Statistics on land use

NAME1	NAME2	CODE	ITEM_CODE	YEAR	ELEMENT_CO	DATA	COMMENTS
Region 1	Ariana	TUN001001	44	1994	031	2100	
Region 1	Ben Arous (Tunis Sud)	TUN001002	44	1994	031	1700	
Region 1	Tunis	TUN001003	44	1994	031	300	
Region 2	Bizerte	TUN002001	44	1994	031	6000	
Region 2	Nabul	TUN002002	44	1994	031	17300	
Region 2	Saghuan	TUN002003	44	1994	031	2800	
Region 1	Ariana	TUN001001	44	1994	051	1900	
Region 1	Ben Arous (Tunis Sud)	TUN001002	44	1994	051	1500	
Region 1	Tunis	TUN001003	44	1994	051	400	
Region 2	Bizerte	TUN002001	44	1994	051	5400	
Region 2	Nabul	TUN002002	44	1994	051	18600	
Region 2	Saghuan	TUN002003	44	1994	051	3400	

Hubert George

Land and Plant Nutrition Management Service, AGLL
Land and Water Development Division
FAO

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Outline

- Environmental & policy issues
- Sources of land use & land cover statistics
  - the institutional aspects
- Concepts, methods & classifications
- The UNSD questionnaire on land use statistics & linkages with other statistics
- The Agro-MAPS initiative

Setting the scope: Environmental & Policy Issues

Land resources

…a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface --

Total land area Total area of a country, minus area under major inland/tidal water bodies.

- the near-surface climate,
- the soil and terrain forms,
- the surface hydrology (including shallow lakes, rivers, marshes and swamps),
- the near surface sedimentary layers and associated groundwater and geo-hydrological reserve,
- the plant and animal populations,
- the human settlements pattern and physical results of past and present human activities" FAO, 1995

Land use

"..human activities which are directly related to land, making use of its resources or having an impact on it ..."
FAO, 1995

- Socio-economic purpose of the activities (functional definition)
- Usually multiple purposes
- Manipulation of natural ecosystems in order to obtain benefits
- Material benefits/ products (e.g. cereals, livestock)
- Immaterial benefits/ services (e.g. erosion prevention)
- Often some unwanted impacts!!

production vs. extractive process

What is the land used for?

Why we need LU information

- Land resources are finite & usually scarce!
- Competition among various land uses (e.g. urban expansion into agricultural areas): dissimilar impacts on the environment
- Thus, knowledge of current LU (& land resources) is needed for formulating changes leading to sustainable use of the resources

LU information
- Key input for planning & policy formulation

Decisions will be taken in absence of information !

Agricultural development

Typical issues

- Protect the most productive arable land from permanent loss to other uses?
- Increase crop production?
- Minimize the impact of drought on crop production?
- Reduce the rate of deforestation? biodiversity loss?
- Reduce the environmental impacts of LU?
- Develop better land use systems to sustain growing populations?
- Minimize threats to wildlife due to habitat destruction?

The greater the scope of LU information collected (i.e. products, services & management) – the wider the range of decision making supported:
but Trade offs!!

Scope of LU information to collect

Examples of Issues	Required LU data		
	Goods	*Services*	*Mgmt.*
Impact of drought on agricultural production	●		
Impact of loss of agricultural land on production	●		
Pollution caused by use of fertilizers/ pesticides	●		●
Threats to wildlife due to habitat destruction	●	●	●
Land evaluation for agriculture	●	●	●
Areas at risk to land degradation	●	●	●
Remedial measures to counter inappropriate land management	●	●	●

Arable Land: a finite resource

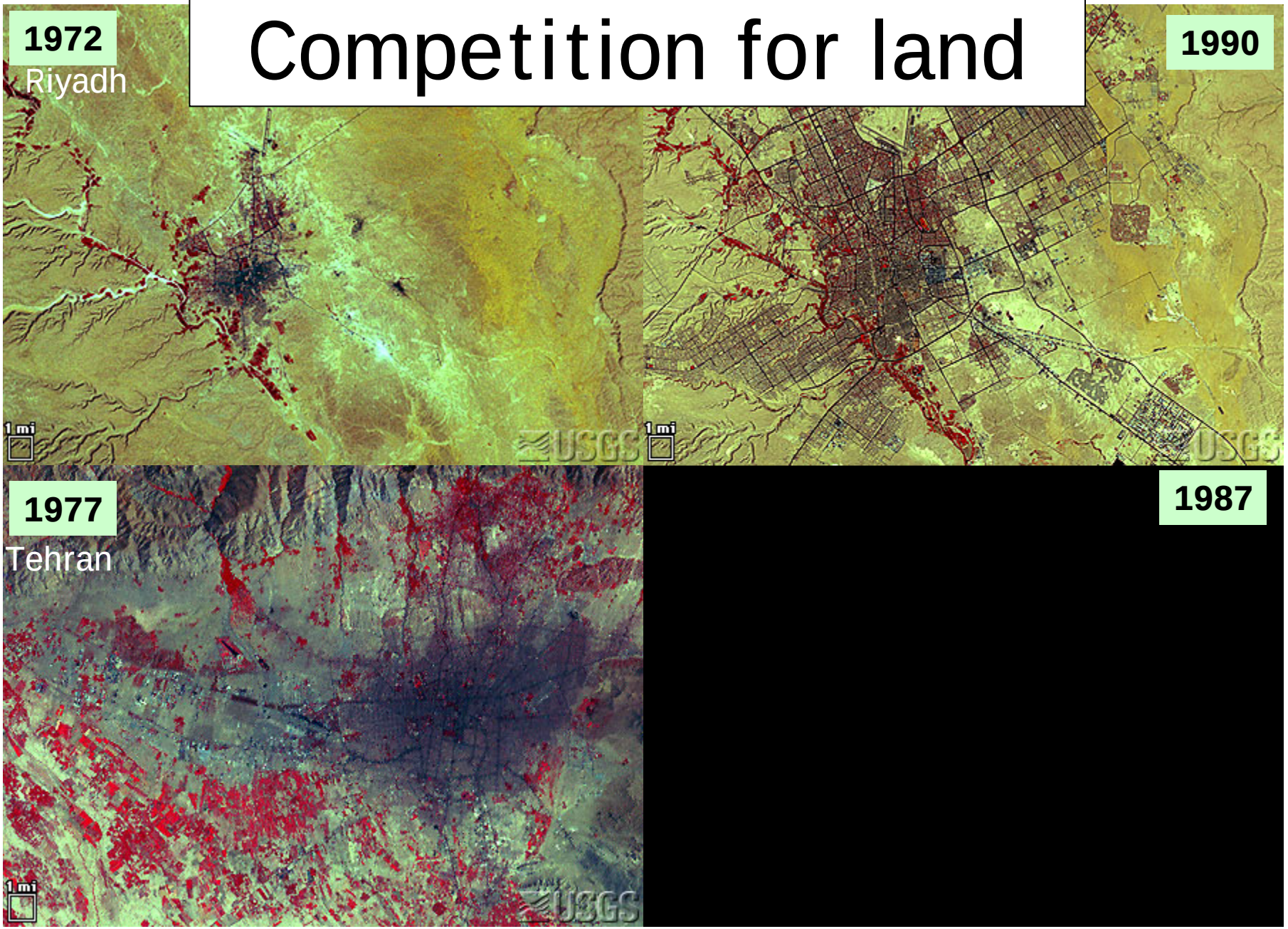
Arable land in use as % of potentially arable land

