

Lecture # 25 – Environmental Issues in Developing and Emerging Economies

I. Environmental Priorities in Developing Countries

- Thanks to everyone for a productive discussion in class today. My notes below summarize some of the key points from the reading, but do not attempt to capture everything that was said during our discussion.
- We begin by thinking about what issues are priorities for citizens of developing and emerging economies?
 - Are there differences from the priorities of those in rich countries?
 - Can we “grown now, clean up later”?
 - Based on the logic of the environmental Kuznets curve
- What motivates changes in environmental policy?
 - Industrial nations observed a key turning point
 - Cuyahoga River fire in US
 - Mercury spill from a plastics factory in Japan killed thousands around the bay of Minamata
- Environmental problems are often, but not always, worse in low and middle-income countries
 - Deaths from air pollution increase with income (Source: Greenstone & Jack, *Journal of Economic Literature* 2015)
 - These trends still hold)
 - A 2018 World Health Organization report found that 90% of air pollution-related deaths occur in low- and middle-income countries
 - Between 2010 & 2016, air quality got worse in 70% of poor cities in south and south-east Asia
- Which issues are priorities in developing countries?
 - Local environmental problems are a priority
 - Particulate matter emissions highest in Asia and parts of Africa
 - Access to clean water is a concern
 - Indoor air pollution a problem in poor areas. Homes use wood and waste as fuel.
 - Household smoke kills 2.6m people per year
 - Urban air pollution a problem in large Indian cities
 - Role of public pressure
 - When most environmental problems are local, rather than national, in nature, it is difficult to develop a mass movement for policy.

II. Growth and the Environment

- Driving forces of environmental problems in developing countries include:
 - Population growth
 - Most are in developing countries.
 - Increasing urbanization
 - As in the developed world, developing countries are seeing a movement from rural areas to cities.
 - Most people move to cities for jobs.
 - Industrialization
 - Developed countries moved from agriculture to industry to services.
 - Industry ⇒ more pollution
 - Services ⇒ less pollution
 - Changing preferences (e.g. more consumption)
- These trends led to the hypothesis of the environmental Kuznets curve (EKC)
 - Posits an inverted-U shape relationship between per capita income and pollution
 - Lead in the US and elsewhere is an example
 - But different pollutants follow different paths, as the examples from the reading show.
 - CO₂ per capita higher in richer countries
 - Particulate levels in cities better in richer countries than poorer countries
 - Local issues that are highly visible (e.g. air pollution) are typically addressed as countries grow
 - This trend holds for other goods where demand increases as income increases, such as safe water and sanitation facilities. These are clearly normal goods.
 - Ozone shows no clear relationship
- Thus, there is no one answer to whether development helps or hurts the environment

- To assess the impact of growing income and economic development on environmental quality, we start with a theoretical framework. This comes from Greenstone and Jack (*Journal of Economic Literature* 2015), which is referenced in the reading by Jayachandran
 - Their model derives the marginal willingness to pay for environmental quality ($MWTP_E$). Key assumptions:
 - Individuals maximize utility choosing levels of consumption, improvements in environmental quality, and self-protection
 - Assume no other market failures
 - Thus, the model provides first-best outcomes
 - Factors determining $MWTP_E$:
 - Environmental quality affects utility directly (e.g. aesthetic preferences)
 - Environmental quality affects utility indirectly via health
 - Health also affects income
 - E.g. workers exposed to pollution may be less productive
 - Can mitigate health effects by spending on self-protection
 - E.g. air filters, water purifiers
 - Environmental quality affects income, which affects utility via the budget constraint
 - E.g. revenues from tourism depend on environmental quality
 - Consumption may affect environmental quality
 - Directly, by changing environmental quality
 - Indirectly, through consumption and self-protection
 - Key results
 - WTP for environmental quality is the marginal rate of substitution between income and environmental quality.
 - Decreasing marginal utility of income =>
 - low $MWTP_E$
 - spend more on self-protection as consumption goes up
 - True even if self-protection harms environment (e.g. using more air conditioning)
 - Implications:
 - High marginal utility of consumption
 - Money goes to consumption first
 - Implies low environmental quality is efficient
 - As incomes increase, consumption increases, but so do expenditures to protect the environment

