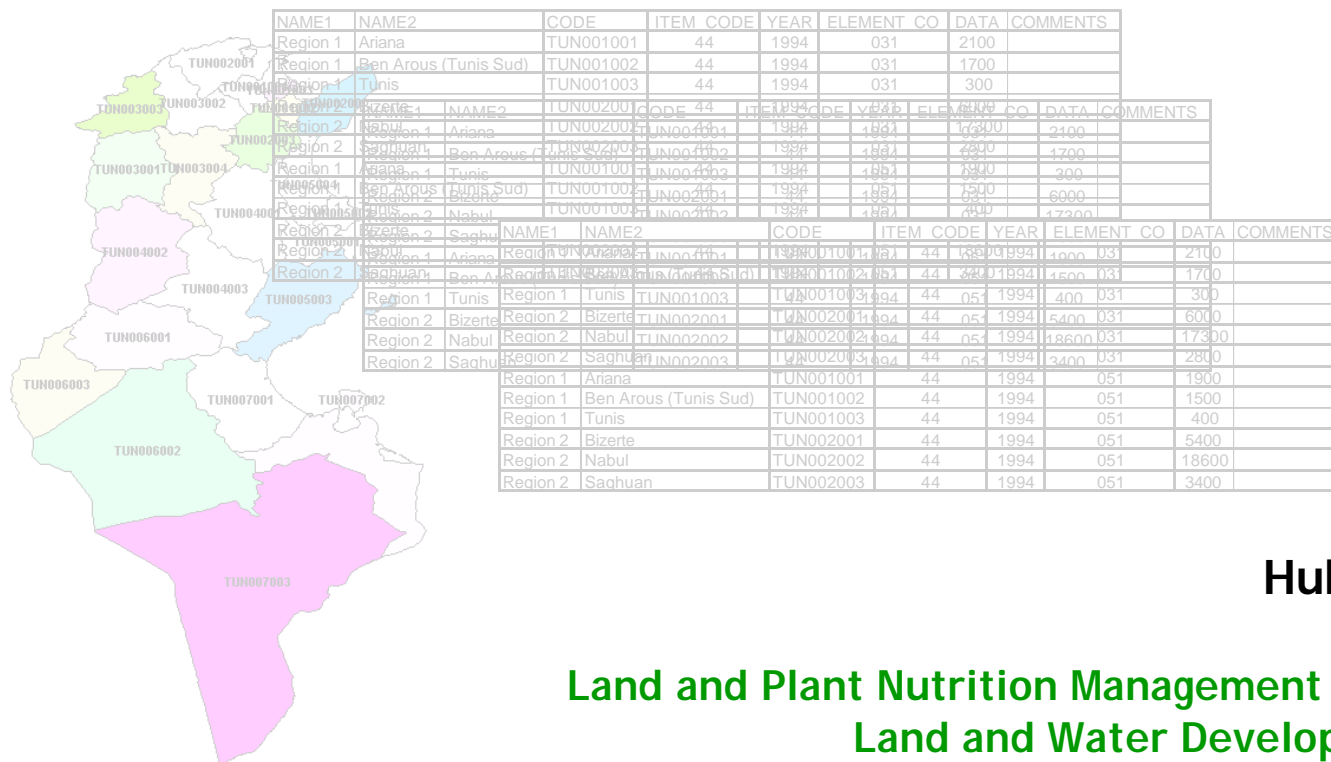


Statistics on land use



Hubert George

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 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

LAND.. 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!!



Why we need LU information

- Different land uses affect the natural equilibrium of ecosystems differently - dissimilar impacts on the sustainable flow of goods & services
- Land resources are finite & usually scarce!
- Competition among various land uses (e.g. urban expansion into agricultural areas)
- 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 !

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!!

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?

Scope of LU information to collect

Examples of Issues	Required LU data		
	<i>Goods</i>	<i>Services</i>	<i>Mgmt.</i>
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

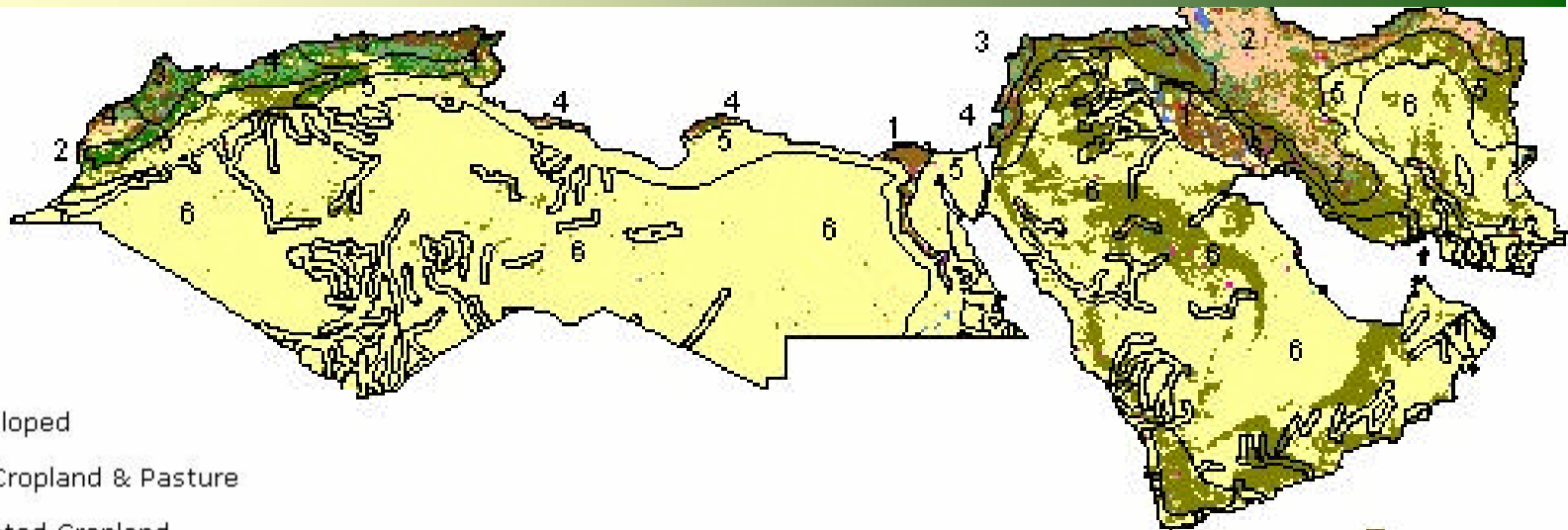
Arable land in use as % of potentially arable land