Region	1997/99	2030
Sub-Saharan Africa	22	28
Near East/ North Africa	87	94
Latin America & Caribbean	19	23
South Asia	94	98
East Asia	63	65
East Asia excluding China	52	60

Expansion of arable land to support growing populations comes at expense of other land uses (e.g. forestry)

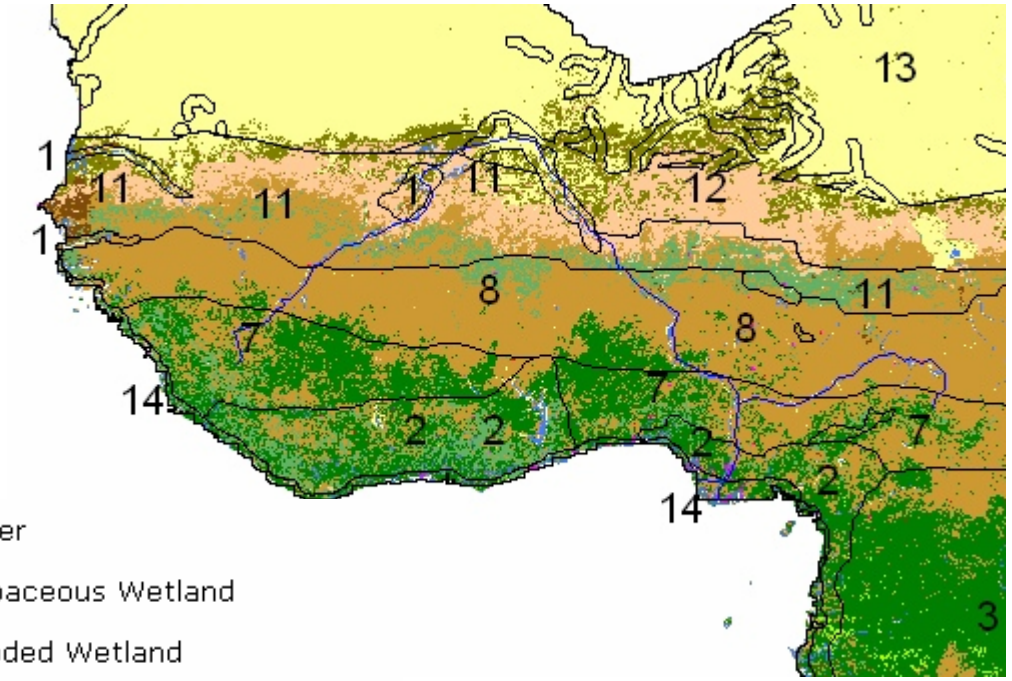
Source: FAO. World Agriculture: towards 2015/2030

Competition for land



Land cover: sub Saharan Africa

- Developed
- Dry Cropland & Pasture
- Irrigated Cropland
- Cropland/Grassland
- Cropland/Woodland
- Grassland
- Shrubland
- Shrubland/Grassland
- Savanna
- Deciduous Broadleaf Forest
- Deciduous Needleleaf Forest
- Evegreen Broadleaf Forest
- Evergreen Needleleaf Forest
- Mixed Forest
- Water
- Herbaceous Wetland
- Wooded Wetland
- Barren
- Herbaceous Tundra
- Wooded Tundra
- Mixed Tundra
- Bare Tundra
- Snow or Ice
- Partly Developed
- Unclassified

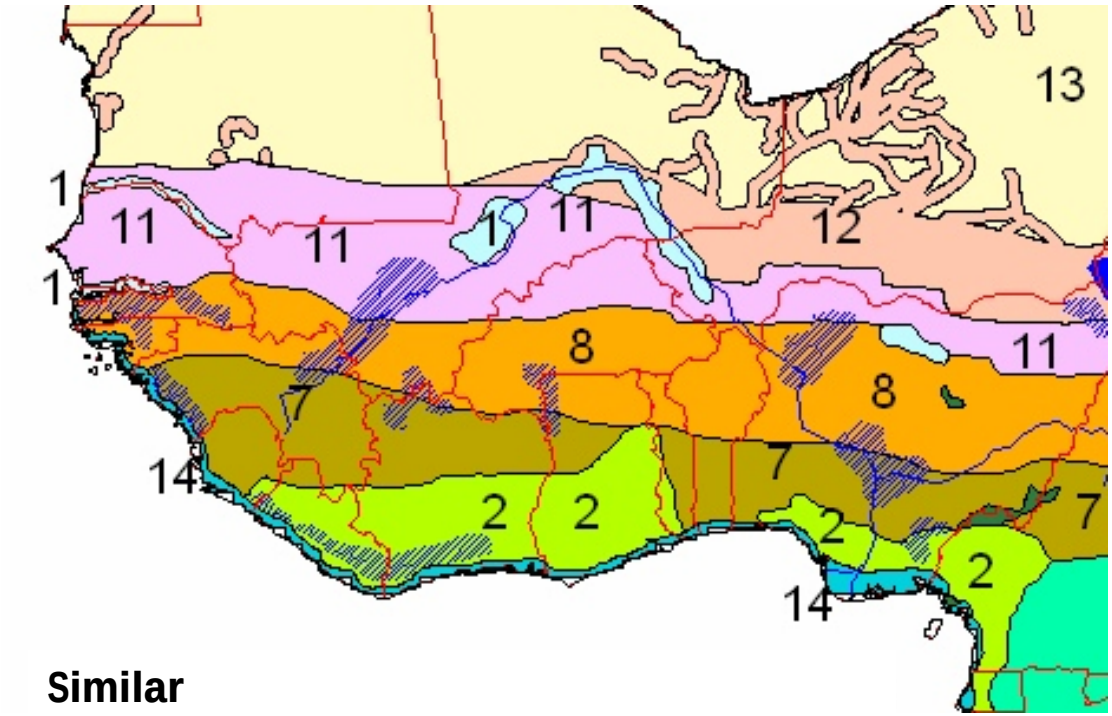


… the observed (bio)physical cover on the earth's surface (LCCS, 2000)

