



***Life Cycle Assessment***  
*A product-oriented method  
for sustainability analysis*

*UNEP LCA Training Kit*  
*Module j – Life cycle costing & eco-efficiency*



UNEP

Life Cycle



Initiative



## Contents

It is helpful to have viewed modules a and b prior to this module.

- **Sustainability analysis**
- **Extending LCA**
  - **economic dimension**
  - **social dimension**
- **Life cycle costing**
- **Eco-efficiency**
- **Combining LCA and LCC**
  - **separate**
  - **divide**
  - **sum**

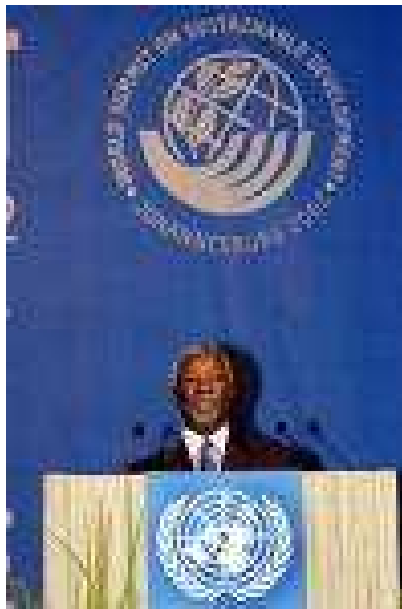
# Sustainability analysis

- **World Commission on Environment and Development**
  - “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”  
(Brundtland, 1987)



# Sustainability analysis

- **World Summit for Sustainable Development**  
Johannesburg, August 2002
  - “The Summit meets under the theme "People, Planet and Prosperity". It focuses on the improvement of people's lives everywhere, through sustainable development.”  
(Thabo Mbeki, President of the Republic of South Africa)

