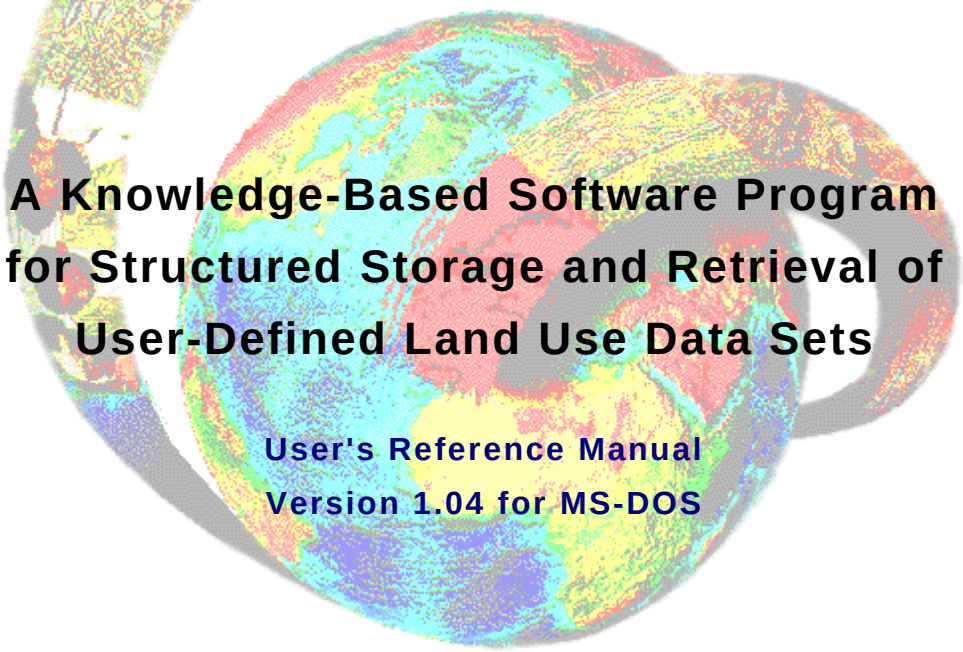
The Land Use Database



A Knowledge-Based Software Program for Structured Storage and Retrieval of User-Defined Land Use Data Sets

User's Reference Manual
Version 1.04 for MS-DOS

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ITC **FAO** **WAU** **UNEP**

- Initiated by FAO.
- Conceptual development by ITC, FAO, and WAU.
- Software development by ITC.

1. Conceptual Design, Software Development, and Production of User's Manual.
2. Software Design and Development, and Production of Technical Manual.
3. Production of User's Manual and Final Software Presentation.

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4. P.C.M. Jansen, Lemmens R.H.M.J., Oyen L.P.A., Siemonsma J.S., Stavast F.M., van Valkenburg J.L.C.H (eds.), 1991. PROSEA: Plant Resources of South-East Asia. Basic List of Species and Commodity Grouping - Final Version. Pudoc, Wageningen.

Disclaimer

The concepts used to develop The Land Use Database reflect opinions held by the authors and do not necessarily represent the general opinions and views of ITC, FAO, UNEP and WAU.

Freeware Statement

This software is Freeware. It can be used free of any charges, and can be provided to other interested parties on a non-profit basis in its original and complete form (i.e., software, demos and manual).

To avoid parallel software developments, the source code will always remain with one of the copyright holders for it's maintenance.

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Comments and suggestions for software improvements are always welcomed. Include your name, designation, organisation, address, and E-mail address.

Internet Address

The “Land Use Database” web site contains general information plus options to download the latest version of The Land Use Database as software demos. The URL is:

HTTP:/WWW.ITC.NL/EDUCATION/LARUS/LUSE

Introduction

Conceptual Basis

1. Introduction

A general introduction to The Land Use Database, discussing its background, features and structure.

1.1 What is The Land Use Database?

The Land Use Database is a knowledge-based DOS-software for consistent and well-structured storage and retrieval of primary and secondary land use data. A large number of data sets with user-defined extent and level of detail can be stored by the program in digital format.

