Contributions of the geospatial fields to monitoring sustainability of urban environments

John Trinder

School of Civil and Environmental Engineering

Never Stand Still

IMPACT OF HUMAN DEVELOPMENT

- Humans are modifying the energy and mass exchanges that occur between the atmosphere, oceans and biota
- The resulting changes may be beyond the resilience of the Earth's environment to absorb them
- World Summit Sustainable Development declaration includes the three 'pillars' of Sustainable Development:
  - Economic
  - Social
  - Environmental

  All 3 should be assessed for sustainability

SUSTAINABLE DEVELOPMENT

- Practices for a satisfactory standard of living today, and will not impair the capacity for future generations.
- Development that meets the needs of the present without foreclosing the needs of future generations
- Requires equilibrium between production and the consumption of energy
- Achieving a sustainable society cannot be divorced from equity, welfare, lifestyle and standards of living

TOWARDS A SUSTAINABLE FUTURE

Scenarios for developing a sustainable human society (Gallopin & Raskin 2002) :

- market forces
- policy reform
- eco-communalism
- muddling through

Ecosocial market (Rademaker 2004)

- consensus, and respect for civil rights and human equity
- human behaviour is agreed globally by social contract

Sustainability Indicators (SI)

- Developed to assess the impact of policies on natural resource development
- Exact measures of single factors and their combination into meaningful parameters
- Compresses information on a relatively complex process into a more understandable form
  - May be application specific
  - Should be unbiased
  - Sensitive to changes
  - Convenient to communicate and collect.
  - Separate SI for economic, social and ecological

SI FRAMEWORKS

- Many hundreds of SI developed
- Simple approach to developing SI inadequate
- SI frameworks include linkages between the three areas:-
- Typical conceptual frameworks recommended by authors:
  - domain-based, issue-based, goal-based

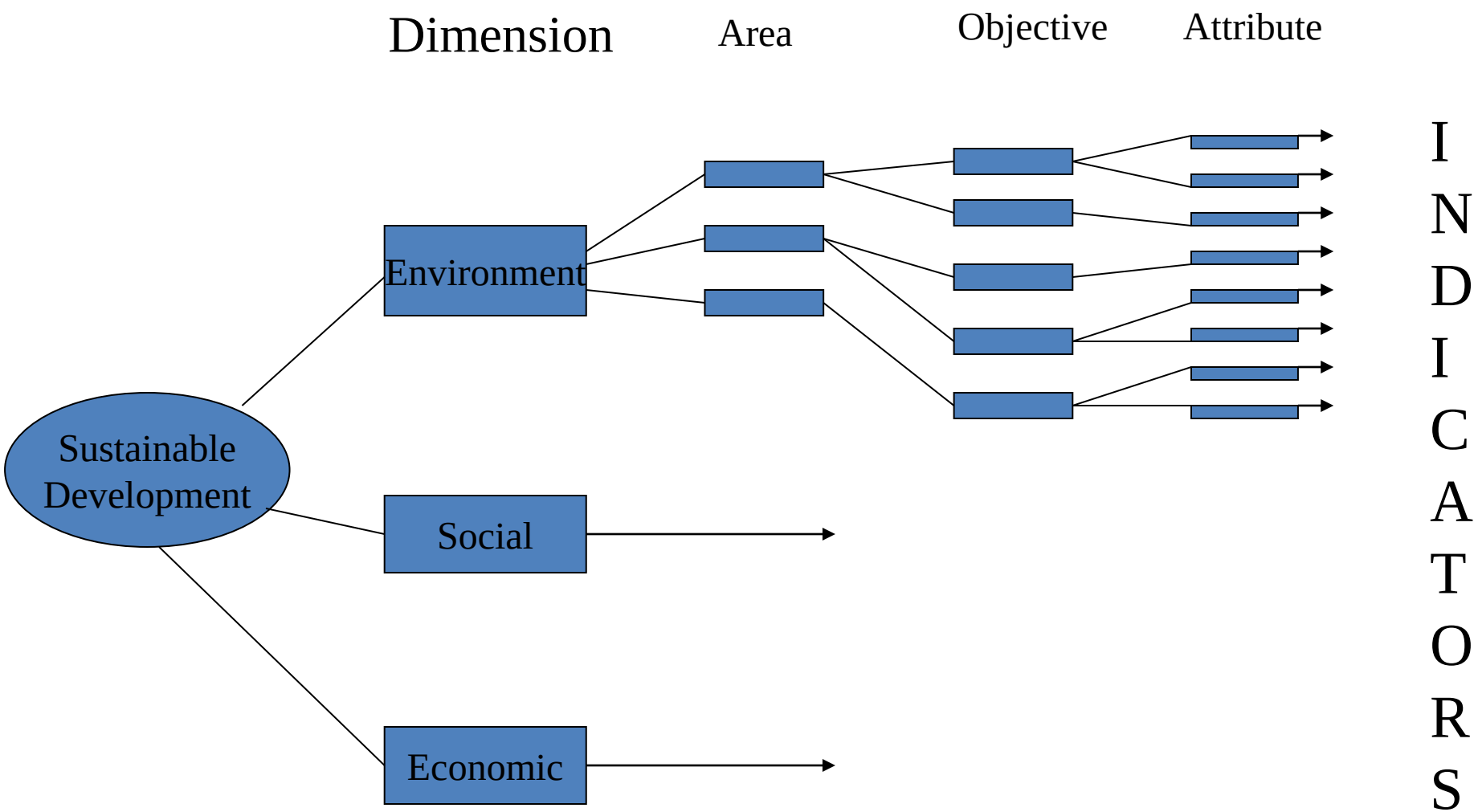
SI FRAMEWORKS

Hierarchical concept

– economic, social and ecological

– each subdivide into

- Area
- Objective
- Attribute
- Indicators



Hierarchical framework of indicator system.