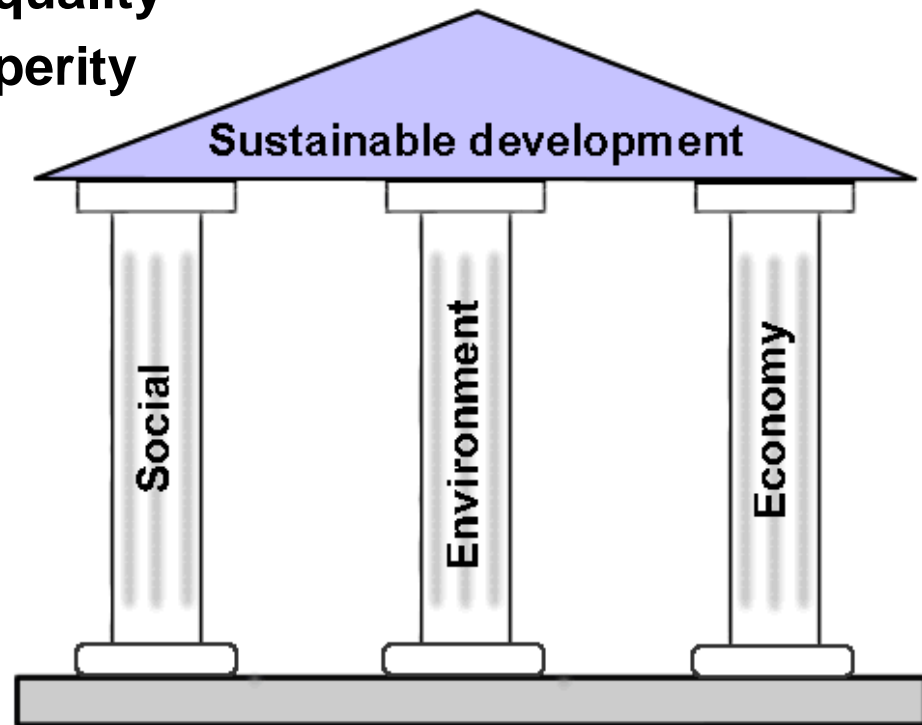


# Sustainability analysis

- The Triple Bottom Line of 21st Century Business

**Three pillars of sustainability** (SustainAbility, John Elkington, 1998)

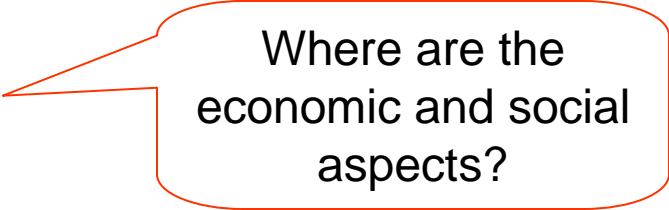
- **social justice**
- **environmental quality**
- **economic prosperity**



# Sustainability analysis

- **LCA according to ISO:**

- LCA is the “compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle”
- “Economic and social aspects and impacts are, typically, outside the scope of the LCA. Other tools may be combined with LCA for more extensive assessments.”



Where are the economic and social aspects?

# Extending LCA

- **Extension to the economic dimension**
  - life cycle costing (LCC)
- **Extension to the social dimension**
  - work environment
  - Employment
- **ISO 14040:**
  - “LCA typically does not address the economic or social aspects of a product, but the life cycle approach and methodologies described in this International Standard can be applied to these other aspects.”

# Life cycle costing

- **Life cycle cost are the costs induced by a product in its life cycle**
  - directly and indirectly
  - by public and private actors
  - possibly including cost of external effects
- **Life cycle costing (LCC) is a method to establish life cycle cost**



# Life cycle costing

- **History**
  - US Army
    - ‘cheapest purchase meeting specifications’
    - cheapest functioning
    - best cost-function relation
  - RAND Corporation
    - Planning, Programming, Budgeting System (PPBS)
  - Cost benefit analysis (CBA)
    - not budget cost but social cost

# Life cycle costing

- **Cost categories**
  - which costs will be included?
- **Cost bearers**
  - whose cost will be included?
- **Cost models**
  - How are the effects quantified?
- **Cost aggregation**
  - How are the results aggregated?

# Life cycle costing

- **Cost categories**
  - economics
    - budget costs, market costs, collective costs, alternative costs; social costs, ...
  - life cycle stages
    - R&D, primary production, manufacturing, use, disposal, ...
  - activity types
    - design, transport, sales, manufacturing, ...

# Life cycle costing

<b>Cost bearer</b>	<b>Upstream</b>	<b>Downstream</b>
Producer	Almost all	None
Supply chain	All	None
Owner	Almost all	Almost all
User (not owner)	Almost all	Almost all
Life cycle (all involved)	All	All
Country's society	All	All
Global society	All	All

# Life cycle costing

- **Cost models**
  - steady state models
  - comparative static equilibrium models
  - static optimization models
  - quasi-dynamic models
  - dynamic optimization models
  - dynamic models
  - system dynamic models

# Life cycle costing

Method	Discounting	Costs and benefits separate
Net present value	+	-
Average yearly cost	-	-
Steady-state cost	-	-
Annuity	+	-
Pay-back time	-	+
Benefit-cost ratio	+	+

# Life cycle costing

- **Discounting**
  - No discounting
  - Market rate (but which one?)
  - Individual time preference (but whose?)
  - Social time preference (but how derived?)


# Aligning LCA and LCC

- **Aligning environmental and economic dimension**  
(2/3 of sustainability)
- **Systematically link**
  - economic/cost
  - environmental consequences
- **Approach**
  - Defining LCA compatible with LCC
  - Defining LCC compatible with LCA
  - Mix of '1' and '2'
- **Combined LCA/LCC results** help specify eco-efficiency or environmental cost-effectiveness of decisions.
  - e.g. as 'cost per unit of environmental improvement'



# Aligning LCA and LCC

<b>Model type</b>	<b>Example</b>
Comparative static equilibrium analysis	LCA
Optimization models	LP/OR
Quasi-dynamic analysis	LCC/CBA
Dynamic analysis	Macro-economic models