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)

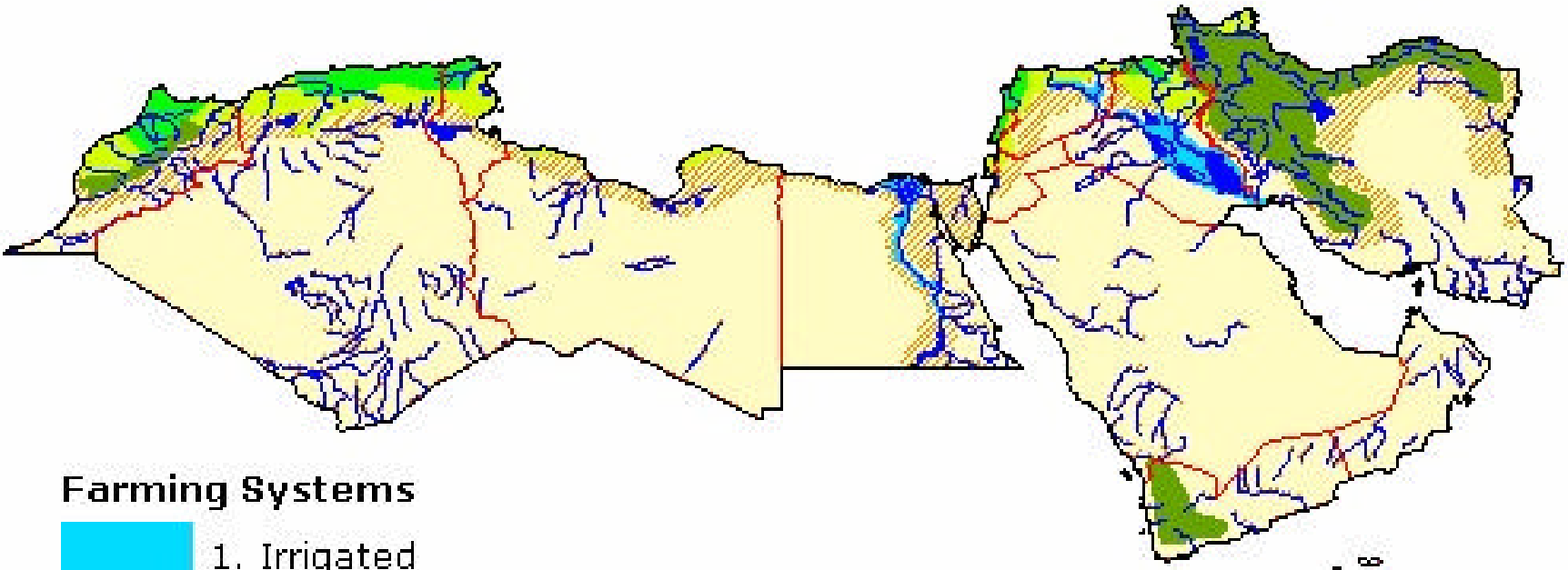
Source: FAO. *World Agriculture: towards 2015/2030*

Land cover: North Africa & ME



limited croplands !

Farming systems: North Africa & ME



Farming Systems

-  1. Irrigated
-  2. Highland mixed
-  3. Rainfed mixed
-  4. Dryland mixed
-  5. Pastoral
-  6. Sparse (arid)

Waterbodies



Analysis of human livelihoods & poverty

Farm system:

....."the household, its resources, and the resource flows and interactions"

FS & poverty: North Africa & ME

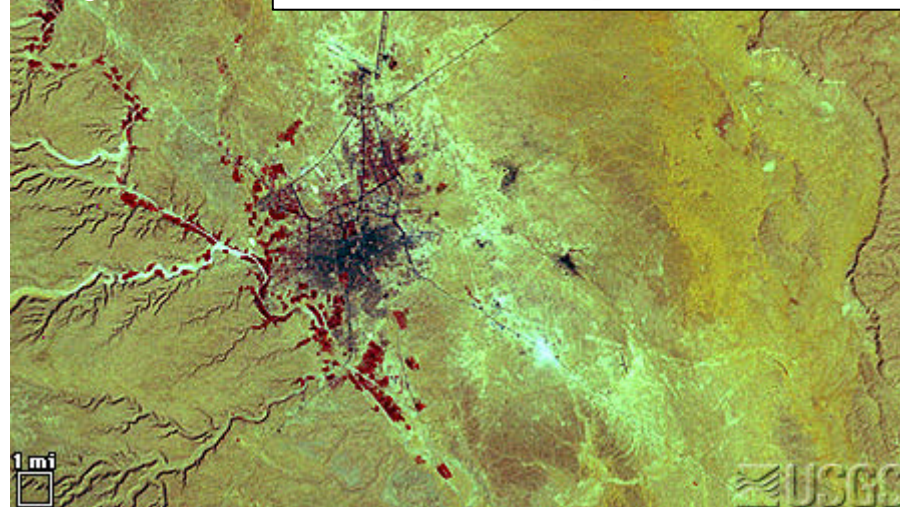
Farming Systems	% Land area	% Agri. Popn.	Principal Livelihoods	Poverty
Irrigated	2	17	Fruits, vegetables, cash crops	Moderate
Highland mixed	7	30	Cereals, legumes, sheep, off-farm work	Extensive
Rainfed Mixed	2	18	Tree crops, cereals, legumes, off-farm work	Moderate
Dryland mixed	4	14	Cereals, sheep, off-farm work	Extensive
Pastoral	23	9	Sheep, goats, barley, off-farm work	Extensive
Sparse (arid)	62	5	Camels, sheep, off-farm work	Limited
Coastal artisanal fishing	1	1	Fishing, off-farm work	Moderate
Urban based	<1	6	Horticulture, poultry, off-farm work	Limited

