends on rights assignment.
- Ill-defined property rights for global commons; future generations cannot bargain.

Significance

- Shifted focus from Pigouvian taxes to **property rights** and institutions; foundation of **Law and Economics**; underpins tradable-permit markets.

Exam pointers: conditions (zero transaction costs, well-defined property rights); efficiency independent of rights; limitations; Coase vs Pigou.

4. Cost–Benefit Analysis and Compensation Criteria

Cost–Benefit Analysis (CBA)

- A tool for evaluating public projects by comparing the present value of social benefits with social costs.
- **Steps:** identify project and alternatives → identify all costs and benefits (including externalities) → value them in money (using **shadow prices** where market prices are distorted) → discount to present value → apply decision criterion → sensitivity analysis.

Criterion	Rule
Net Present Value (NPV) = $\Sigma\ (B_t - C_t)/(1 + r)^t$	Accept if NPV > 0
Benefit–Cost Ratio (BCR) = PV(B)/PV(C)	Accept if BCR > 1
Internal Rate of Return (IRR) — discount rate at which NPV = 0	Accept if IRR > social discount rate

- **Social discount rate:** social rate of time preference vs opportunity cost of capital. **Stern Review (2006)** used a very low pure time-preference rate (0.1%) on ethical grounds; Nordhaus favoured market-based rates — central to climate debates.
- **Shadow pricing approaches:** Little–Mirrlees (OECD Manual, 1969 — world prices as numéraire), **UNIDO Guidelines (Dasgupta, Marglin, Sen, 1972)** — domestic consumption as numéraire.
- **Environmental Impact Assessment (EIA)** — mandatory in India for listed projects (EIA notification, 2006).
- Limitations: valuation of intangibles and human life, distributional effects, uncertainty, choice of discount rate, irreversibility (**quasi-option value**).

Compensation criteria

- CBA rests on the **Kaldor–Hicks potential compensation test:** a project is worthwhile if gainers could compensate losers and still be better off — actual compensation not required.

- **Kaldor (1939):** gainers can compensate losers. **Hicks (1939):** losers cannot bribe gainers to forgo the change. **Scitovsky double criterion (1941):** Kaldor test passed for the move and failed for the reversal. **Little (1950):** adds a distributional condition. **Samuelson:** utility possibility frontier must shift outward everywhere.
- Distributional weights (equity-weighted CBA) address the neglect of distribution.

Exam pointers: NPV, BCR, IRR rules; social discount rate debate (Stern vs Nordhaus); Little–Mirrlees vs UNIDO; Kaldor–Hicks basis of CBA.

5. Valuation of Environmental Goods

Environmental goods lack market prices, so economists infer their value.

Total Economic Value (TEV)

Component	Meaning
Use value — direct use	Timber, fishing, recreation
Use value — indirect use	Ecological functions (flood control, carbon sequestration)
Option value	Value of keeping the option of future use
Non-use (passive use) values	**Existence value** (knowing it exists) and **bequest value** (for future generations) — Krutilla (1967)

Valuation methods

Approach	Method	Description
Revealed preference (indirect)	**Travel cost method** (Hotelling, Clawson)	Value of recreation sites from visitors' travel costs and time
	Hedonic pricing (Rosen, 1974)	Property values or wages reflect environmental attributes (air quality, noise)
	Averting / defensive expenditure	Spending on water purifiers, air filters
	Cost of illness, production function / dose–response	Damage to health or output
Stated preference (direct)	**Contingent valuation method (CVM)**	Surveys ask willingness to pay (WTP) or willingness to accept (WTA); only method capturing non-use values; NOAA Panel guidelines (Arrow–Solow, 1993)
	Choice experiments / conjoint analysis	Respondents choose among bundles of attributes
Market-based	Replacement cost, restoration cost, opportunity cost	Cost of restoring or replacing the service

Approach	Method	Description
Benefit transfer		Applying values from existing studies to a new site

- Biases in CVM: hypothetical, strategic, embedding (part–whole), starting-point, information bias; WTA typically exceeds WTP (endowment effect).
- **Green accounting:** System of Environmental-Economic Accounting (SEEA, UN 2012); net domestic product adjusted for resource depletion and degradation; India's **Partha Dasgupta committee (2013)** on green national accounts; Dasgupta Review on the economics of biodiversity (2021).

