Sustainable Development and cyclical economy

David Zilberman
Department of Agricultural and resource Economics
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Overview

- The challenges of the next fifty years
- Sustainable development
- The circular economy and bioeconomy
- Let a thousand flowers bloom

The challenges

- Feed another three billion people
- Control climate change and protect biodiversity
- Develop alternative sources of energy – more people want access to cars and electronics
- Reduce poverty and eliminate mal-nutrition

New management Strategy

- Many new concepts
  - Circularity
  - The Bioeconomy
  - Regenerative agriculture
  - Agro-ecology
  - Precision farming
- The public is confused
- The primary concept is Sustainable development-a sound framework
  - Other can be view within this framework

In search of sustainable development [Sus Dev]

- Sustainable development: a paradox?....oxymoron
  - Sustainable – Capacity to endure; unchanging
    - Static
    - Synonyms include “maintain", "support", or "endure”.
  - Development – Change for the better
    - Dynamic
- Sus Dev is a challenge of bridging conflicts: how to keep the essential while minimizing nonessentials
- It applies to economics and biological systems

Sustainable development

- It is not a slogan, it is a challenge.
- It dealing with a conflict between two objective
  - It is different than environmental protection or conservation per se
  - It is not keeping things the same; because evolution occurs, things move
  - It is not unbridled growth
- It is a tough balancing act
- Requires policies that incentivize growth and penalize pollution and resource degradation
- It does not aim to stop individuals and societies from taking risks, but aims to control them in the expectation that things will improve and the probabilities of disaster will be eliminated

Multiple dimensions of sustainability

- Sus Dev is desirable, but interpretations vary
- Agreeing to pursue it represents a political compromise
- Over time a vocabulary to discuss sustainability was introduced, emphasizing the three pillars:
  - Economy
  - Society
  - Environment
- It is used to provide criteria for policy assessment
- We present an economic framework for Sus Dev relying on major tools developed by Applied economists
- A starting point for analysis is the Brundtland Commission.

Brundtland Commission:
March 20, 1987

- *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*
- This definition and economics are both anthropocentric:
  - Assume that humans are the most significant species
  - Human Utility maximization is the premier criteria
  - Other species are significant only if they provide utility to humans (pets, food) or affect productivity (fish, livestock)
  - Some environmental groups may take another perspective
    - leads to conflicts between sustainability and sustainable development
- This definition represents a constrained optimization problem—ideal for economic analysis

Sus Dev and economics

- Sus Dev changed how growth is modeled in several ways:
  - Adding new dimensions to standard growth models
  - Expanding policy considerations and tools
  - Introducing science into economics
- Sus Dev sets a constraint on growth, namely future utility should not lie below present utility or some defined lower bound
- Expanding the concern for inequity
  - Deriving growth strategies that aim to improve the welfare of poor or less fortunate generations.
- Addressing resilience
  - set probability limits on the occurrence of undesirable outcomes (i.e. disasters)

Sus development -Growth with Environmental Sustainability

- Economic growth models should explicitly introduce the environment and consider various manifestation of pollutions.
  - E.g. stock pollution (the externality is a function of the accumulated pollution) vs. temporal pollution (felt immediately)
- They include natural capital—the stock of natural assets that yield ecosystem goods or services (stabilize climate, increase water quality, etc.)—and their interaction with human action and policies

Expansion of economic Sus Dev models

- Economic models of Sus Dev need to explicitly incorporate biophysical processes and the environment
  - Economic models capable of doing this exist
  - Applied economists have developed frameworks to model technologies that incorporate pollution generation for production and address various types of innovations
- Economic models of sustainability need to better address dynamics of natural resources
- They need to introduce science into economics
- Before we present this model let have an historical persepctive

Lessons of the past

- With growing reliance on science
  - Food production increased faster than population growth
  - Shift from land and labor to capital, water and chemicals
    - Taking advantage of power of genetics
  - Increasing life expectancy and health
- But there are side effect
  - Pollution problem –extinctions, climate change
  - Failure of
    - policy to response to scientific knowledge
    - Limited knowledge
- Forces that brought us here –part of the solution
  - Science based technologies
  - Investment in research
  - Mixing market forces with government policies to correct market failures

Mixing market forces and enlightened active governments

- The educational industrial complex
  - Public sector finance; basic research
  - Companies commercialize innovations
- Power of incentives
  - Lead to change of behavior—green choices
- Market failures
  - Need intervention to provide incentives for pollution control
  - Address monopolistic behavior
  - Underinvestment in R&D (orphan industries/crops)