Competition for land

1972

Riyadh

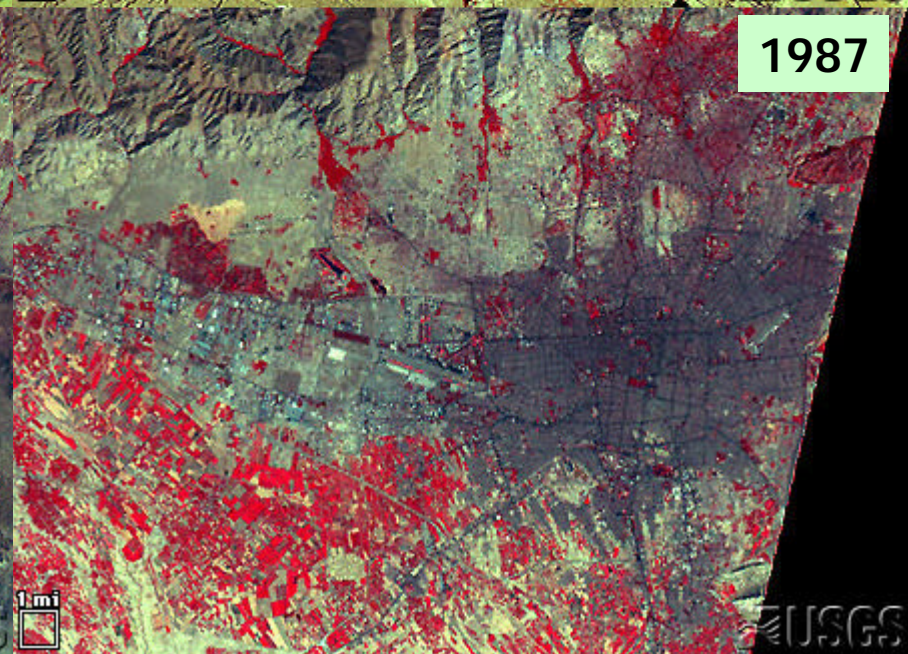
1990



1977

Tehran

1987



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		
	<i>Goods</i>	<i>Services</i>	<i>Mgmt.</i>
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	
LC	Forest & other wooded land	
LU	Built-up & related land	
LC	Open land	Wet (no vegtn.)
		Dry (with special vegtn. <2m)
		n.e.s (with no vegtn)
LC	Waters	

UNSD questionnaire

Ministry of Agriculture
Department of Forests
Urban & regional Planning
Ministry of Natural Resources
Department of Fisheries Ministry of Natural Resources

...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](#)

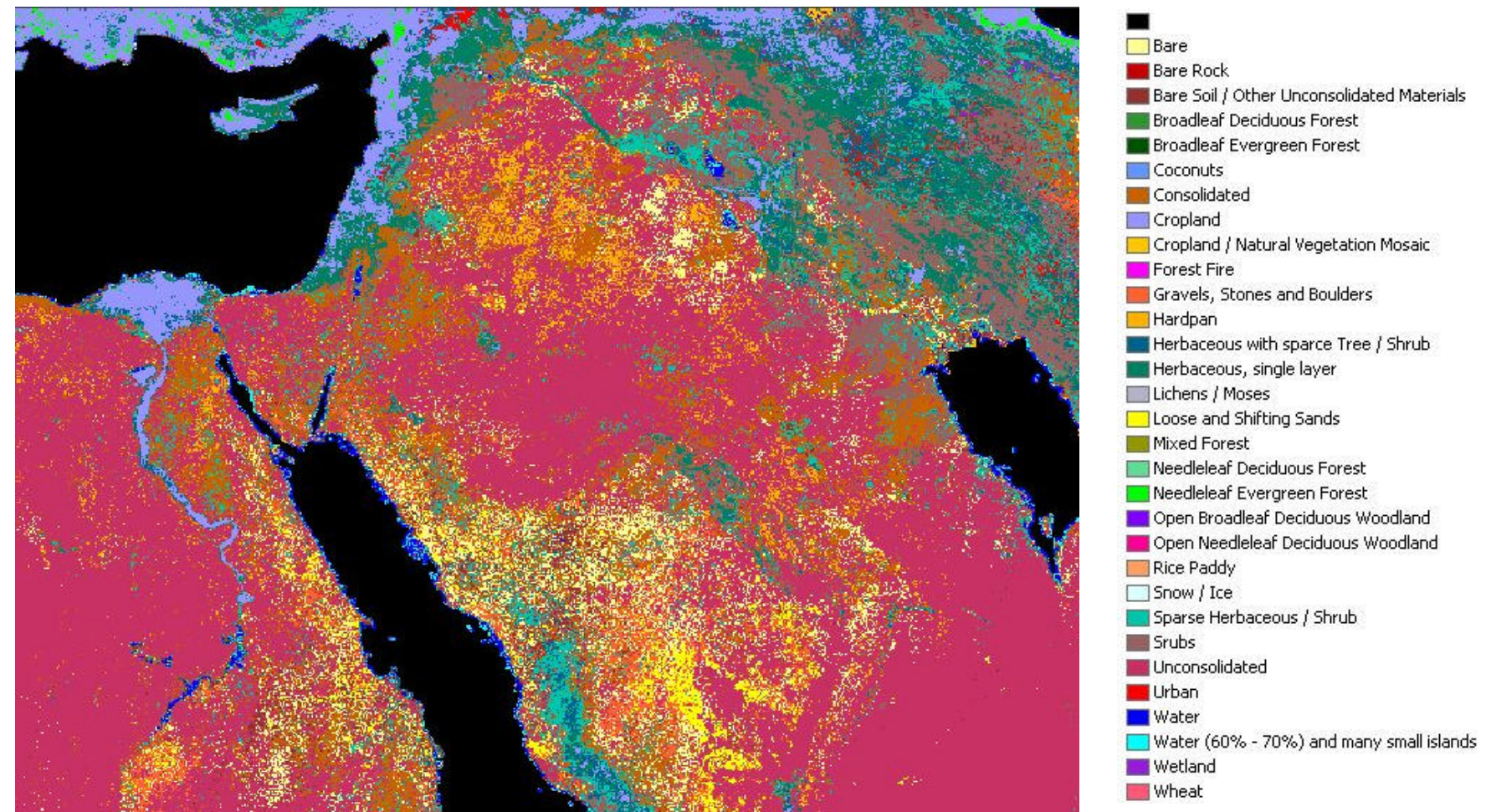
Shortcomings of global regional/global : ± limited coverage / number of classes; non-standard definitions; insufficient information on management aspects; insufficient detail; modelled data