# Aligning LCA and LCC

- **For both the LCA and LCC model:**
  - express inventory processes as flows per year
  - adapt FU accordingly
- **Two directions for alignment:**
  - make LCA quasi-dynamic
  - make LCC steady state

# Aligning LCA and LCC

- **LCA as (quasi) dynamic model**
  - functional unit may change per year
  - life cycle processes spread out in time
  - impact assessment partially spread out in time
- **Conclusion:**
  - Quasi-dynamic LCA is possible but conceptually inconsistent

# Aligning LCA and LCC

- **LCC as a steady state model.**
  - all (net) cost specified on a yearly average basis
  - infinite time horizon
- **Conclusion:**
  - This niche may well be filled to connect LCC to LCA

# Aligning LCA and LCC

- **There is not “one LCC”, nor is there “one LCA”.**
- **Aligning requires explicit choices and adaptations.**
- **The LCA functional unit is to be expressed on a per-year basis, allowing for alignment with cost per year.**
- **Adapting LCA leads to time-related inconsistencies:**
  - Discounting may conflict with strong sustainability requirements.
- **Adapting LCC yields consistent but unusual LCC.**

# Combining LCA and LCC

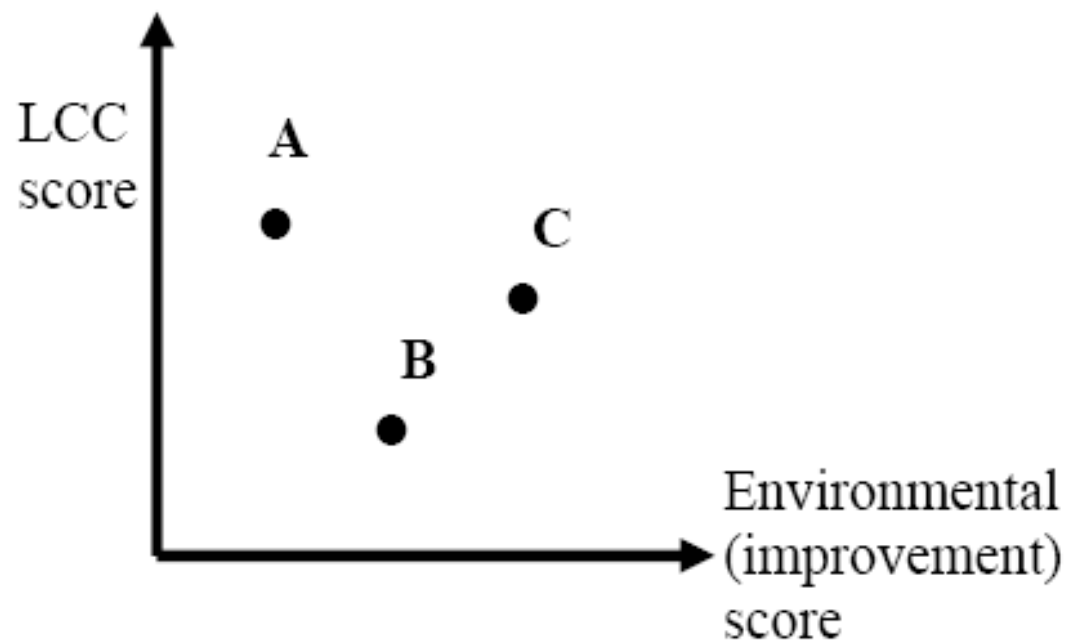
- **What to do with two results?**
  - an environmental indicator (E), e.g., with LCA
  - an economic indicator (C), e.g., with LCC
- **Three approaches:**
  - keep separate (separate indicators)
  - divide (ratio)
  - add (common metric)