Main elements to attain Sus Dev

- Conservation – reduces consumption of energy and non-renewables. Can be achieved by:
  - Improving input use efficiency
  - Adoption of precision systems
  - Triggered by policies
- Avoiding non renewables
- Recycling
  - Allows sustainable use of minerals
- Use of renewable energy sources, e.g solar, wind, etc.
- The bioeconomy (discussed in more detail on the following slide)

We Can not avoid Circularity

- Conservation of mass is a physical law we can not ignore
- So linear system that link input and output and neglect mass balance accounting may be convenient – btu lead to errors
- Need to recognize circularity – in system and policy design design – that aim to design sustainable development
- Recognizing the difference between applied and effective inputs
  - Unutilized effective input is source of pollution
  - Yet can be utilize- be input for valuable product
- That require investment in research and enlightened policy pricing pollution and waste
- Key elements in moving towards circularity

Conservation Technologies

- Increase input use efficiency (IUE)
  - Actual fertilizer has frequently 37%
    - Residue lead to water contamination
- Technology & environment affect IUE
    - flood irrigation 15% in sand 75% in heavy soils. Drip irrigation may have 95% IUE.
- higher IUE tends to increase yield, reduce input and pollution, but raises fixed costs.
- Conservation technology- should not be adopted everywhere
- Under adopted if pollution and externalities are not priced

Precision farming

- Takes advantage of information technology
- Diversify application of inputs based on information
- Improves timing -reduce residues and minimize pollution and waste.
- May increase average yield, but saves inputs and reduces pollution
- Impact increases with variability of conditions

Challenge of precision

- Requires – monitoring assessment and application
  - Remote sensing methods improve monitoring
  - Modeling (include AI and adaptive ,learning) Improve assessment
  - Application is costly- become feasible with drown and internet
- Better science and connectivity improves precision

Transition to renewables

- Sustainable systems avoids dependence on non renewable
- Renewable resources
  - Physical renewables (Sun, Water, Wind)
- Living systems (Plants ,Animals)
- Living systems divided between
  - harvesting (hunting, fishing) and husbandry (farming)
  - Farming includes
    - breeding
    - Feeding
    - Harvesting
  - Farming system are cheaper overall
  - Precision breeding (genetic) and cheaper feeding (fertilizers) and harvesting (mechanization) gives it the edge
  - Challenge – multiple usage of output to minimize residues
- Higher IUE of farming – include through reuse use of residue – contributes to sustainability

The bioeconomy defined

- The bioeconomy is defined as:

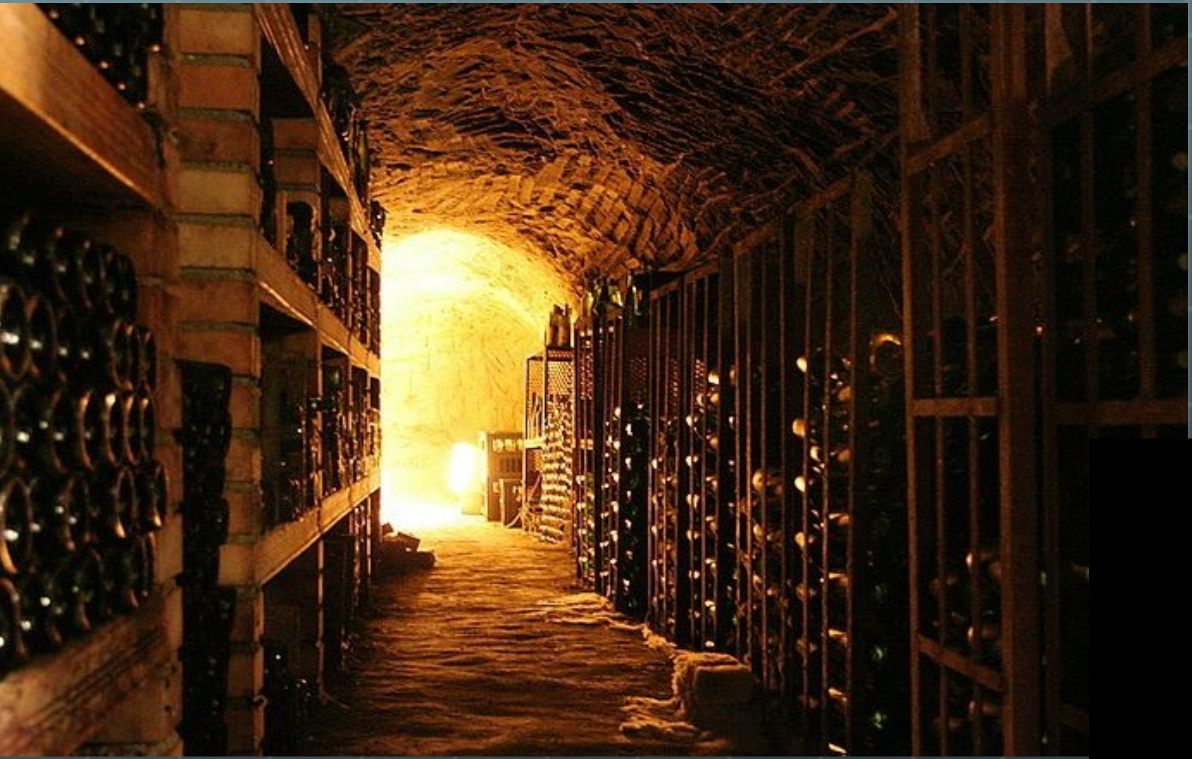
"The part of the economy that utilizes new biological knowledge for commercial and industrial purposes, and for improving human welfare" (Enriquez-Cabot 1998).

