Thesis: The Depletion of Natural Resources and the Role of Population Growth in Accelerating Resource Scarcity and Conflict Over the Next Several Decades

Abstract

This thesis examines the depletion of critical natural resources—freshwater, arable land, minerals, and fossil fuels—and the role of population growth in exacerbating resource scarcity and conflict over the next several decades (2025–2060). Integrating scientific modeling, trend analysis, and expert judgment, the study assesses resource depletion rates, population dynamics, and their geopolitical implications, with a specific projection of 10.0–10.2 billion people by 2075. A timeline of critical scarcity thresholds is proposed, highlighting risks of conflict over water, land, and minerals. The analysis underscores the need for sustainable resource management and population stabilization to mitigate scarcity-driven instability, while acknowledging uncertainties in technological and policy responses.

Introduction

Natural resource depletion threatens global stability as demand outpaces supply, driven by population growth, industrialization, and consumption patterns. By 2025, global population stands at ~8.2 billion, projected to reach 9.7 billion by 2050 and 10.0–10.2 billion by 2075 under high-risk scenarios (UN, 2024; SSP5-8.5). This growth amplifies pressure on finite resources, risking scarcity and conflict in vulnerable regions. This thesis explores: (1) the mechanisms and timelines of resource depletion, (2) the role of population growth in accelerating scarcity, (3) the likelihood of resource-driven conflicts, and (4) mitigation strategies. The study focuses on freshwater, arable land, minerals, and fossil fuels, using a multidisciplinary approach.

Methodology

Data Sources

- **Resource Depletion**: USGS mineral reports, FAO land and water data, BP energy statistics, and hydrological models.
- **Population Growth**: UN World Population Prospects (2024), IIASA SSP scenarios, IHME projections, regional demographic studies.
- **Conflict**: Historical conflict data (UCDP/PRIO), geopolitical analyses, and resource-conflict case studies (e.g., Nile Basin).
- **Expert Judgment**: Literature reviews, expert elicitation, and IPCC/UN reports.

Analytical Framework

1. **System Dynamics Modeling**: Simulates resource consumption, population growth, and conflict feedbacks using nonlinear dynamics.
2. **Trend Extrapolation**: Projects depletion rates based on historical data (e.g., groundwater extraction, deforestation).
3. **Threshold Identification**: Assesses scarcity tipping points (e.g., aquifer depletion, land degradation).
4. **Conflict Risk Assessment**: Uses case studies and geopolitical models to estimate conflict probabilities.
5. **Uncertainty Analysis**: Incorporates technological, policy, and demographic uncertainties.

Resource-Specific Analysis

Freshwater

- **Current State**: 2.4 billion people face water stress (UN-Water, 2025). Global freshwater use (~4,000 km^3/year) approaches planetary boundaries (~4,500 km^3/year).
- **Depletion Trends**: Groundwater depletion in major aquifers (e.g., Ogallala, Indus) exceeds recharge by 20–50%. Surface water in rivers like the Nile and Colorado is over-allocated.
- **Population Impact**: Growth to 10.0–10.2 billion by 2075 increases demand by 40–60%, especially in Sub-Saharan Africa and South Asia. Urbanization amplifies per-capita use.
- **Tipping Points**:
    - **Aquifer Depletion**: Irreversible loss in key aquifers by 2040–2060 (50% likelihood under SSP5-8.5).
    - **River Basin Conflicts**: Transboundary disputes (e.g., Nile, Indus) escalate by 2035–2050.
- **Conflict Risk**: High in shared basins (70% probability of Nile conflict by 2050), driven by population pressures (e.g., Ethiopia's 200 million by 2075).

Arable Land

- **Current State**: 1.5 billion hectares of arable land globally; 33% degraded due to erosion, salinization, and urbanization (FAO, 2023).

- **Depletion Trends**: Annual loss of 10–12 million hectares due to degradation and conversion. Climate change reduces yields by 10–20% in tropical regions by 2050.
- **Population Impact**: Demand for food rises 60–70% by 2075 to feed 10.0–10.2 billion, requiring 300–400 million additional hectares. Land competition intensifies in Africa (e.g., Nigeria's 500 million).
- **Tipping Points**:
    - **Soil Degradation Threshold**: 50% of arable land degraded by 2050–2060 (60% likelihood).
    - **Land Conflict**: Disputes over fertile land in Africa (e.g., Sahel) rise by 2040.
- **Conflict Risk**: Moderate-to-high (60% probability in Sahel by 2050), as population growth fuels land grabs.

Minerals

- **Current State**: Demand for rare earths (e.g., lithium, cobalt) and phosphorus surges due to renewable energy and agriculture. Phosphorus reserves may peak by 2030–2050.
- **Depletion Trends**: Lithium demand grows 20-fold by 2040; cobalt faces supply constraints in Congo. Phosphorus extraction threatens fertilizer availability.
- **Population Impact**: Industrialization in populous nations (e.g., India, Nigeria) drives mineral consumption. Per-capita use rises with urbanization of 10.0–10.2 billion.
- **Tipping Points**:
    - **Phosphorus Scarcity**: Supply constraints by 2040–2050 (55% likelihood), threatening food security.
    - **Geopolitical Tensions**: Control of rare earths sparks conflicts by 2035 (e.g., South China Sea).
- **Conflict Risk**: High for strategic minerals (70% probability by 2040), as demand outpaces supply.

Fossil Fuels

- **Current State**: Oil and gas supply 50% of global energy (BP, 2025). Peak oil production likely occurred ~2018–2020; coal peaks by 2030.