# Combining LCA and LCC

- Option 1: **Keep E and C separate**
- Calculating
  - an environmental indicator (E), e.g., with LCA
  - an economic indicator (C), e.g., with LCC
- Using two analyses, e.g. LCA and LCC
- Using one analysis, e.g.: LCA and LCC

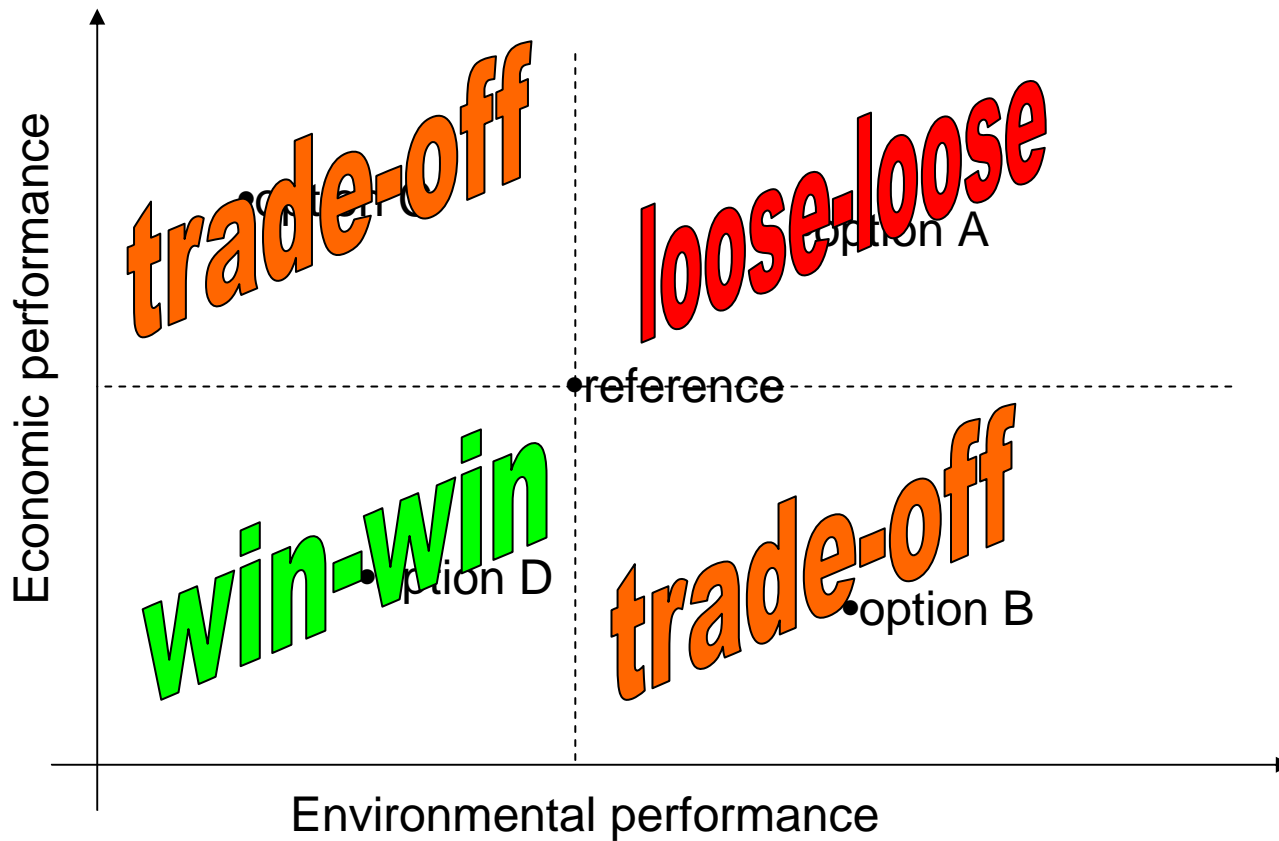
# Combining LCA and LCC

Economic and environmental performance graph





# Combining LCA and LCC



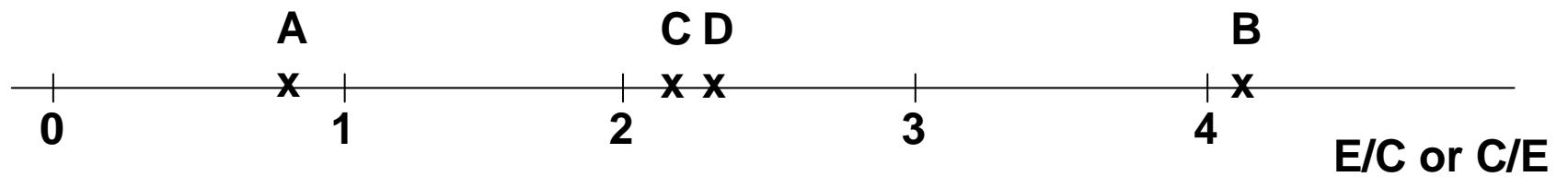
# Combining LCA and LCC

- Option 2: **Dividing E and C**
- Calculating
  - an environmental indicator (E), e.g., with LCA
  - an economic indicator (C), e.g., with LCC
- Forming eco-efficiency ratio
  - $E/C$  (environmental productivity or improvement cost)
  - $C/E$  (environmental intensity or cost-effectiveness)

# Combining LCA and LCC

	<b>product or production primary</b>	<b>environmental improvement primary</b>
<b>economy divided by environment</b>	<i>environmental productivity</i>	<i>improvement cost</i>
<b>environment divided by economy</b>	<i>environmental intensity</i>	<i>environmental cost-effectiveness</i>