… a component of the natural resources base

Source: EROS Land characteristics database

Farming systems: 2001 global study



Farming Systems

- 1. Irrigated
- 2. Tree crop
- 3. Forest based
- 4. Rice-tree crop
- 5. Highland perennial
- 6. Highland temperate mixed
- 7. Root crop
- 8. Cereal-root crop mixed
- 9. Maize mixed
- 10. Large commercial & smallholder
- 11. Agro-pastoral millet/sorghum
- 12. Pastoral
- 13. Sparse (arid)
- 14. Coastal artisanal fishing
- Irrigated area in rainfed farming system

Similar

- **resource base**
- **enterprise (activity) patterns**
- **household livelihoods & constraints**

Analysis of human livelihoods & poverty

Source

FS & poverty: S-Saharan Africa

Farming Systems	% Land area	% Agri. Popn.	Principal Livelihoods	Poverty
Irrigated	1	2	Rice, cotton, vegetables, rainfed crops, cattle, poultry	Limited
Tree crop	3	6	Cocoa, coffee, oil palm, rubber, yams, maize, off-farm work	Limited-Moderate
Root crop	11	11	Yams, cassava, legumes, off-farm work	Limited – Moderate
Cereal root-crop mixed	13	15	Maize, sorghum, millet, cassava, yams, legumes, cattle	Limited
Agro-pastoral Millet-sorghum	8	8	Sorghum,, millet, pulses, sesame, cattle, sheep, goats, poultry, off-farm work	Extensive
Sparse (arid)	17	1	Irrigated, maize, vegetables, date palms, cattle, off-farm work	Extensive
Coastal artisanal fishing	2	3	Fishing, coconut, cashew, banana, yams, fruit, goats, poultry, off-farm work	Moderate

Environmental conventions

- **The Convention on Wetlands (Ramsar Convention), 1971**
  - Programs to conserve and use wisely all wetlands; 137 Parties;
- **Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES 1975**
  - To safeguard species from over exploitation; 164 parties; Appropriate wildlife management & trade policies
- **Convention on Biological Diversity, CBD 1992**
  - 187 Parties; biodiversity conservation
- **UN Framework Convention on Climate Change, 1992**
- **Kyoto Protocol (joint implementation, CDM, emissions trading)**
- **UN Convention to Combat Desertification, UNCCD, 1994**
  - Programs to reduce degradation of land in arid, semi-arid and dry sub-humid areas; 166 Parties;

Scope of LU information to collect

Selected information requirements UNFCC, Kyoto Protocol	Required LU data		
	Goods	*Services*	*Mgmt.*
Forest & wooded land (unmanaged)	●	●	
Forest & wooded land (managed)	●	●	●
Cropland	●	●	●
Pasture (improved grassland)	●	●	●
Wetland	●	●	
Settlements (villages, urban)	●	●	
Other land	●	●	
Cropland/ grazing land management;	●	●	●
Long-term cultivated; improved pasture, unimproved pasture, new set aside, old set aside, wetland/paddy, shifting agriculture, abandoned/ degraded	●	●	●

Sources of land use & land cover statistics: the institutional aspect

Sources of LU & LC statistics I

- Land use – socio-economic purpose (inputs, management & outputs)
- Land cover – biophysical cover of land (forests, shrubs, soils, rock, wetland ..)
- closely related but dissimilar terms!!
  - livestock grazing in different LC types
  - a forest supporting multiple LU -- e.g. shifting agriculture, timber production, hunting, livestock grazing (60% in India) ..
- LU/LC supports a wide range of decision making

..data collection by several different government depts. (e.g. forestry, agriculture, livestock, fisheries,..)!!

Sources of LU & LC statistics II

LU	Agricultural land		Ministry of Agriculture
LC	Forest & other wooded land		Department of Forests
LU	Built-up & related land		Urban & regional Planning
LC	Open land	Wet (no vegtn.)	Ministry of Natural Resources
		Dry (with special vegtn. <2m)	
		n.e.s (with no vegtn)	
LC	Waters		Department of Fisheries Ministry of Natural Resources

UNSD questionnaire

…indicative only!!

Sources of LU & LC statistics III

Potential difficulties due to LU & LC data being collected by multiple national organizations

- Overlaps in data collection efforts
- Different end purposes (e.g. maps, statistics,.. accuracies, detail, ..)
- Incompatible data; formats; definitions
- Different conditions for data access
- Increased cost of LU & LC data collection
- Increased difficulties in data integration & analysis
- ....

Also, difficulties in preparing global compilations from national data!

Sources of LU & LC statistics IV

Overcoming difficulties to LU & LC data being collected by multiple national organizations

- Set up mechanism for coordination
- Rationalize data collection efforts (who does what) taking present & future needs into account
- Review relevant mandates/ legislation
- Adopt common technical standards (SDI initiatives)
- Develop protocols for data access/ sharing/ distribution (data clearing house?); free vs. restricted access
- Reinforce national capacities

Sources of LU & LC statistics V

1. National data: line departments (& projects)
2. Regional/ global data

• Crops	FAOSTAT, IFPRI, Agro-MAPS.
• Forests	FAO (FRA)
• Water	AQUASTAT, U. Kassel
• Cultivation intensity	NASA
• Eco systems	USGS
• Protected areas	UNEP-WCMC
• Land cover/ land use	FAO(Africover); USGS, IFPRI, SAGE, LUCC, MA ,GLC2000 Global Mapping; Agro-MAPS

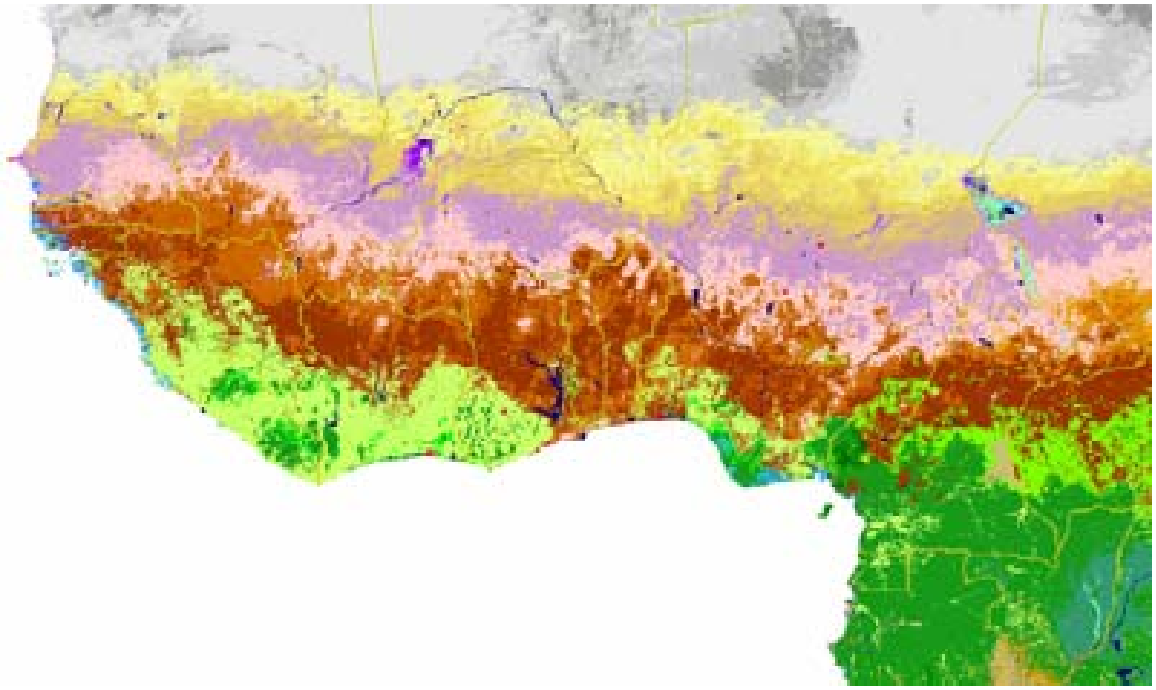
Shortcomings of global regional/global : ± limited coverage / number of classes; non-standard definitions; insufficient information on management aspects; insufficient detail; modelled data