***Concepts, methods &
classifications***

Land classification

- 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)

FAO - LC classification system

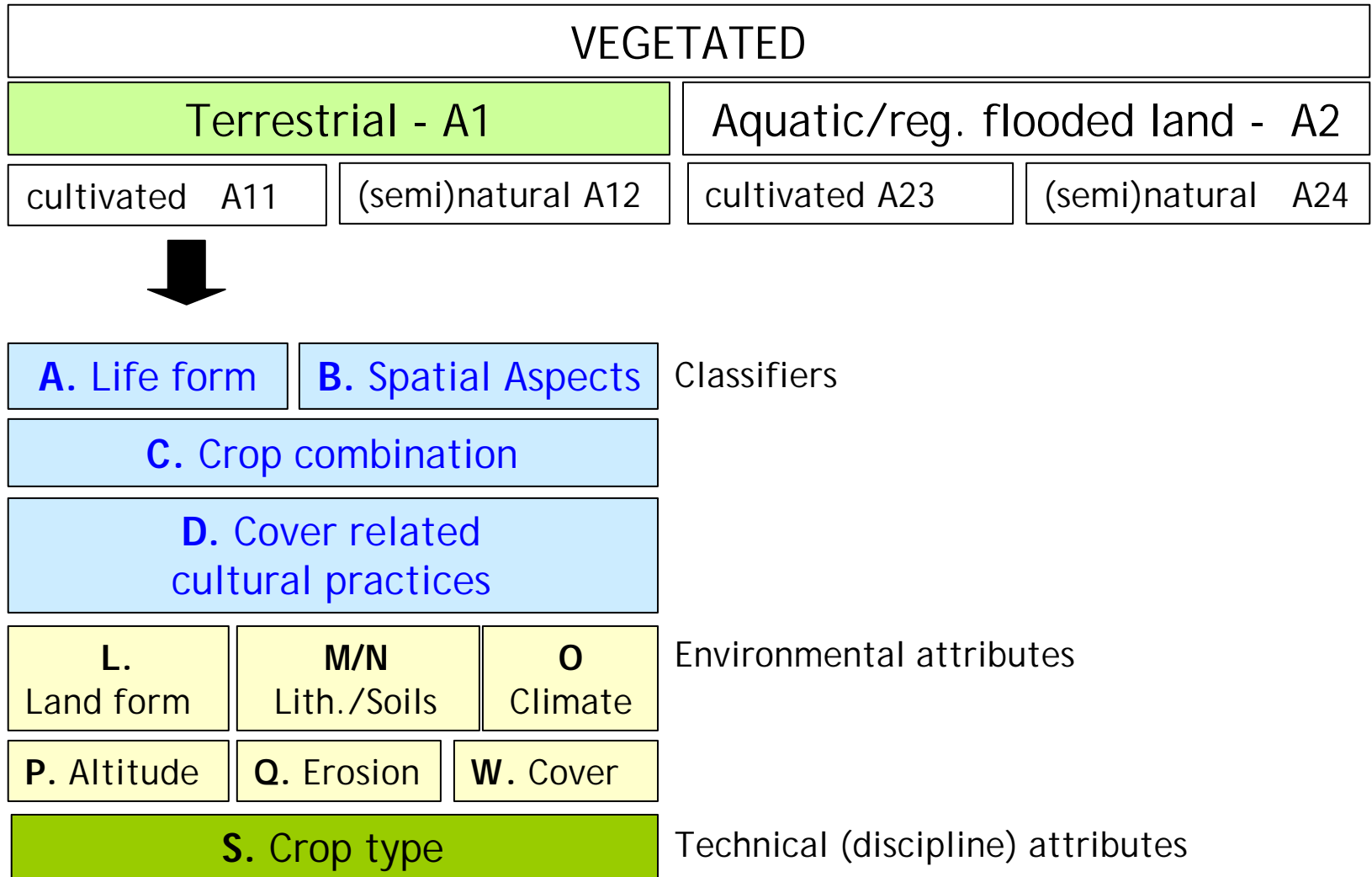
VEGETATED			
Terrestrial		Aquatic or regularly flooded land	
A1		A2	
culti- vated	natural /semi- natural	cultiv- ated	natural /semi- natural
A11	A12	A23	A24

NON-VEGETATED			
Terrestrial		Aquatic or regularly flooded land	
B1		B2	
built up & assoc. areas	bare areas	arti- ficial water- bodies	inland water
B15	B18	B27	B28

+ 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



LCCS: Classifiers & attributes -A11

A. Life form

B. Spatial Aspects

C. Crop combination

D. Cultural practices

L. Land form

M/N. Lithology /Soils

O. Climate

P. Altitude

Q. Erosion

W. Crop Cover/ density

S. Crop type

- trees, shrubs, herbaceous, .