Exam pointers: TEV components; travel cost vs hedonic vs CVM; existence and bequest values; WTP vs WTA gap; SEEA.

6. Theories of Population

Malthusian theory

- **T.R. Malthus, *An Essay on the Principle of Population* (1798).**
- Population tends to grow in geometric progression (1, 2, 4, 8 …), doubling every 25 years; food supply in arithmetic progression (1, 2, 3, 4 …) due to diminishing returns.
- Checks: **preventive checks** (moral restraint, late marriage) and **positive checks** (famine, disease, war).
- Criticisms: ignored technological progress in agriculture, the demographic transition and the role of rising living standards in lowering fertility.
- **Neo-Malthusians** advocate birth control; Club of Rome *Limits to Growth* (1972).

Optimum theory of population

- Edwin Cannan, Robbins, Dalton: the optimum population is the size at which per capita income is maximum given resources and technology.
- **Dalton's degree of maladjustment** $M = (A - O)/O$ (A = actual, O = optimum population); positive = over-population, negative = under-population.
- Dynamic: the optimum shifts with technology.

Theory of Demographic Transition

- Based on Warren Thompson (1929) and Frank Notestein (1945): societies pass through stages as they develop.

Stage	Birth rate	Death rate	Population growth
I — High stationary (pre-industrial)	High	High	Slow/stable
II — Early expanding	High	Falling rapidly	Rapid (population explosion)
III — Late expanding	Falling	Low	Slowing
IV — Low stationary	Low	Low	Stable/slow
V (sometimes added) — Declining	Very low	Low	Negative

- India is in late stage III, with TFR now below replacement.

Other theories

- **Marx:** relative surplus population (reserve army) arises from capitalism, not natural law.
- **Leibenstein's economic theory of fertility (1957):** couples weigh utility of an extra child (consumption, labour, old-age security) against costs (direct, opportunity).
- **Becker's theory (1960):** children as durable consumer goods; **quantity–quality trade-off**.
- **Easterlin's relative income hypothesis.**
- **Caldwell's wealth flows theory (1976):** fertility falls when intergenerational wealth flows reverse (from parents to children).
- **Boserup (1965):** population pressure induces agricultural innovation (optimistic view).
- **Julian Simon:** people as "the ultimate resource".

Exam pointers: Malthus GP vs AP; preventive vs positive checks; Dalton's maladjustment formula; stages of demographic transition; Becker and Leibenstein.

7. Concepts and Measures: Fertility, Morbidity, Mortality

Fertility

Measure	Formula / meaning
Crude Birth Rate (CBR)	Live births in a year per 1,000 mid-year population
General Fertility Rate (GFR)	Live births per 1,000 women aged 15–49
Age-Specific Fertility Rate (ASFR)	Births to women in an age group per 1,000 women of that group
Total Fertility Rate (TFR)	Sum of ASFRs (× 5 for five-year groups)/1,000 — average number of children per woman over her reproductive life
Gross Reproduction Rate (GRR)	TFR counting only female births — daughters per woman
Net Reproduction Rate (NRR)	GRR adjusted for female mortality; **NRR = 1 means replacement level**
Child–woman ratio	Children 0–4 per 1,000 women 15–49

- **Replacement-level TFR ≈ 2.1.** India's TFR fell to **2.0** (NFHS-5, 2019–21), below replacement; it is higher in Bihar, Uttar Pradesh, Meghalaya and lower in southern States.
- **Fecundity** (biological capacity) vs **fertility** (actual births).
- **Bongaarts' proximate determinants:** marriage, contraception, postpartum infecundability, abortion.