Concepts, methods & classifications

Land classification schemes

- Used as a guide for collecting selected information on land relevant for decision making
  - policy formulation; environmental monitoring (e. land degradation); .....
- Systematic arrangement ; grouping by similar characteristics
  - land cover (bio-physical cover) (LCCS-FAO)
  - land use (purpose: goods & services, inputs, management)
- Class definition
  - 'a priori' (before data collection)
    - standardized classes; rigid
  - 'a posteriori' (cluster after data collection)
    - could yield non-standardized classes; flexible
- hierarchic vs. non hierarchic (different scales!)
- Characterization vs. classification

Land cover map using LCCS



… the observed (bio)physical cover on the earth's surface (LCCS, 2000)

source

Forest	Agriculture	Wetlands
Tree Cover, broadleaved evergreen	Cultivated and managed areas	Tree Cover, regularly flooded, fresh and brackish water
Tree Cover, broadleaved deciduous, closed	Mosaic: Cropland / Tree cover / Other natural vegetation	Tree cover, regularly flooded, saline water
Tree Cover, broadleaved deciduous, open	Mosaic: Cropland / Shrub or Grass Cover	Regularly flooded Shrub and/or Herbaceous cover
Tree Cover, needle-leaved evergreen	**Deserts**	**Grasslands and Shrublands**
Tree Cover, needle-leaved deciduous	Bare, sandy	Shrub Cover, closed-open, evergreen
Tree Cover, mixed leaf type	Bare, gravel	Shrub Cover, closed-open, deciduous
Mosaic: Tree cover / Other natural vegetation	Bare, rocky	Herbaceous Cover, closed-open
Tree Cover, burnt	**Other**	Sparse Herbaceous or sparse Shrub cover
Snow and Ice	Water bodies	**Urban**
Snow and Ice	No data	Artificial surfaces

Distinguishing LU from LC

Single forest cover can have **multiple** possible 'uses'

- timber production
- shifting cultivation
- hunting/ gathering
- fuel-wood collection
- recreation
- wildlife preserve
- watershed protection

A **single** use (e.g. grazing) - in several types of land cover

Automatic translation from LC to LU is not practical except for geographically small, well-known areas !!

Principles of classification

- Should cover total area of land and all activities
- Clear rules; categories should not overlap (mutually exclusive)
- Independence of scale and data-collection tools
- Spatially and temporally consistent
- Account for multiple-purpose nature of land use
- Comprehensive rules for describing & naming classes

- Promotes consistent terminology
- Permits cross-referencing of different national systems
- Facilitates compilation of regional-global LU data bases
- Preserves national investment in local classification

International LU classification

A proposal using 'a priori' classes, Young 1998

Conservation	total; partial
Collection	plant; plant, animal, plant & animal products
Forestry	Management of natural forests; forest plantation
Livestock	Extensive/ intensive grazing; confined
Crops	shifting cultivation; temporary/ permanent cropping; wetland cultivation; confined
Fisheries	Fishing (capture); aqua-culture
Recreation	Recreation (many classes)
Mineral extraction	mining; quarrying
Settlement	residential; commercial; industrial activities; settlement infrastructure
Security uses	Use restricted by security

National LU classification systems

Generally, 'a priori' systems (Classes defined before data collection)

Reasons for updating many national systems

- Incomplete inventories of existing land uses
- Insufficient consistency and precision in categorizing land uses
- Greater user expectations of data content (must support an increasing range of LU applications e.g. site selection, taxation, environmental impact assessment, ..)
- inadequate standards for data collection (at times related to lack of inter-agency cooperation) & data sharing
- outdated data inventory methodologies that do not exploit GIS, databases and other modern information technologies

Classification vs. characterization I

Parametric characterization of land use

1. Describe land use activity (activities) by their attributes,
    - Attributes (Inputs, management, outputs)
2. Group attributes into classes according to end-user criteria
    - GIS analysis

Complexity of agricultural land use

How?
Management:
inputs, technologies

How much?
Quantities:
areas, products, ..

When?
Timing of
operations

What?
Objectives:
Products,
services

Why?
eg. reasons (biophysical,
socio-economic,.)