The Land Use Database allows the user to define the type of land use data to store; it does not limit possible study objectives. The interface used for data entry is flexible and can be moulded to the user's requirements.

The Land Use Database was designed to be applicable in a variety of land use surveys and studies, e.g. mapping, monitoring, modelling, and analysis. Researchers of various disciplines, including land use planners, agronomists, surveyors, farming systems analysts and land evaluators, can use it.

The Land Use Database is specifically designed to capture and manage land use information as obtained through interviews with land users; it is not meant to store and retrieve tabular land use statistics (e.g., time series by crop and administrative unit on area grown and total production achieved).

This software can be used as a stand-alone application (under DOS) or as a multi-user application within a Novell network.

1.2 Background and Objectives

Global concerns about food security, the quality of life for future generations, and a growing awareness about environmental degradation, are posing penetrating questions to the world of science. Influenced by the UNCED 1992 in Rio de Janeiro, definitions of sustainable land use have been reviewed and made more interdisciplinary, recognizing its inherent complexity. To follow up on Agenda 21 Chapter 10, the Programme of Action for Sustainable Development, the FAO is preparing an "Integrated approach to the planning and management of land resources". This approach requires, amongst others, the availability of proper land use information at various scales, i.e. from individual farmer's fields to broad agro-ecological regions.

A FAO report[5] on the implementation of Agenda 21 (UNCED) states this necessity in the following terms:

5. FAO, 1994. Integrated Approach to the Planning and Management of Land Resources. Draft report of the UN Secretary-General on the Implementation of Chapter 10 of Agenda 21 (UNCED) to the Commission on Sustainable Development. Third Draft of Task Manager's Report. FAO/AGL, 28 November 1994, Rome. 30 pp.

- "The world as a whole has experienced a doubling of its human population over the past half century ... the costs to the planet has been high, in terms of destruction of the resource base, degradation of the environment, and effect on global systems."

- "Unless a radical and significantly more effective approach to resource management is adopted now, the most likely scenario is a large increase in poverty, hunger, social instability, war, ..."

- "Decision-making about the use of land resources depends on the availability of the necessary information on physical factors such as climate, soil, water, and present land use, social factors, and economic factors."

A precise analysis of the performance of a specific land use (i.e., its biophysical and ecological productivity, feasibility and sustainability, plus the socio-economic feasibility, acceptability and impact) can only be conducted if quantitative land use data are available.

Data collected by numerous agricultural and regional development projects, carried out during the last decades, are generally difficult to access. They are hidden away in survey reports, and when available, difficult to use because standard descriptors of land use are lacking [6].

The development of a generally applicable database can provide the means to store efficiently and consistently the required data on the basis of well defined terms, so that the "expensive" data will remain available for future studies.

To study and capture the complex attributes of land use, a multi-organizational approach is followed. In August 1992, the "Land Use Information Systems" (LUIS) working group was established by ITC, FAO, and WAU to discuss concepts for describing and classifying land use and to support the development of the database software. Simultaneously, the FAO established an Interdepartmental Working Group on Land Use Planning, Sub-Group-1: Methodology. The two groups regularly exchanged ideas and kept each other informed on their progress.

The LUIS group started their activities by adopting the "Operation Sequence" concept[7,8] (***Chapter 2***), also referred to as "Series of Activities" (FAO/AGLS). Both refer to land use information sub-divided into operations, e.g. ploughing, planting and harvesting.

This and all other concepts used are presented in ***Chapter 2***, covering the questions: "what is land use", "how to describe land use", and "how to classify land use". Adopted concepts are duly cited, while new concepts are the sole responsibility of the authors.

The software was thoroughly tested by the FAO in 1993/94 in four Southern African countries. Local consultants who received a two weeks training conducted these field tests.