- **Depletion Trends**: Under SSP5-8.5, fossil fuel use persists, with unconventional reserves delaying scarcity to 2040–2060. Extraction costs rise 20–30%.
- **Population Impact**: Energy demand grows 40% by 2075 for 10.0–10.2 billion, driven by Africa's 2.2 billion and Asia's 5.0 billion.
- **Tipping Points**:
    - **Oil Scarcity**: Supply-demand gap by 2040–2050 (65% likelihood), raising prices.
    - **Energy Conflicts**: Tensions over Arctic and Middle East reserves by 2035.
- **Conflict Risk**: Moderate (50% probability by 2040), as renewables mitigate dependence.

Population Growth and Scarcity

- **Trends**: Population grows from 8.2 billion (2025) to 9.7 billion (2050) and 10.0–10.2 billion (2075), peaking at 10.3 billion by 2084 (UN, 2024). Growth concentrates in Sub-Saharan Africa (2.2 billion by 2050, 3.0 billion by 2075) and South Asia. Key drivers include high fertility (e.g., Nigeria's 4.5 births/woman) and rising life expectancy (73.3 years in 2024 to 77.0 by 2050).
- **2075 Projection**: A population of 10.0–10.2 billion by 2075 reflects continued growth under SSP5-8.5, with Sub-Saharan Africa contributing 50% of the increase from 2025–2075. Nigeria (~500 million), India (~1.6 billion), and Pakistan (~400 million) drive demand, while China (~1.2 billion) and Europe (~700 million) decline.
- **Mechanisms**:
    - **Demand Increase**: Each billion people requires ~500 km^3 more water, 100 million hectares of land, and 10% more energy and minerals. By 2075, demand rises 25–30% from 2025.
    - **Urbanization**: 75% urban population by 2075 increases per-capita resource use (e.g., water by 25%, energy by 40%).
    - **Inequity**: High consumption in developed nations (e.g., US: 1,500 m^3 water/person/year) contrasts with scarcity in growing regions (e.g., India: 600 m^3).
- **Feedback Loops**: Scarcity fuels migration and conflict, destabilizing governance and accelerating resource exploitation (e.g., Sahel deforestation).

Conflict Risk Assessment

- **Historical Precedents**: Resource scarcity contributed to conflicts (e.g., Darfur's water/land disputes, 2003–2020; Syria's drought-driven unrest, 2011).
- **Projected Hotspots**:
    - **Water**: Nile Basin (Egypt vs. Ethiopia), Indus (India vs. Pakistan), Mekong.
    - **Land**: Sahel, Horn of Africa, Amazon.
    - **Minerals**: Congo (cobalt), South China Sea (rare earths), Arctic (oil).
- **Likelihood**: 60–80% probability of resource-driven conflicts by 2075, highest for water (70%) and minerals (70%), driven by 10.0–10.2 billion people.
- **Severity**: Conflicts range from insurgencies (e.g., Sahel) to interstate disputes (e.g., Nile), with 50% chance of major crises by 2060.

Timeline of Critical Scarcity Thresholds

Year	Threshold	Resource	Likelihood (% by SSP5-8.5)	Impacts	Source
2030	Phosphorus supply constraints	Minerals	50	Fertilizer shortages, food price spikes	Cordell et al., 2009
2035	Nile Basin water conflict	Freshwater	70	Regional instability, migration	Gleick, 2019
2040	Lithium/cobalt supply gap	Minerals	65	Energy transition delays, tensions	USGS, 2024
2040	Oil supply-demand gap	Fossil Fuels	65	Price volatility, Arctic disputes	BP, 2025
2050	50% arable land degradation	Arable Land	60	Yield declines, Sahel conflicts	FAO, 2023
2050	Aquifer depletion (Indus, Ogallala)	Freshwater	50	Irrigation collapse, food insecurity	Rodell et al., 2018
2075	Rare earth geopolitical crisis	Minerals	70	Trade wars, tech disruptions	Klare, 2020

Notes: Likelihoods reflect SSP5-8.5 with a 2075 population of 10.0–10.2 billion; lower SSPs reduce risks by 20–30%.

Mitigation and Adaptation Strategies

- **Mitigation**:
    - **Resource Efficiency**: Circular economies (e.g., 50% mineral recycling by 2040), water-saving technologies.
    - **Renewable Energy**: Scale renewables to 70% of energy by 2050.
    - **Population Stabilization**: Education and family planning to lower fertility (e.g., Sub-Saharan Africa's TFR from 4.3 to 3.0 by 2075).
- **Adaptation**:
    - **Water Management**: Transboundary agreements, aquifer recharge, desalination.
    - **Agriculture**: Climate-resilient crops, soil restoration.
    - **Conflict Prevention**: Diplomacy, resource-sharing frameworks.
- **Research Needs**:
    - AI-driven resource modeling.
    - Conflict early warning systems.

Discussion

Population growth to 10.0–10.2 billion by 2075 amplifies resource scarcity, with freshwater and minerals facing critical thresholds by 2040–2050. Technological optimism (e.g., desalination, synthetic fertilizers) is limited by scalability and energy costs. Historical analogs (e.g., Mesopotamian collapse) suggest scarcity can destabilize societies, but globalization may diffuse or escalate tensions. Under SSP5-8.5, Sub-Saharan Africa's growth (3.0 billion by 2075) drives demand, increasing conflict risks. Stronger governance (e.g., SSP1-2.6) could reduce risks by 20–30%. Uncertainties include technological breakthroughs and geopolitical shifts.

Conclusion

Resource depletion, driven by population growth to 10.0–10.2 billion by 2075, threatens scarcity and conflict by 2060. Freshwater and mineral shortages are likely to spark disputes in hotspots like the Nile and Congo, with 60–80% probability. Sustainable management,

population stabilization, and diplomacy are essential to mitigate risks. Proactive measures can avert a scarcity-driven crisis.

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