Where?
Location
& spatial extent

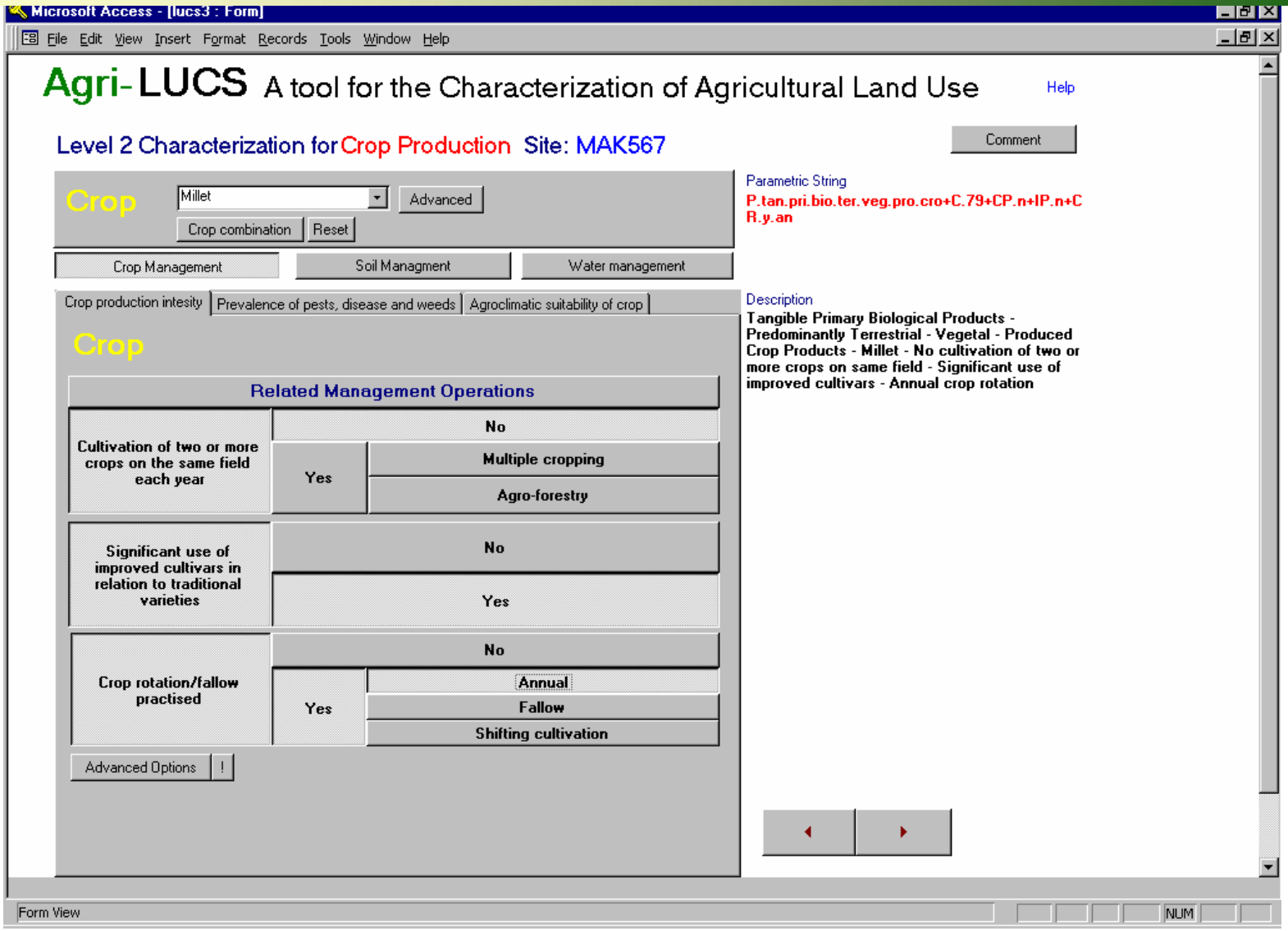
- *Socio-economic purpose (s) driving modifications of existing environment*
- *Uses: simultaneous/ different periods of 1 yr/ different uses in different years*

Attributes: agricultural land use

Benefits	
Material products	Food; freshwater; fibre; bio-chemicals, genetic resources
Regulating services	Climate regulation, disease control, flood control, detoxification, ..
Cultural services	Spiritual, recreational, aesthetic, inspirational; educational, communal, symbolic,..

Management attributes	
Crops	cropping systems; pest/weed management; nutrients, erosion, water, power sources
Livestock	Level of intensification, access to feed & water resources; access to services (e.g. veterinary, extension,..)
Forestry	Harvest technology, silviculture, disturbances, timber exploitation,..

Development of LU data entry tools



Inventory methodologies

Land cover inventory

- Interpretation air photographs/ remote sensing imagery
- Timing of imagery acquisition (single/ multiple dates)
- Scale / spatial resolution of imagery
- Approaches
  - Grid sampling (& interpretation keys)
  - mapping approaches (e.g. Africover) using LCCS

Land use inventory

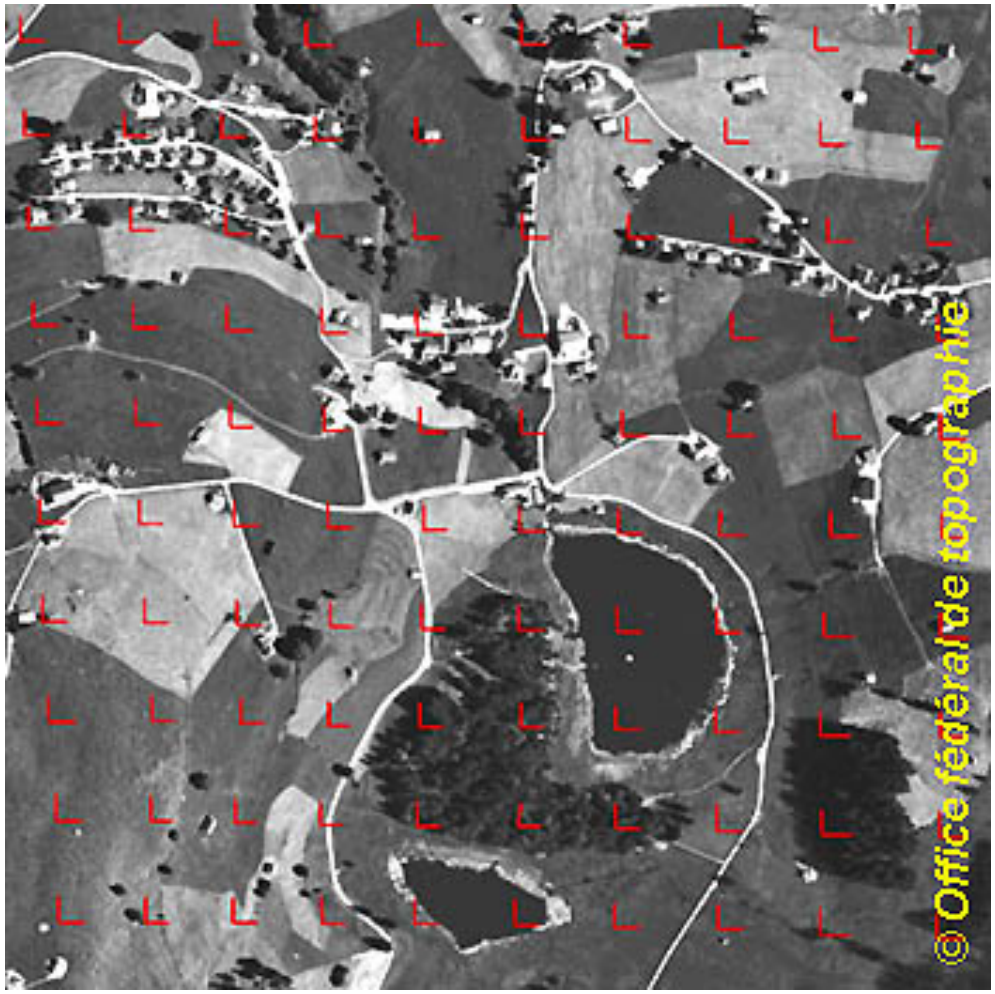
1. Inference from land cover maps
   - problematic, but ready availability of LC data
   - participatory LU mapping
2. Direct observation, interviews, questionnaires
   - full enumeration, accurate but costly
   - statistical-based sampling (e.g. area frame - National census); statistics not maps
3. Inference from statistical & other data (e.g. population); incompatibilities
4. Designated use areas
   - actual use may be different (e.g. illegal incursions of protected areas)