- large, medium, small sized fields
- continuous, scattered (clustered, isolated)

- single, multiple crop

- rainfed, post flooding, irrigated, .
- shifting cultivation, fallow, permanent

- level, sloping, steep land; composite landforms

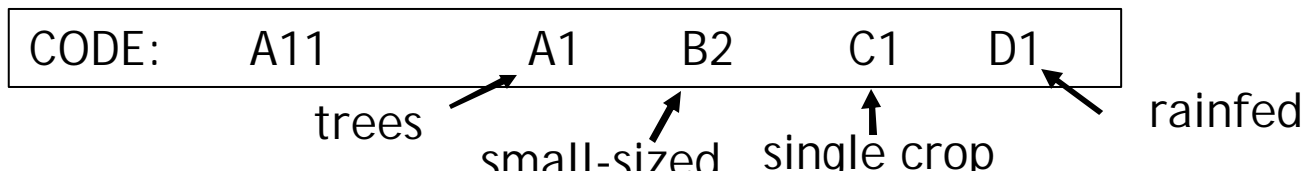
- igneous, sedimentary, metamorphic
- bare rock, soil, loose sands, hard pans; soil group
- tropics, sub-tropics, temperate,; LGP

- <300, 300-1500, 1500-3000, 3000->5000 metres, .

- erosion visible, not visible.

- permanent (trees, shrubs); temporary (herbaceous)

- food/ non-food crops



Land use definition

“ ..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!!



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 (**I**nputs, **m**anagement, **o**utputs)
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

Microsoft Access - [lucs3 : Form]

File Edit View Insert Format Records Tools Window Help

Agri-LUCS A tool for the Characterization of Agricultural Land Use [Help](#)

Level 2 Characterization for **Crop Production** Site: **MAK567**

Crop

Crop production intensity | Prevalence of pests, disease and weeds | **Agroclimatic suitability of crop**

Crop

Related Management Operations

Cultivation of two or more crops on the same field each year	No
	Yes Multiple cropping Agro-forestry
Significant use of improved cultivars in relation to traditional varieties	No
	Yes
Crop rotation/fallow practised	No
	Yes Annual
	Fallow Shifting cultivation

Parametric String
**P.tan.pri.bio.ter.veg.pro.cro+C.79+CP.n+IP.n+C
R.y.an**

Description
Tangible Primary Biological Products - Predominantly Terrestrial - Vegetal - Produced Crop Products - Millet - No cultivation of two or more crops on same field - Significant use of improved cultivars - Annual crop rotation

Form View NUM

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

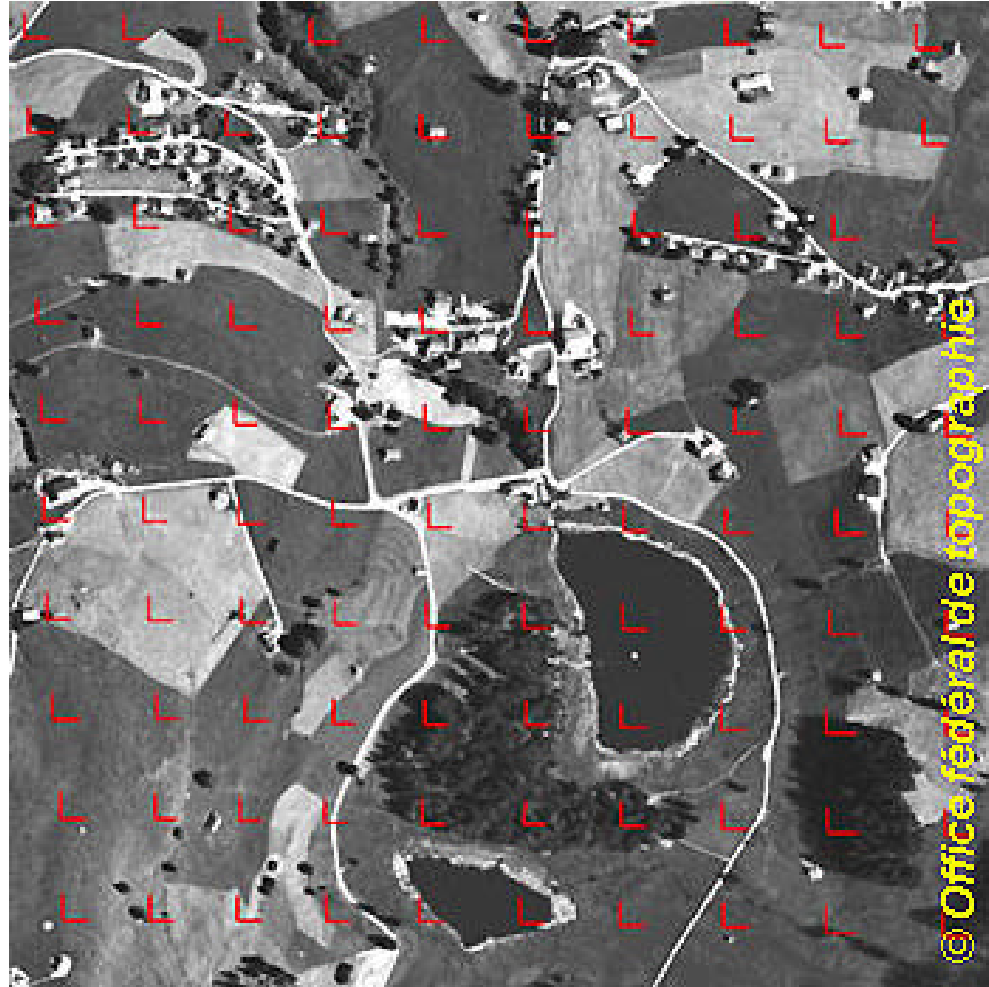
1. Inference from land cover maps
 - problematic, but ready availability of LC data
 - participatory LU mapping
2. Direct observation, interviews, questionnaires
 - full enumeration, accurate but costly
 - statistical-based sampling (e.g. area frame - National census); statistics not maps
3. Inference 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