- But other factors besides income matter. Jayachandran's paper extends this work, looking at multiple possible links between economic growth and environmental quality. How do these affect environmental quality as income increases?
 - Factors likely to increase environmental quality as income increases
 - Stronger property rights increase long-term investment in land
 - The expected return to investing in one's land is higher if the risk of land expropriation is lower
 - Formally owning property allows one to use it as collateral, which helps lower the cost of borrowing.
 - If the property can be sold to someone who can use it more productively, investments that might not be profitable for the current owner become attractive
 - Someone who expects to use their land for a sustained period will pursue sustainable agricultural practices. A forest owner with a short time horizon might cut down trees and sell them, or a farmer might over-farm their land. With more secure property rights, this deforestation and over-farming might be avoided
 - Most, but not all, of the studies cited in this section find that improved property rights reduced tree loss
 - Regulatory capacity
 - Resources matter
 - Access to satellite imagery improved Brazil's enforcement of illegal deforestation (Assuncao et al (2020))
 - Increased inspections at Indian industrial plants reduced pollution (Duffo et al. 2015)
 - Corruption reduces effectiveness of policies
 - Third-party auditors often used for enforcement
 - Population growth
 - Birth rates typically fall as incomes rise

- Factors likely to decrease environmental quality as income increases
 - Consumption increases as households have more income. But what they consume also changes
 - Examples in Jayachandran include Randomized Control Trials where treated families are given extra income.
 - Energy
 - Richer households more likely to use electricity
 - What does this displace?
 - Richer households more likely to drive cars
 - Diet
 - Meat and dairy consumption increases
- Uncertain impacts on environmental quality
 - Access to capital
 - Whether access to capital is good or bad for the environment depends on whether the credit-constrained option is better or worse for the environment
 - Empirical evidence is mixed
 - Results where access to capital hurts the environment
 - Assuncao et al. (2020) used a DiD design to study a tightening of access to credit in rural Brazil
 - The policy change reduced deforestation, as access to credit helped landowners pursue cattle ranching
 - Wilebore et al. (2019) found that access to capital had a similar negative effect on forest protection in Sierra Leone
 - Cash transfers helped households purchase agricultural inputs, labor, and tools to clear land

- Results where access to capital helps the environment
 - Lopez-Feldman and Chavez (2017) showed that remittances sent from international migrants to families in Mexico caused family members to shift away from environmentally-intensive activities
 - Andersen (2016) and Andersen (2017) found that increases in access to credit among manufacturing firms had positive environmental effect
 - Allows firms to purchase more pollution abatement equipment
 - Several studies show access to credit increased use of energy efficient cookstoves in Africa
 - In a payments for ecosystems program to that gave payments conditional on tree survival on their land, more cotton farmers in Zambia participated if upfront costs (e.g. purchase of seedlings) were subsidized (Oliva et al. 2020)
- Natural resources can be a source of emergency cash
 - E,g, cutting down forests when money is tight
 - Ferraro and Simorangkir (2020) found cash transfers to poor households in rural Indonesia reduced forest cover loss by 30%
 - This benefit occurred in years with low rainfall, so that agricultural output was low
 - Jayachandrian (2013)
 - Households forgo two types of income when they stop deforesting.
 - 1) The clear less land for growing crops and so have a lower flow of income from agriculture.
 - 2) They no longer earn lump-sum income from selling timber.
 - Payment levels that are high enough to offset lost agricultural income and typical revenue from timber may not be adequate when a household has an emergency need for cash.

- Technology and infrastructure
 - New technology allows producing goods at lower costs
 - Expanded production can hurt environment
 - Might also reduce use of natural resources, which helps environment
 - Effect on agriculture and land use
 - Borlaug hypothesis: higher yields reduce pressure to clear land
 - Jevons paradox: Increased productivity lowers costs, shifting the supply curve out. Farmers demand more land
 - Empirical evidence is mixed
 - Effect on transportation
 - Building roads increases pollution and deforestation
 - Public transport reduces pollution
 - Although not noted in the article, this seems to suggest different effects at different levels of development – e.g. which comes first?
- Can we “grow now, clean up later”? Should environmental protection be more of a priority in developing countries?
 - Key criticisms of EKC
 - Need to distinguish between environmental impacts that affect welfare through income and consumption versus those affecting welfare through amenity value
 - Poor may place less weight on amenity value
 - But care about access to clean drinking water, solid waste management, flood control, etc.
 - Poor may care about environment but not have the voice to make concerns heard
 - Are policies implemented in developing countries more representative of the elite?
 - Influence of environment is often indirect, so that people may not link environmental problems to health consequences
 - Information is a barrier
 - Not all measures of environmental quality improve with income
 - Local issues that are highly visible (e.g. air pollution) are typically addressed as countries grow
 - Global public goods with long term consequences are more difficult to address.