6. Stomph, T.J. and L.O. Fresco, 1991. Procedures and Database for the Description and Analysis of Agricultural Land Use. A draft. FAO, Rome; ITC, Enschede; Wageningen Agricultural University. 76 pp.
7. Sims, D., 1993. Definition of Land Use Types and Production Systems in Relation to the AD 2000 Agricultural Census. Census Outline Paper 27/5/93, FAO, Rome. 31pp.
8. Stomph, T.J., L.O. Fresco, and H. van Keulen, 1994. Land Use System Evaluation: Concepts and Methodology. Agricultural Systems 44: 243-255.

Three M.SC students of ITC used The Land Use Database for their studies on land use in Thailand.

In 1996, with financial support of UNEP, a series of annotated demos were prepared to display on screen most aspects of the software. Users confirmed that viewing the demos is required to properly learn the software. Note however that, like statistical software, sound knowledge of concepts used, remains a must.
With the help of information and communication technology, land use information can now be integrated in knowledge structures and networks with the overall objective to improve land use planning aspects.

In summary, the objectives of the study were:

- to support the development of better land use planning methodologies.
- to customise existing concepts and to develop new concepts for describing and handling quantitative land use information.
- to formulate guidelines for classifying land use information.
- to develop a widely applicable software package for storage and retrieval of quantitative and geo-referenced land use information.

1.3 General Structure of The Land Use Database

The Land Use Database consists of three modules, i.e. the Glossary, Data Entry, and Query Modules. These modules provide several functions to the user (**Figure 1**), and give access to the database files in which data are stored. These database files are mutually linked (relational), but groups of files may be distinguished; they will be referred to as Glossary, Land Use Data, and Land Use Classes. In **Figure 1** it is shown in which module which groups of files are maintained.

For information on the data model: Section 2.4

1.3.1 The Glossary Module

In this module the user can maintain the Glossary in which items used to describe land use, i.e. parameter values, are stored in hierarchical 'trees'. Examples of Glossary trees are: Material Inputs, Operation names, Gender and Age Classes, and Infrastructures.
In the Glossary Module, parameters required to describe land use may be selected and put in a "Filter". In this filter, for a number of selected parameters, also a pre-selection of possible glossary items (parameter values) can be made (**Figure 2**). By defining such a filter, the data entry procedures can be tailored according to the needs and objectives of the user.

For more information on the Glossary Module: Chapter 5

1.3.2 The Data Entry Module

This module provides options to store and edit Land Use Data as well as Land Use Classes, and options to change program settings.

Land use data are stored in "data sets". Each data set may consist of four levels. The first three levels accommodate spatial information, i.e. to identify the data set and the site for

which land use systems are described. The third level stores general aspects of land use descriptions, whereas the fourth level is reserved for detailed land use data, i.e. for descriptions of operations and observations. Levels 3 and 4 accommodate both temporal land use system informations.