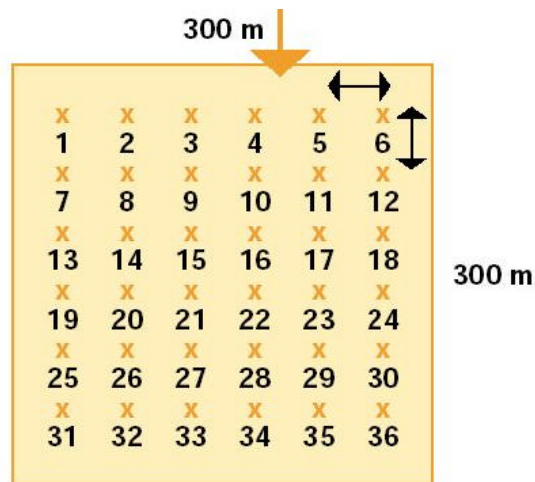
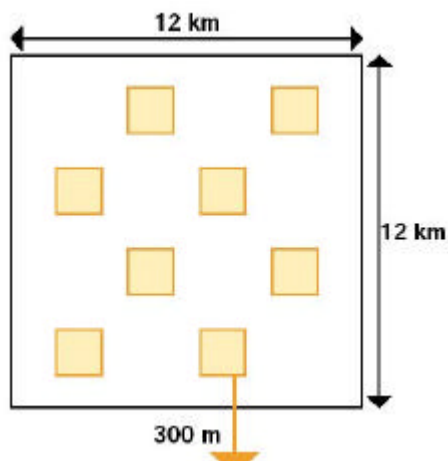
- 41,285 sq. km.
- Air-photo interpretation.
(1:28,000 to 1:32,000)
- Regular grid: 100m by 100m
- 74 predefined hierarchical LU classes
- 1 type of LU per point;
(4.1million points)
- Some field verification



LU inventory: France



4700 grid cells



France

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

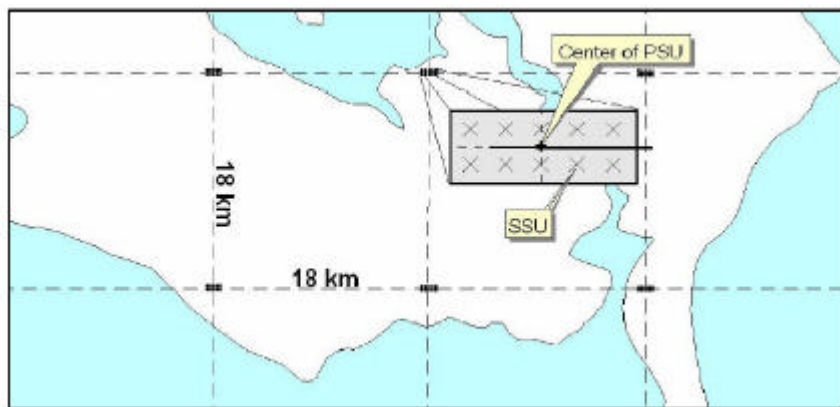
FUNCTIONAL NOMENCLATURE	
Level I	
Primary production	
Secondary production	
Services and miscellaneous	
PHYSICAL NOMENCLATURE	
Level I	
Permanent waters and wetlands	
Rock, pebbles, sand	
Wooded area	
Utilized agricultural area	
Artificial areas	

8 segments per grid
4 segments for observation

36 observation points

LU inventory: EU

Land use/ cover area frame statistical survey - LUCAS



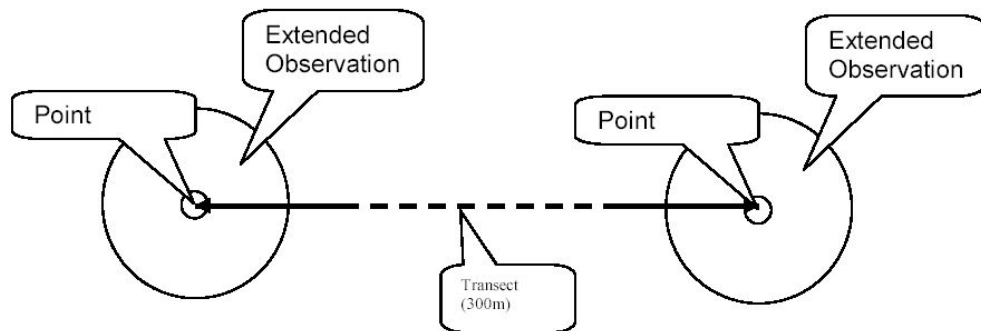
- 15 EU countries;
- Harmonized data
- Spring: LC/LU & environment
- Autumn: farmer interview for info on yields, agricultural practices