- Show a correlation, but not the mechanism for change
 - Authors of original study (Grossman and Krueger 1991) emphasize that there is nothing inevitable about their relationship
 - Key contribution was to show that growth need not lead to a dirtier environment.
 - But whether growth can lead to a cleaner environment is more controversial
- Delay can be costly
 - It may be more economical to reduce or prevent pollution at an early stage than clean up afterwards
 - Important if infrastructure investment locks-in polluting technologies
 - Relevant in developing countries, where infrastructure may not yet be in place
 - May be easier to never build a coal-fired power plant than to replace an existing one
 - E.g.: denser cities have lower CO₂ emissions from transportation.
 - Influencing the shape and density of cities now important if want more energy efficient cities in the future.
 - Cost of needed technologies won't fall unless there is sufficient demand to deploy them to scale
 - The argument is that new technologies will only be developed with sufficient demand for them.
 - Early action justified by the technological change induced.
- Some damage is irreversible
 - Lost biodiversity is an example

III. Infrastructure

- Availability of infrastructure for water and electricity is also important.
- How does a lack of infrastructure for water affect health? What makes infrastructure an environmental problem?
 - Dirty water and poor sanitation kill 5,000 children per day
 - 1.2 billion people defecate in the open and do not have access to running water to wash their hands afterwards
 - Diarrhea and related diseases are the leading cause of death in children
 - These children need clean water for rehydration
 - Even if survive, at risk for malnutrition
 - Early nutrition matters
 - Study in Guatemala followed children in four villages through adulthood
 - In two villages, the children received a nutrition supplement during their first seven years. In the other villages, received a less nutritious supplement
 - Boys receiving the more nutritious supplement:
 - had larger bodies, a greater capacity for physical work, more schooling, and better cognitive skills
 - Earned 46% higher average wages
 - Studies in Ghana and Pakistan suggest malnutrition from diarrhea costs each country 4-5% of GDP
 - Malaria and poor access to water adds another 4-5%
- Note that the problem is not just water scarcity, but infrastructure
 - There is a shortage of safe drinking water and sanitation
 - Most migrants to cities in Africa live in slums
 - In these cities $\frac{1}{4}$ to $\frac{1}{2}$ of the population has no access to sanitation or piped water
 - In Delhi (in 2010), 40% of water supply fails to reach customers because of lack of maintenance on pipes
 - Utility rations water
 - Provides access for only a limited number of hours per day
 - Restricts quantity in some places
 - Residents build tanks to store water when it is available
 - Developers drill boreholes to reach water
 - As more boreholes drilled, need to drill deeper
 - The city's main source of drinking water, the Yamuna River, is polluted
 - Untreated sewage and industrial wastes flow into it
 - Runoff from farms also a concern
 - Raising money for maintenance difficult
 - While people can drink bottled water, that is a significant expense for the poor.

- What about infrastructure and electricity?
- Why (and when) is demand growing? Vietnam provides an example
 - Electricity demand increases most quickly when the middle class is growing
 - This is when people begin to buy appliances and motorbikes
 - In contrast, low income families use additional income to buy food
 - High income families do not continue to consume more energy as income grows
 - Hot and humid climates increase demand for air conditioning
 - Vietnam's population is 1/3 that of US. But, if its people used air conditioners at the same rate as Americans on hot, humid days, its AC energy consumption would equal that of the US
 - Rural electrification
- Electricity in Africa
 - Without electricity, people spend more money to get lower quality energy
 - May pay up to \$10 per kWh for fuels such as kerosene or batteries for cooking and lighting
 - Often use charcoal or biomass for cooking
 - Even diesel generators have higher costs
 - \$0.35/kWh
 - This is 10X more than electricity from the grid
 - Generate lots of pollution