Evaluation criteria: Inventories

- **Cost**
- **Complexity/ rapidity** of data collection/update procedures
- **Accuracy** and consistency of output data (in space and in time)
- **Compatibility** of output with that from other systems of data collection
- **Flexibility** (e.g. classification adapts to changes in scale; supports a broad range of analyses)

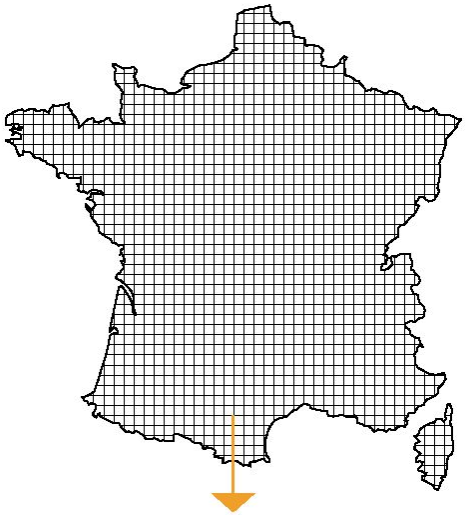
LU inventory: Switzerland

- 41,285 sq. km.
- Air-photo interpretation. (1:28,000 to 1:32,000)
- Regular grid: 100m by 100m
- 74 predefined hierarchical LU classes
- 1 type of LU per point; (4.1million points)
- Some field verification



http://www.statistik.admin.ch/stat_ch/ber02/asch/methode/finterpr.htm

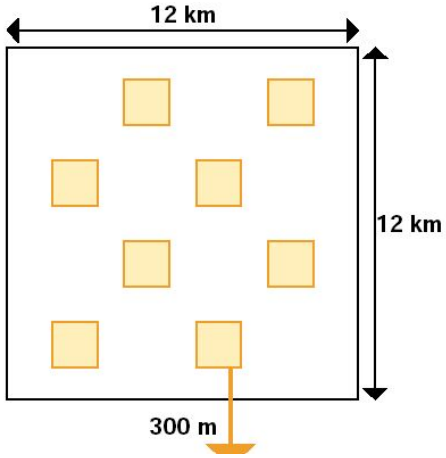
LU inventory: France



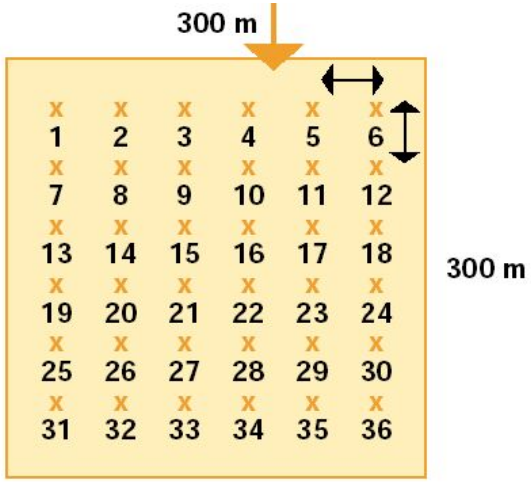
4700 grid cells

France

- (TER-UTI)
- observation sites (3m X 3m)
- 81 physical and 25 functional pre-established LU categories



8 segments per grid
4 segments for observation

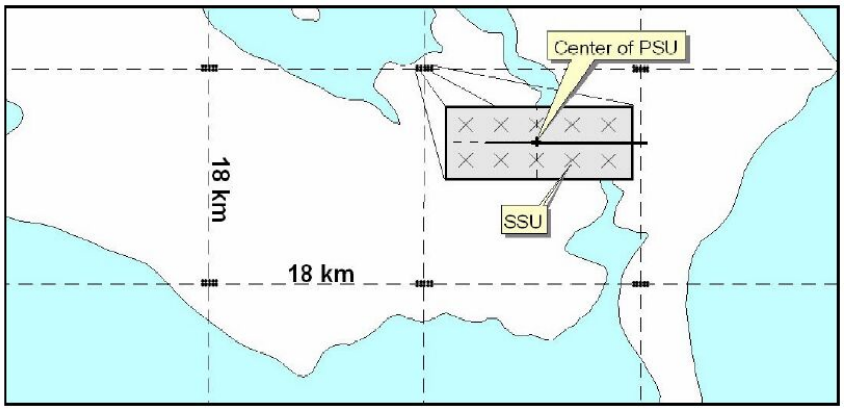


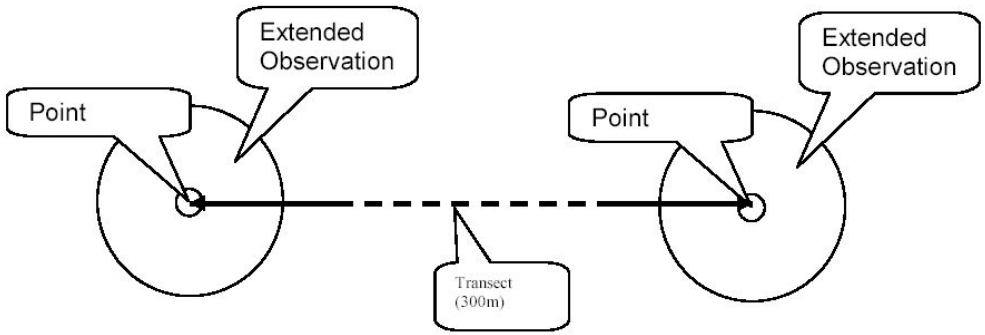
36 observation points

FUNCTIONAL NOMENCLATURE
Level I
Primary production
Secondary production
Services and miscellaneous
PHYSICAL NOMENCLATURE
Level I
Permanent waters and wetlands
Rock, pebbles, sand
Wooded area
Utilized agricultural area
Artificial areas

LU inventory: EU

Land use/ cover area frame statistical survey - LUCAS





- 15 EU countries;
- Harmonized data
- Spring: LC/LU & environment
- Autumn: farmer interview for info on yields, agricultural practices