- It produces foods, fuels, fibers, pharmaceuticals, chemicals, and even computer memory.
- It is a natural resource based industrial system
  - Traditional technologies – fermentation (wine, etc.)
  - New technologies – modern molecular biology (DNA), information technology

Eco-farming

- Takes advantage of ecological knowledge
- Captures ecological services
- Diversifies crops and introduces creative rotations
  - Multi-cropping
  - Integrated crop and livestock systems
  - Takes advantage of traditional knowledge
- Ecological knowledge need to merge with molecular knowledge
- Ecological agriculture that rejects biotechnology may divert is from sustainability
- Can become imported part of integrated bioeconomy

The old and new bioeconomies



The bioeconomy is associated with transition

- From non-renewables to renewables (biofuel, green chemistry)
- From harvesting to husbandry (using some biotechnology)
- Improvement of husbandry systems
  - Better breeding and raising (biotechnology)
- Development of new value added industries (many in rural areas)
  - Refineries to fuels and fine chemicals
  - Processing of new bio-based products close to source

Objectives and challenges of the bio-economy

- Reducing reliance on nonrenewables
- Increasing overall and farm sector welfare
- Reducing externalities
- Challenges
  - Outputs of the bioeconomy may be renewable but rely on nonrenewable inputs (fertilizers)
    - Fixing nitrogen is a major challenge and a $50 billion opportunity
  - Overall GHGs and other externalities of new products may be greater than those of the products they replace
  - Some bioeconomy activities will reallocate resources away from food production

Biotechnology major tool of the bioeconomy

- Precise application of molecular knowledge to crop breeding
- CRISPR and GM technologies–small modifications
  - Key to medicine – in ag limited use-increase yield reduce inputs use
  - Under right polices may preserve crop biodiversity
  - In infancy (vast potential as genomic knowledge advances)
  - Over-regulated
    - Slow costly uncertain _ Golden rice
  - Cost of over-regulations
    - Millions of lives lost
    - Higher food prices
    - Large ag footprint
    - Slow introduction of bioeconomy – and circularity

Bioeconomy and environmental and food challenges

- In order to assess and improve environmental effects:
  - Conduct Life cycle analyses (LCAs) to assess overall external effects
  - Establish policies that make agents pay social costs of the externalities they create
- Need constant increases in food productivity as well as mechanisms to protect the poor from food price inflation
- With biotechnology -Bioeconomy – can lead to produce food, biofuel, green chemistry-and recycle residues

Agriculture is much more than food

- Traditional agricultural problem: low farm incomes
- There is a need for new sources of income, and the bioeconomy provides it.
  - It increases the product mix of farming systems
  - It is also likely to shift jobs (in refining, processing, quality control, etc.) to rural areas
  - But food is first – need policies to assure food availability and affordability

Policy challenges

- Integrate agricultural, environmental, energy, and other resource policies with the aim of reducing inefficiency and attaining environmental objectives
- Provide incentives and policies to adopt technologies and induce behavioral changes—consistent with Sus Dev
- Develop global trade and other international agreements to enhance efficiency and Sus Dev
- Reduce regulatory burden
- Support for R&D and build up of human capital

Let a thousand flowers bloom

- Eco farming, biotechnology, and biofuel are complementary
  - Eco-farming and biotech can increase yield to allow more space for biofuel
  - Eco-farming and biotech can enhance productivity of fuel feedstock
  - Biotech can restore old varieties to fit ecological niches
- Research efforts and regulations should emphasize integrated approaches
- The challenge of the 21st century require taking advantage of all our tools and taking small risks to address big issues.