Mortality

Measure	Formula / meaning
Crude Death Rate (CDR)	Deaths per 1,000 mid-year population
Age-specific death rate	Deaths in age group per 1,000 persons in the group
Infant Mortality Rate (IMR)	Deaths of infants under one year per 1,000 live births
Neonatal mortality rate	Deaths within 28 days per 1,000 live births

Measure	Formula / meaning
Under-five mortality rate	Deaths under age 5 per 1,000 live births
Maternal Mortality Ratio (MMR)	Maternal deaths per 1,00,000 live births
Standardised death rate	Adjusted for age structure (direct/indirect standardisation)

- India's IMR has fallen to the mid-20s per 1,000 live births (recent SRS bulletins) and MMR to about 93 per 1,00,000 live births (SRS 2019–21).

Morbidity

- **Morbidity** is the incidence or prevalence of disease, illness or disability.
- **Incidence rate:** new cases in a period per 1,000 population at risk. **Prevalence rate:** total existing cases at a point (point prevalence) or during a period.
- **DALY (Disability-Adjusted Life Years)** = years of life lost (YLL) + years lived with disability (YLD) — Global Burden of Disease (World Bank, 1993). **QALY** used in health economics.
- **Epidemiological transition (Omran, 1971):** shift from infectious diseases to chronic, non-communicable diseases as countries develop — India faces a "double burden".
- Data sources in India: Census, Sample Registration System (SRS), Civil Registration System, NFHS, NSS health rounds.

Exam pointers: TFR vs GRR vs NRR; replacement TFR 2.1; IMR and MMR definitions; incidence vs prevalence; DALY.

8. Age Structure and Demographic Dividend

Age structure

- Population classified into **young (0–14)**, **working age (15–64)** and **old (65+)**.
- **Age dependency ratio** = (Population 0–14 + 65+)/(Population 15–64) × 100; split into child (young) and old-age dependency ratios.
- **Population pyramid:** expansive (broad base — high fertility, e.g., stage II), constrictive (narrowing base — declining fertility), stationary (near-rectangular — low fertility and mortality).
- **Median age;** sex ratio (India: females per 1,000 males — 943 in Census 2011; 1,020 in NFHS-5); child sex ratio (918 in Census 2011).
- **Population momentum:** population continues to grow for decades after fertility reaches replacement because of a young age structure.
- **Ageing:** rising proportion of the elderly; India's 60+ share projected to roughly double by 2050 (UNFPA India Ageing Report 2023).

Demographic dividend

- The economic growth potential arising when the share of the **working-age population** is larger than the non-working-age share (falling dependency ratio).
- Channels (Bloom and Williamson): larger labour supply, higher savings, increased female labour force participation, human capital investment.

- India's window of demographic dividend is estimated to last roughly from 2005–06 to about 2055–56; India became the world's most populous country in 2023 (UN estimates).
- **Conditions to reap it:** education and skilling, health, job creation (especially manufacturing and services), female labour force participation, sound macro policies. Otherwise it can become a "demographic burden" (unemployment, unrest).
- **Second demographic dividend:** savings accumulated by an ageing population for retirement boost capital formation.

Exam pointers: dependency ratio formula; types of pyramids; population momentum; demographic dividend window and conditions.

9. Life Table

A **life table** (mortality table) shows the mortality experience of a population by age and gives the life expectancy at each age. First constructed by **John Graunt (1662)** and **Edmund Halley (1693)**.

Types

- **Cohort (generation) life table:** follows an actual birth cohort until all die.
- **Period (current) life table:** applies current age-specific death rates to a hypothetical cohort (radix, usually 1,00,000).
- **Complete** (single years) vs **abridged** (five-year age groups).