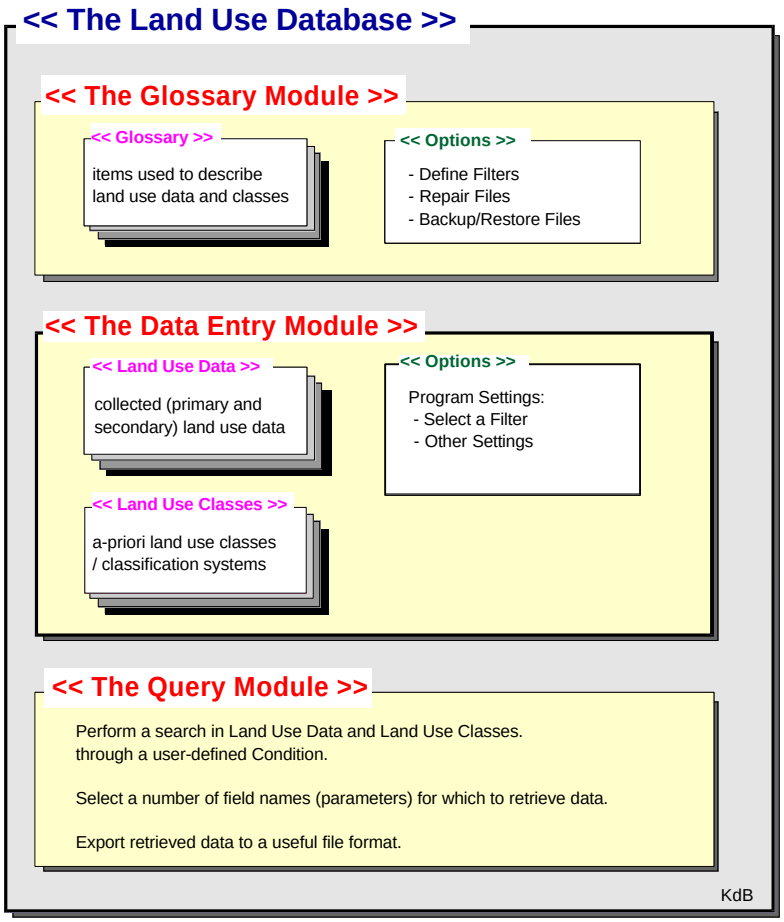

Figure 1. The Three Modules and the three file groups of The Land Use Database.

In hierarchically structured land use classification systems, names and definitions of a-priori land use classes can be stored. These are either user-defined or based on a commonly used land use classification system. A large number of classification systems can be entered. Each set of land use data is linked with an a-priori land use class.

Relevant parameter values to describe land uses and land use classes can be selected from the Glossary.

For more information on the Data Entry Module: Chapter 6

1.3.3 The Query Module

The search and retrieval of data from a database is called a "query". Through this module a search can be conducted on information stored in Land Use Data as in Land Use Classes data files. Simultaneous searches on both file groups are possible. Complex conditions may be defined, containing several criteria for different parameters. Information from data sets that meet the condition can be retrieved. Query output can be exported to various file formats, e.g. spreadsheet, text, or database format (for GIS processing), or viewed on the monitor or printed.

For more information on the Query Module: Chapter 7

1.4 Features of The Land Use Database

1.4.1 Special Features

Generally, databases allow users to enter, store and retrieve information. In addition to these features, The Land Use Database has a fixed data storage structure, is knowledge based, and can be shaped to the user's requirements. Below, the knowledge base and flexibility features are discussed in some detail.

Knowledge base

Aspects of land use are generally described by a limited number of parameters and parameter values. Information on land use must be stored as such. The Land Use Database contains knowledge regarding the required parameters and applicable parameter values (**Figure 2**).

- All defined parameters are organized in a relational database structure, displayed in data entry screens, and presented as data entry prompts.
-
- Parameter values are stored in the glossary. The glossary of The Land Use Database is flexible, i.e. items can be added, edited, deleted, and documented, thus making the possible list virtually limitless. Related glossary items are arranged in hierarchical structures ranging from general to more specific. Items must be rigidly defined and unambiguous. Presently the glossary contains about 10,000 items.

Not all parameters are linked to the glossary, e.g. quantitative parameters. For these, parameter values must be entered manually.

The knowledge base character of The Land Use Database secures consistency in the storage and description of land use, which is a precondition for proper data retrieval and subsequent analysis.

Flexibility

As land use studies differ widely in objectives, scope and detail of the information collected, software for storage of land use descriptions must be flexible and versatile. This is achieved by allowing the user to adjust the data entry procedure through the use of filters (**Figure 2**).