PSU: 18km X 18km

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

Circle 3m diameter

20m for heterogeneous zones



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 works

Water, waste treatment

Construction

Commerce, finance, business

Community services

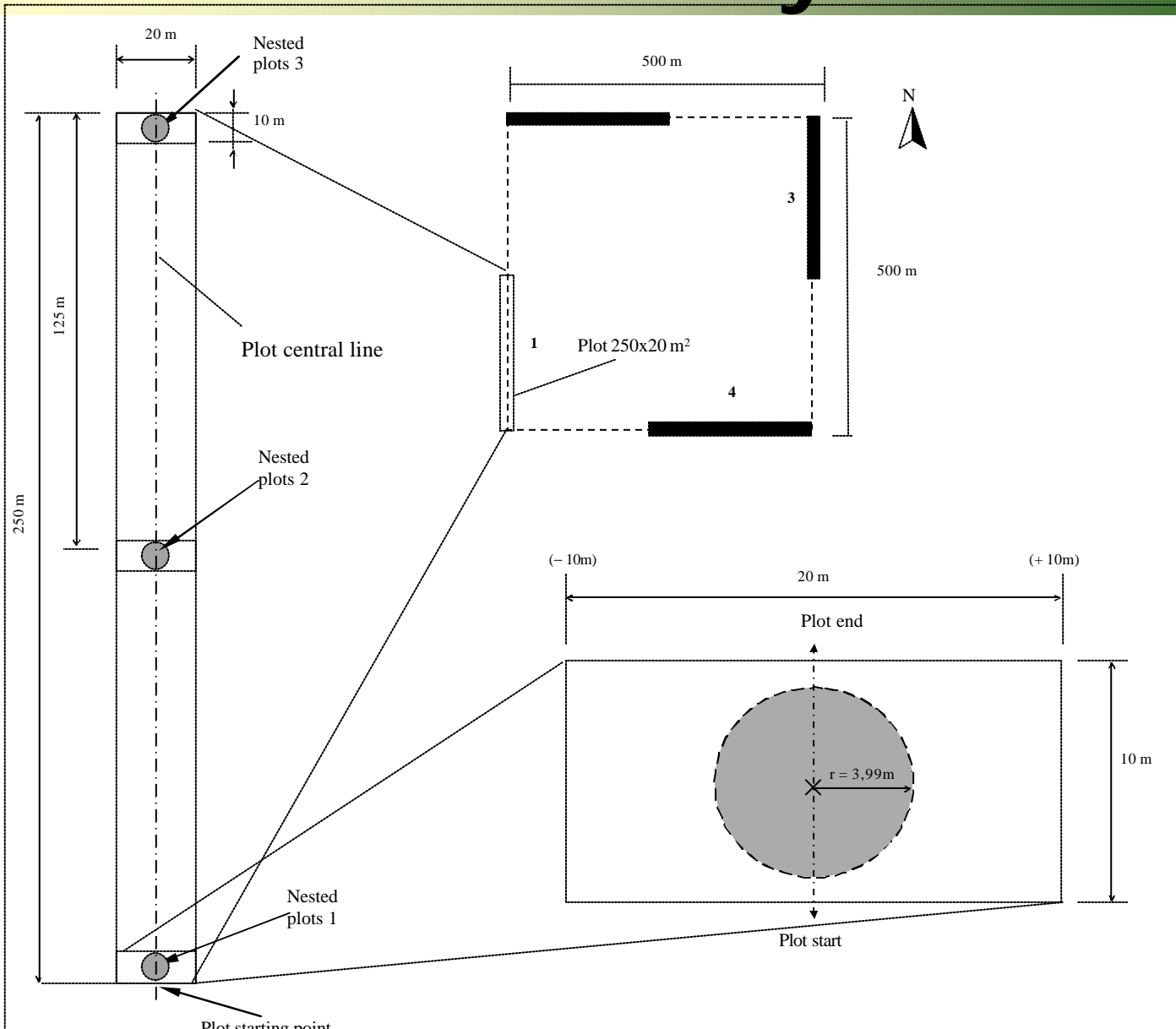
Recreation, leisure, sport

Residential

Unused

SSU: 10 points
(300m X 300m)