Sustainability of urban areas

- 54% of the global population in 2014 lived in cities
- The growth in cities is causing stress on urban environment
- ‘End of the 20th century is a turning point in the history of human civilization’
- Sustainable urban form should be defined by
  - compactness
  - mixed used
  - density
  - sustainable transport
  - diversity
  - greening

Sustainability of urban areas

- Cities depend on resources from the hinterland
- Stretching from nearby areas to globally through exports and imports
- Aspects of a sustainable city
  - Greater viability of public transport
  - Affordable housing that meets a range of demographic groups

Sustainability of urban areas

- Aspects of a sustainable city
  - Greater access to quality education and jobs
  - Supporting neighbourhoods that are engaging in sustainable practices
  - Engagement of governments in providing financial support for sustainable activities
  - Investment in healthy, safe and walkable neighbourhoods.

Data acquisition systems suitable for SI for urban areas

Data Type	Characteristics
RPAS image data - small cameras	with spatial resolutions ranging from 1-2 cm to >10 cm Spectral resolution – RGB or CIR Temporal resolution – as required in daylight
Manned aircraft with Digital aerial cameras	Spatial resolution – 3-5 cm to > 50 cm Spectral resolution – RGB, CIR Hyperspectral sensor acquiring 100s of bands Temporal resolution – as required in daylight
Optical satellite Images – high resolution images from 30 cm to several metres	Spectral resolution – panchromatic (pan) with a single band to multiple bands (MSS) Temporal resolution – from many days to 1 or 2 days depending on location and capabilities of the satellite
SAR Images Microwave sensors installed in satellites or aircraft	Spatial resolution < 1 m for airborne and ranging up to >10 m for space borne with various levels of polarization Spectral resolution – variable Temporal resolution – variable
Airborne lidar – Airborne only	Elevation posts acquired at 2 > 10 posts/m^2 Multi-spectral sensors available

Assessable Sustainability in Urban Areas by RS Technologies

Area - Urban Sustainability Measure	Objective - Measurement by RS technologies
Balanced development	Measurement of impervious surfaces in relation to open space
Transformation of green space to impervious surfaces	Growth in fragmentation of open space versus impervious surfaces
Effective and environmentally sound transportation systems	Mapping and analysis of transport systems
Compactness of cities and walkability	Determine compactness of cities, mapping of walking and cycle paths and township layout
Consumption of natural resources (renewable and non-renewable), from hinterland and its impact	Measurement of deforestation and changes in land cover over time
Effects on biodiversity	Changes in local vegetation and native flora and potential habitats for fauna

Measurement of impervious surfaces

Many papers have been written on the measurement of impervious

Measured normally from high resolution optical images with resolutions less than 1 m.

Hyperspectral images of importance to determine whether surfaces are fully impervious

Ratio of areas of fully impervious surfaces to open spaces

Growth in fragmentation of open space versus impervious surfaces

- Measurement by medium to high resolution remotely sensed images
- Derived parameters from NDVI or similar parameters
  - Diversity
  - Dominance
  - Fragmentation of land use

Mapping and analysis of transport systems

Mapping of transport systems based on medium to high resolution images

Transport Mode Index (TMI)

Determine compactness of cities

Parameters investigated for determination of:

- Sprawl
- Density, expressed in terms of land occupation per capita;
- Degree of distribution of development in a metropolitan area;
- Clustering or centralization of the metropolis.

Some measurable by remote sensing

Measurement of deforestation and changes in hinterland over time

- Medium resolution remote sensing technologies
- Extensive studies of deforestation undertaken eg Brazil
- Vegetation stress from wwithdrawal of water from aquifers
- Withdrawal of water from aquifers h often occurs for urban water supplies

Land use land cover changes

Biodiversity

- Optical sensors with high resolutions using vegetation indices and change detection techniques
- Enable mapping, monitoring and measurement of the areal extent of the changes in biodiversity.
- Requires field work to study details of biodiversity

Land use conversion and loss of habitats

Conclusions

- Definitions of sustainable development
- Assessment of sustainability should be based on appropriate indicators - SI
- Much to be learned about SI to ensure sustainability of development
- SI must consider relationships within the three pillars – economic, social and environmental
- More than 50% of the global population now lives in urban areas

Conclusions

- There is urgency in determining and assessing SI for urban areas.
- Without the sustainability of urban areas less chance of sustainability of the environment
- Remote sensing technologies can make an important contribution
- They must satisfy scientific criteria – subject to strict calibration and validation