- Investment in generation is growing
 - Capacity may increase by half by the end of the decade
 - In South Africa, much new capacity will come from coal. Renewable capacity also being build
 - In other countries, most new capacity from renewables or natural gas
 - Factors driving expansion
 - Governments are opening their markets to private investments and improving regulations that encourage investment
 - Africa has some of the world's best renewable resources
 - Large rivers not yet dammed could provide hydropower
 - Useful for baseload power
 - Sunny deserts for solar
 - Windy uplands
 - Renewables can be built quickly to fill immediate shortages
 - In contrast, large coal plants may take decades to plan and build
 - Costs of renewables falling
 - Although perhaps not competitive than coal or gas, renewables are competitive when compared to the cost of diesel
 - Because of this, subsidies for renewables may not be needed
 - Note how technology developed elsewhere benefits these countries!
 - Solar panel prices have fallen by half in recent years
 - Investors more comfortable committing to a small wind farm than a large power station
 - Wind and solar can provide off-grid power directly to customers
 - Reduces strain on congested transmission lines

- What are the challenges to continued expansion?
 - One roadblock is getting customers to pay their bills
 - Electricity is easier to steal
 - People often have illegal hookups
 - Harder to cut off people who don't pay
 - Compare to cell phone, were service turned off if don't pay
 - One half of the power generated by the utility in Bihar is paid for
 - Customers are reluctant to pay because service is unreliable
 - Households can bypass the grid, such as by using solar
 - Pay for this through loans, repay with mobile money
 - But, industry needs a reliable, large scale power supply.
 - Thus, lack of infrastructure hinders economic development.
 - Regulators keep prices low
 - In Nigeria, distribution companies refuse to buy power from generating companies, arguing they would lose money on it
 - Rural electrification has high fixed costs
 - A single connection in Kenya can cost \$2,5000
 - If rural consumers don't purchase hookups, utility cannot recoup fixed costs
 - Thus, demand is an issue.
 - In addition to infrastructure, an important consideration is whether people can afford appliances necessary to take advantage of an electricity grid.
 - A recent study in Kenya suggests that even when access to the grid is available, not all households choose to purchase.
 - In their data in Kenya, just 5% of rural households and 20% of private businesses within a half-mile of electricity infrastructure have electricity.
 - As a result, their study finds that household demand for an electricity connection is below average cost.
 - Thus, demand never justifies the cost

- Why don't people connect?
 - Cost is high
 - However, even if electricity is subsidized, few people take advantage
 - Lack of financing options
 - Poor service
 - Long wait for hookups (about 7 months)
 - Blackouts common
 - Lack of maintenance staff and materials
 - Need to afford appliances to use electricity
 - Note how this is different than for water infrastructure
 - An electricity company in Kenya, Uganda, and Tanzania offers packages with small appliances that consumers can pay for in installments.
 - Implication: should focus on increasing income before focusing on electricity
- Are “microgrids” a solution?
 - Smaller grids and technologies such as solar lanterns may help households.
 - But the authors argue that while small-scale technologies may be cost effective for small rural communities, it cannot reap the economies of scale of a national power grid.
 - Another [recent study](#) suggests that home solar systems do not provide the same service as an electricity grid.
 - Thus, they argue Africa is not “leapfrogging” over the developed world.
 - Key findings:
 - Asked people what appliance they would purchase next.
 - People want high wattage appliances, such as televisions, radios, and irons
 - Set of appliances currently owned by solar homes more similar to un-electrified households than households with grid connections
 - Homes with solar use almost as much kerosene as un-electrified homes
 - Typically used for lighting. Almost none of the homes in their sample use kerosene for cooking
- What about privatization?
 - Note that most promising areas get hooked up first

- Another challenge is integrating renewables into the electric grid
 - Donors prefer renewables, so as to not lock in countries to new fossil fuel plants
 - But renewables are expensive and intermittent
 - Need good baseload power to develop industry
 - Possible baseload sources:
 - geothermal
 - hydro
 - In 2013, the majority of new power-generating capacity built in China was renewable, rather than fossil or nuclear.
 - Local air pollution is a concern
 - Global pressures to reduce carbon emissions
 - However, not all the power produced reaches markets
 - Curtailment rates (energy generated but not taken up on grid) for wind over 15% in 2016
 - While China is building more capacity, still expected to be around 15% in 2018
 - New regulations give priority to renewables
 - Compare to less than 2% in Britain
 - Power generation in China is dominated by state-owned enterprises (SOE)
 - They have little incentive to compete on price, efficiency, or environmental quality