Columns of a life table

Column	Meaning
x	Exact age
$\mathbf{l_x}$	Number surviving to exact age x out of the radix l_0
$\mathbf{d_x}$	Number dying between age x and x + 1: $d_x = l_x - l_{x+1}$
$\mathbf{q_x}$	Probability of dying between x and x + 1: $q_x = d_x/l_x$
$\mathbf{p_x}$	Probability of surviving: $p_x = 1 - q_x = l_{x+1}/l_x$
$\mathbf{L_x}$	Person-years lived between x and x + 1 $\approx (l_x + l_{x+1})/2$
$\mathbf{T_x}$	Total person-years lived after age x: $T_x = \Sigma L_x$ (from x onwards)
$\mathbf{e_x^0}$	**Expectation of life** at age x: $e_x^0 = T_x/l_x$

- e_0^0 is **life expectancy at birth**. Because of high infant mortality, life expectancy at age 1 can exceed that at birth.
- India's life expectancy at birth is about 70 years (SRS abridged life tables 2016–20 and later), with females living longer than males.

Uses

- Life insurance premiums and pension planning; population projections; measuring health status; computing NRR; comparison of mortality across regions and over time; family planning evaluation.
- **Multiple decrement tables** (several causes of exit) and **working life tables**.

Exam pointers: life table columns and formulas; $e_x^0 = T_x/l_x$; cohort vs period; Graunt and Halley; why e_1 may exceed e_0.

10. Migration

Migration is a change of usual residence across a defined boundary.

Types

- **Internal** (within a country) vs **international**.
- By stream: rural–rural (largest in India, dominated by marriage migration of women), rural–urban, urban–urban, urban–rural.
- By duration: permanent, semi-permanent, seasonal/circular, temporary.
- Voluntary vs forced (refugees, displacement); distress migration.
- Census of India measures migration by **place of birth** and **place of last residence**; Census 2011 recorded about 45.6 crore internal migrants (37% of population); marriage is the leading reason for women, work/employment for men.

Measures

- In-migration and out-migration rates; **net migration rate** = (In-migrants − Out-migrants)/population × 1,000; gross migration (migration turnover); migration effectiveness index.

Theories

Theory	Author	Key idea
Laws of migration	E.G. Ravenstein (1885, 1889)	Most migrants move short distances; step-by-step migration; each stream has a counter-stream; women migrate more over short distances; urban natives less migratory
Push–pull theory	Everett Lee (1966)	Factors at origin (push), destination (pull), intervening obstacles and personal factors
Lewis model	W.A. Lewis (1954)	Surplus rural labour moves to urban capitalist sector at fixed wage
Todaro / Harris–Todaro model	Todaro (1969), Harris–Todaro (1970)	Migration responds to **expected** urban–rural income differential (urban wage × probability of employment); explains migration despite urban unemployment; urban job creation can raise unemployment (**Todaro paradox**)
Human capital approach	Sjaastad (1962)	Migration is an investment; move if PV of benefits exceeds costs
New Economics of Labour Migration	Oded Stark (1991)	Household decision to diversify risk; remittances; relative deprivation
Dual labour market theory	Piore (1979)	Demand for low-wage migrant labour in developed economies
Zelinsky's mobility	Zelinsky	Migration patterns change with the stages of demographic transition

Theory	Author	Key idea
transition (1971)		

Consequences

- **For origin:** remittances (India is the largest recipient of remittances in the world — about US$ 129 billion in 2024 per the World Bank), reduced pressure on land, brain drain, ageing and feminisation of agriculture.
- **For destination:** labour supply, urbanisation, slums, pressure on infrastructure, informal sector growth.
- Policy in India: One Nation One Ration Card, e-Shram portal (2021), affordable rental housing complexes for migrants, inter-State Migrant Workmen Act (subsumed in the Occupational Safety, Health and Working Conditions Code, 2020).

Exam pointers: Ravenstein's laws; Lee's push–pull; Harris–Todaro expected income; Stark's NELM; migration measures.