PSU: 18km X 18km

SSU: 10 points (300m X 300m) at centre of PSU

Circle 3m diameter

20m for heterogeneous zones

From Bettio et al, 2002

LU inventory: EU

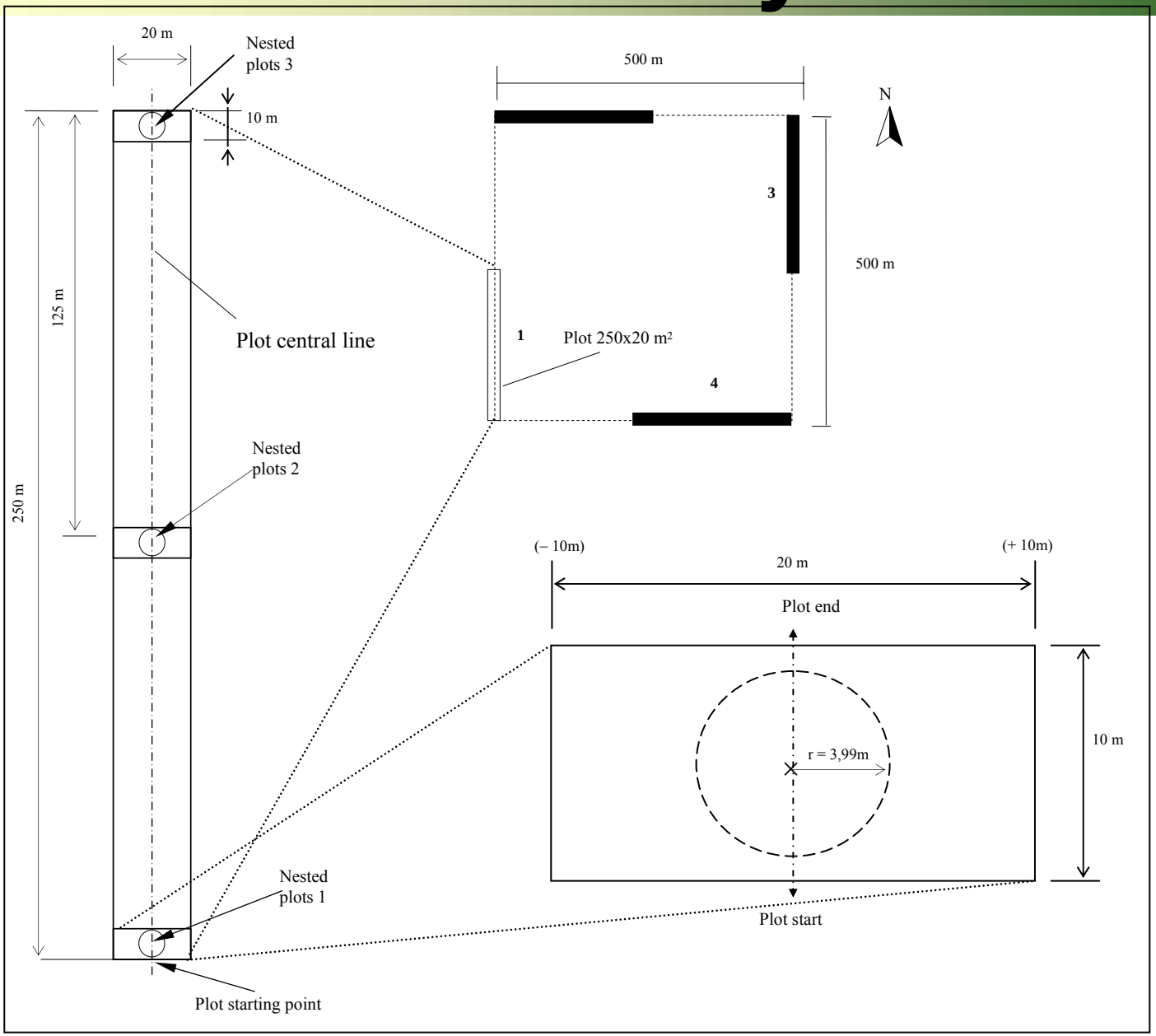
Land use/ cover area frame statistical survey - LUCAS

Land Use Classes
Agriculture
Forestry
Fishing
Mining, Quarrying
Energy production
Industry, manufacturing
Transport, communication, storage, protective woks
Water, waste treatment
Construction
Commerce, finance, business
Community services
Recreation, leisure, sport
Residential
Unused

SSU: 10 points
(300m X 300m)

From Bettio et al, 2002

FRA/ ILUA inventory



Summary – main points

- LU & LC data are useful for decision making in a wide range of environmental & policy issues
- Different approaches for classification/ characterization & inventory of LU & LC in different countries, depending on needs
- Different sources of LU & LC data –
  - Importance of Inter-agency coordination/ cooperation in harmonization, data collection & reporting
  - Importance of relating national definitions of LU/LC classes to the UNSD questionnaire on land use statistics

Policy formulation & planning

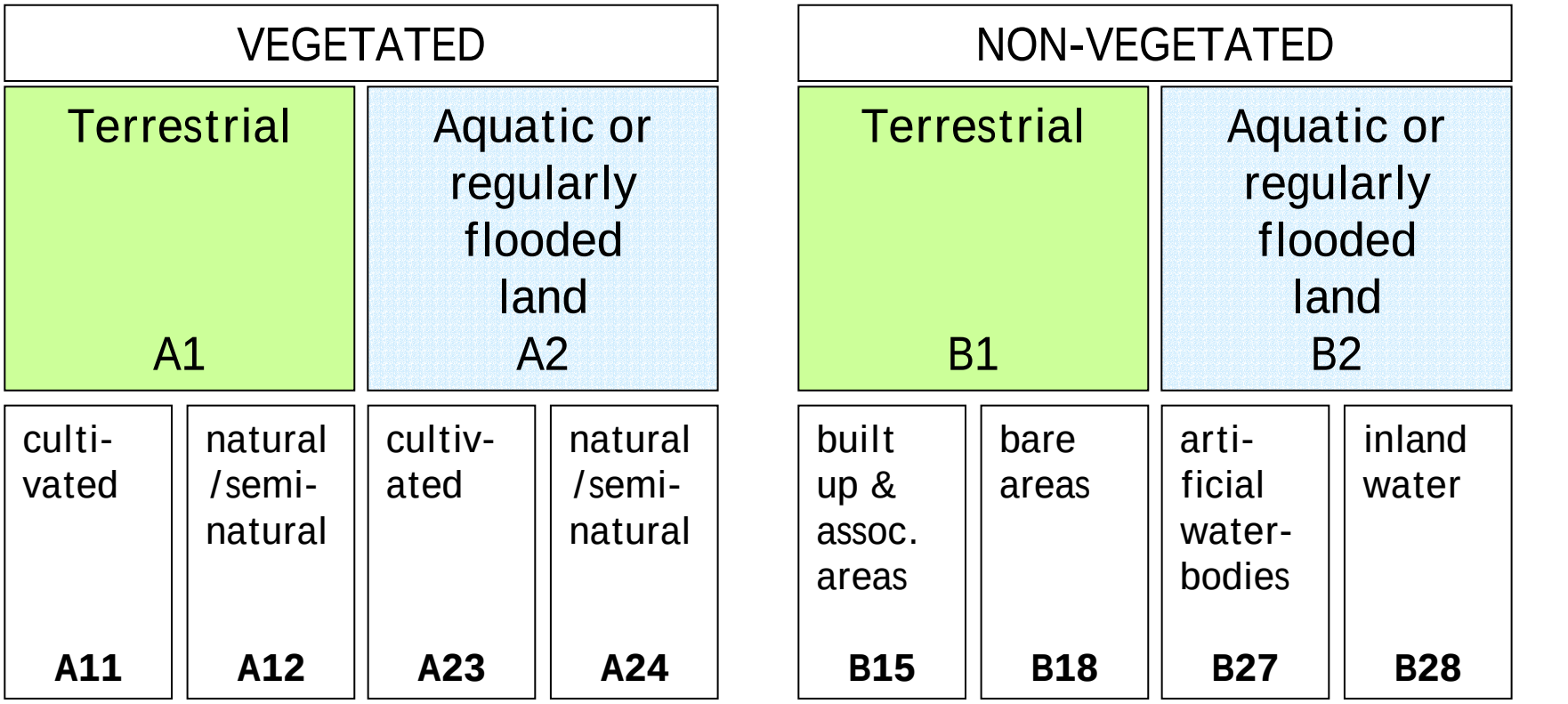
Major national development sectors in DCs