# Combining LCA and LCC



# Combining LCA and LCC

- Option 3: **adding E and C**
- Calculating
  - an environmental indicator (E), e.g., with LCA
  - an economic indicator (C), e.g., with LCC
- Forming sum
  - $cE+C$  (monetarized environmental impacts)
  - $E+eC$  (“ecologized economics”)
  - $\gamma E+\varepsilon C$  (weighted sum)

# Combining LCA and LCC

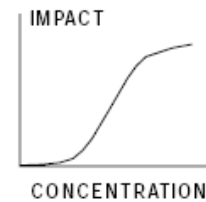
**EMISSIONS**  
(e.g. tonnes/year of SO<sub>2</sub>)



**DISPERSION**  
INCREASE IN AMBIENT  
CONCENTRATIONS  
(e.g. ppb SO<sub>2</sub> for all affected  
regions)



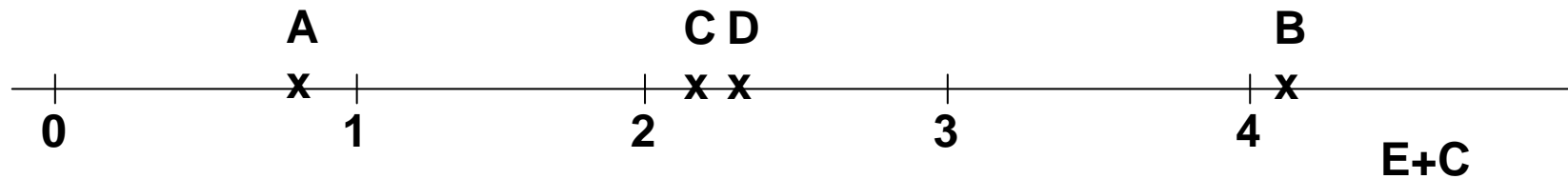
**IMPACT**  
(e.g. change in crop yield)



**COST**



# Combining LCA and LCC





- **Sustainability analysis**
- **Extending LCA**
  - economic dimension
  - social dimension
- **Life cycle costing**
- **Eco-efficiency**
- **Combining LCA and LCC**
  - separate
  - divide
  - sum





The remaining modules explore these topics.

Module	contents
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- |   |                    |
|---|--------------------|
| k | Uncertainty in LCA |
| l | Carbon footprint   |