FRA/ ILUA inventory



***Linkages to other statistics
& the UNSD Questionnaire***

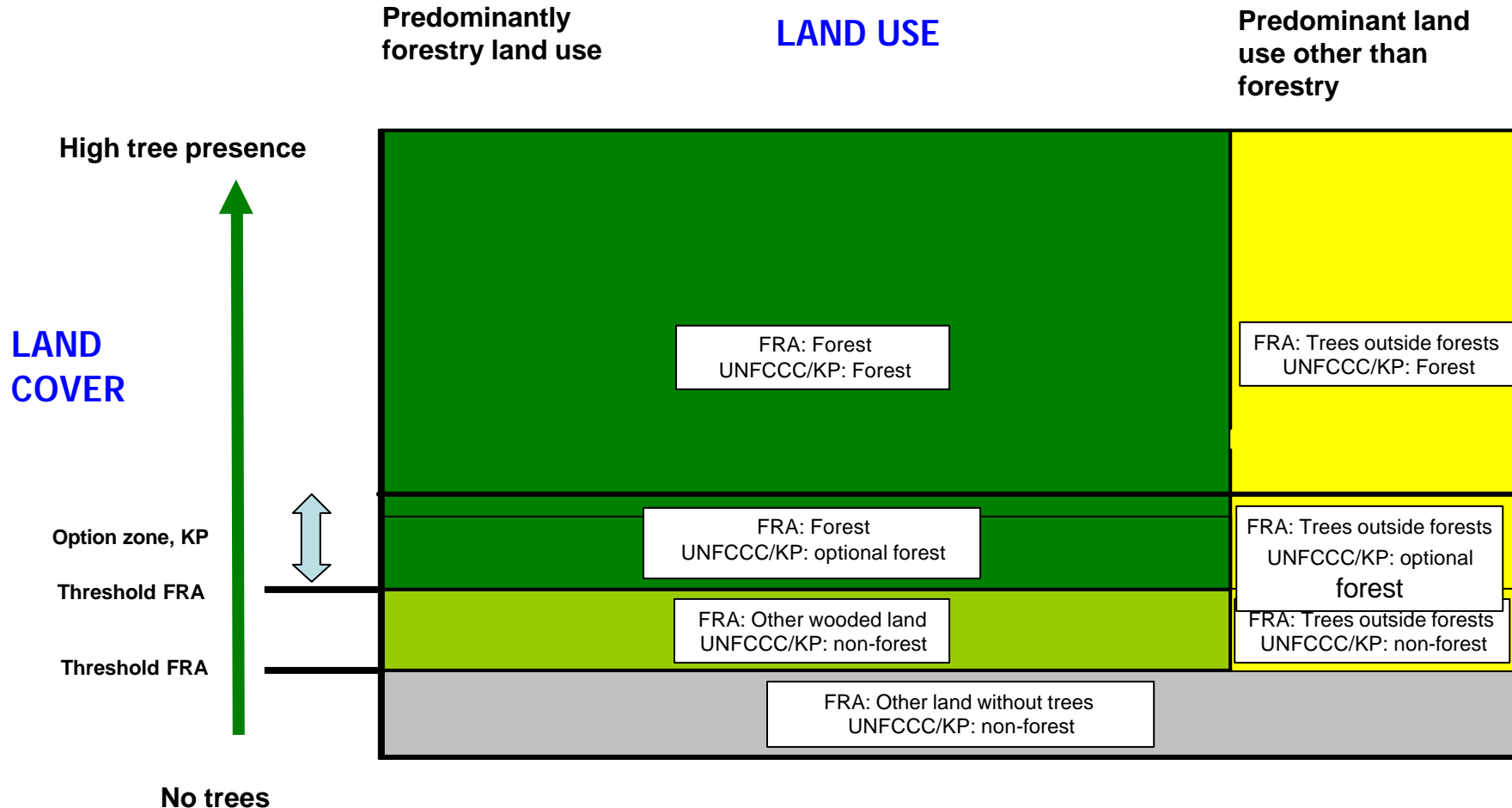
Linkages to other statistics

Land use & land degradation statistics

- LU involves modifications of natural ecosystems in order to obtain benefits
- Unsuitable LU (land management practices) can induce land degradation
 - changes in soil quality
 - erosion/ salinization, biodiversity
 - water quality (e.g. pollution)
- Spatial correlations between land use classes & land degradation

Land use & forestry (FRA) statistics

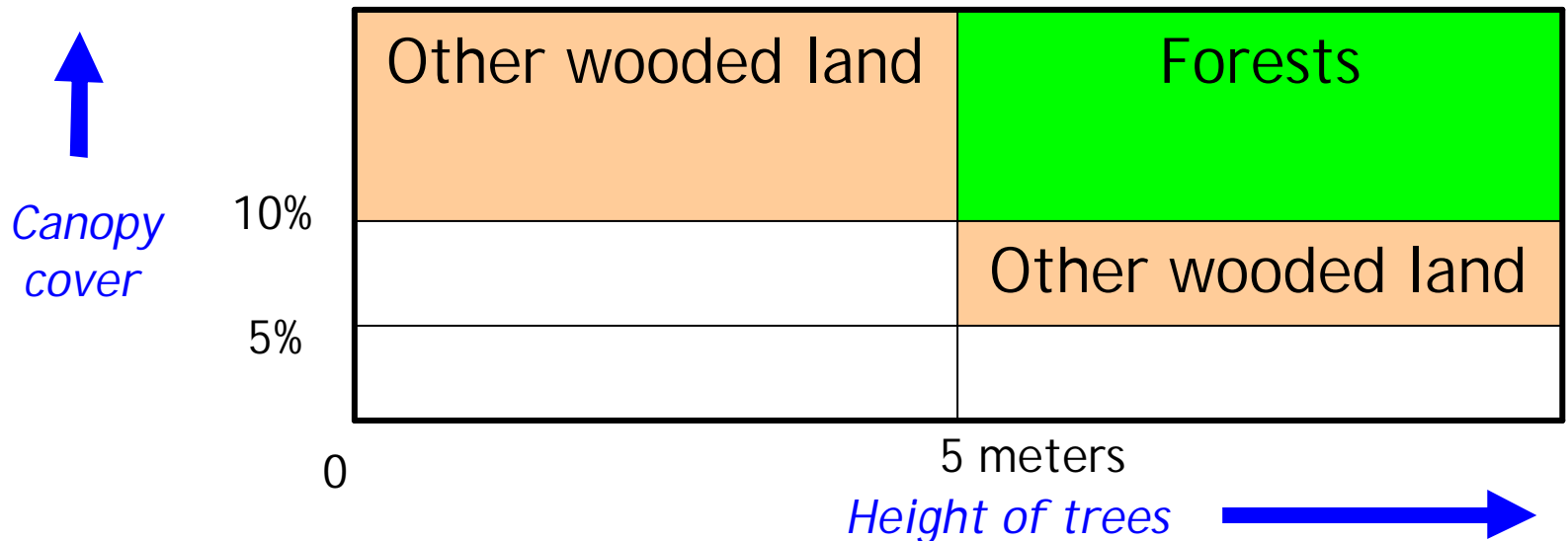
Harmonizing definitions



Linkages to other statistics

FRA 2005 definition (=UNSD)

Other wooded land: land under forestry or no land use, spanning more than 0.5 ha; with trees > 5m & a canopy cover of 5-10%, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes & trees over 10%



Linkages to other statistics

FRA 2005 definition (= UNSD)

Forest: land under forestry or no land use, spanning more than 0.5 ha; with trees > 5m & a canopy cover of > 10%, or trees able to reach these thresholds in situ

- includes areas under reforestation; temporarily unstocked areas that are able to regenerate
- includes firebreaks, windbreaks, tree corridors with area > 0.5ha & width > 20m
- excludes tree stands used in agricultural production systems (e.g. fruit plantations, agroforestry systems,..)

canopy cover: % of ground area that is directly covered by tree crowns

FRA classification

Forest	Forest Plantation	
	Natural Forest	
Other Wooded land	Shrubs	
	Fallow	<i>(forest fallow; < 5m)</i>
	Wooded grassland (cc 5-10%)	
Other land	Natural	Barren land
		Grassland
		Marshland
	Cultivated land	Annual crop
		Perennial crop
		Pastures
Built-up area		
Inland water		

linkages between FRA & to UNSD categories ?

UNSD Questionnaire - LAND

LU	Agricultural land	Arable land
		Permanent crops
		Permanent meadows & pastures
		Other agricultural land n.e.s
LC	Forest & other wooded land	Land under forest
		Other wooded land
LU	Built-up & related land	Residential land
		Industrial land
		Other built-up land n.e.s
LC	Open land: wet (no. vegtn)	
	Open land: dry (special vegtn <2m)	
	Open land: n.e.s (no vegtn.)	
LC	Waters	

NOTE: Fallow agricultural land (% of arable land, permanent crops permanent meadows & pastures)

Summary

- LU & LC data are useful for wide range of decisions
- Different approaches for classification/ characterization & inventory
- Importance of understanding the definitions of land-use classes - The UNSD questionnaire on land use statistics
- Diverse sources of LU/LC statistics at national & international levels
- Importance of Inter-agency coordination/ cooperation in harmonization & data collection