- Natural resources & the environment (agriculture, agro-industries, forestry, minerals, water, fisheries,..)
- Human resources (e.g. education, health services & infrastructure)
- Prevention & mitigation of natural disasters & military conflicts
- Crime prevention

The greater the scope of LU information collected (i.e. products, services & management) – the wider the range of decision making supported

Trade offs!!

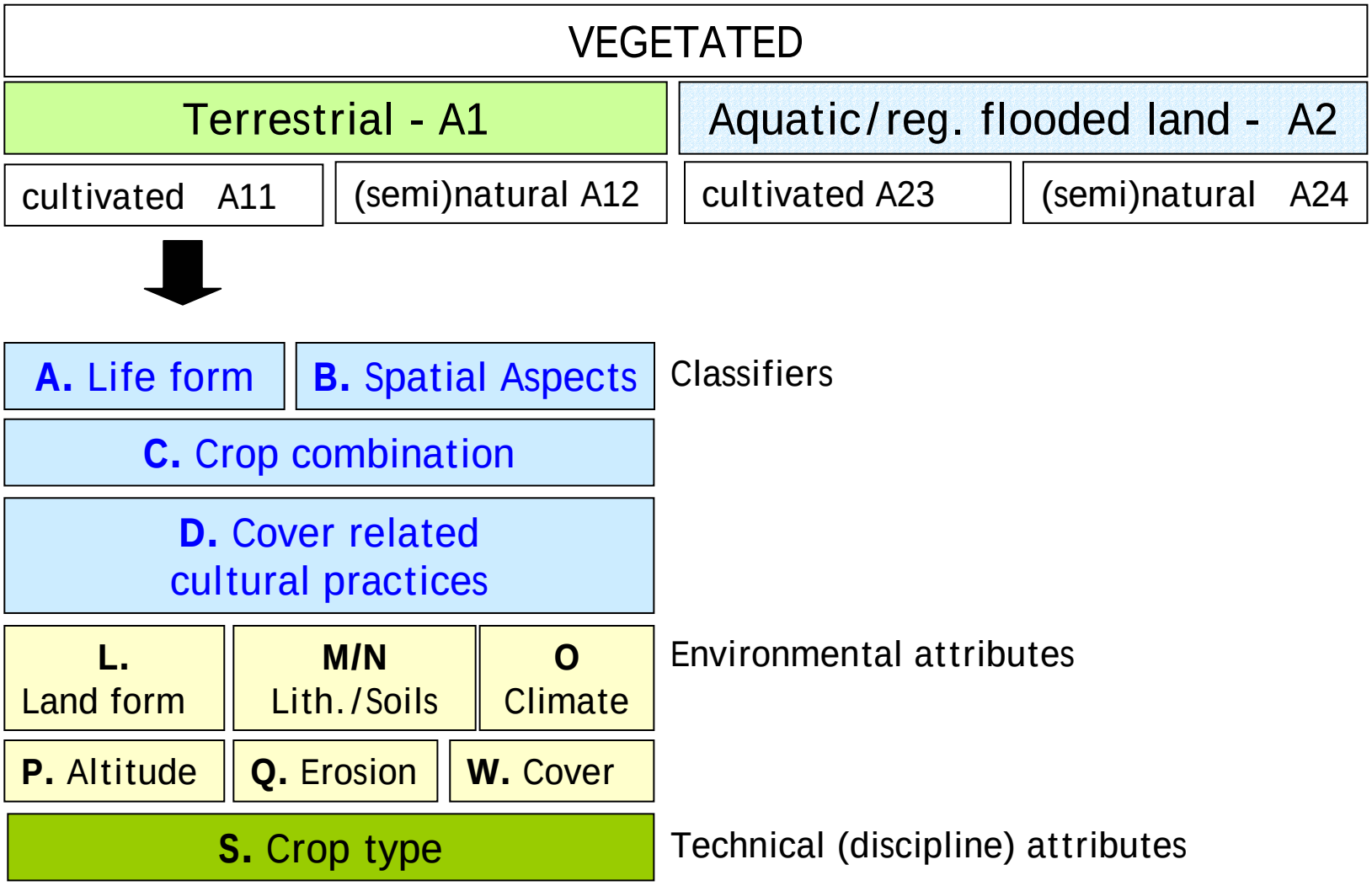
FAO - LC classification system



+ more classifiers & optional Attributes

- *increasing worldwide adoption of LCCS as standard*
- *possible to relate LCCS & UNSD classes (NB. forest thresholds differ – 15 vs. 10%)*

FAO Land cover classification system II



LCCS: Classifiers & attributes -A11

A. Life form	•trees, shrubs, herbaceous,.
B. Spatial Aspects	•large, medium, small sized fields •continuous, scattered (clustered, isolated)
C. Crop combination	•single, multiple crop
D. Cultural practices	•rainfed, post flooding, irrigated,. •shifting cultivation, fallow, permanent
L. Land form	•level, sloping, steep land; composite landforms
M/N. Lithology /Soils	•igneous, sedimentary, metamorphic •bare rock, soil, loose sands, hard pans; soil group
O. Climate	•tropics, sub-tropics, temperate, … .; LGP
P. Altitude	•<300, 300-1500, 1500-3000, 3000->5000 metres,.
Q. Erosion	•erosion visible, not visible.
W. Crop Cover/ density	•permanent (trees, shrubs); temporary (herbaceous)
S. Crop type	•food/ non-food crops