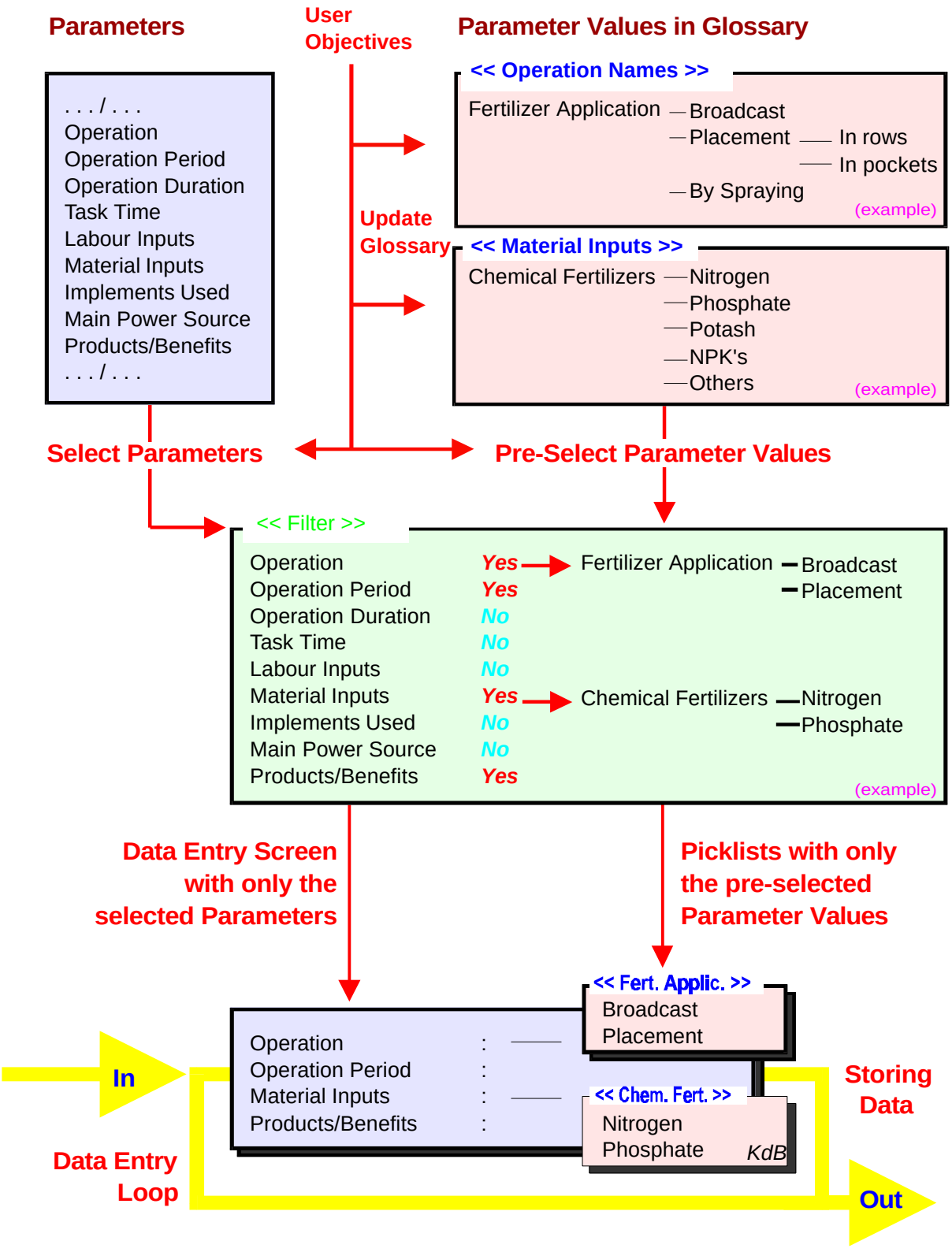

Figure 2. **Flow-chart showing the Data Entry procedure, the preparation of a Filter to adjust this Procedure (Flexibility), and the use of Glossary Items (Knowledge Base).**

According to the objectives of the user, a selection can be made from the available parameters. For included parameters a number of parameter values can be selected from the glossary. The selections made are stored in a filter. Preparing the filter is the responsibility of the user and must be done before the actual data are entered, preferably even before the actual data collection takes place. The glossary and filter can be amended when required. The filter determines which parameters and parameter values can be used during data entry procedures; it shapes the data entry screens.

1.4.2 Other Features

Data entry and Storage

The Land Use Database allows the user to enter and store qualitative and quantitative land use information, collected through fieldwork or from literature (primary and secondary information). Selected data describing the context of the land use can also be stored, e.g. information on parcel, tenure, map unit, holding, or administrative area. The program is designed to store land use data in quantitative format whenever applicable. In addition, The Land Use Database can store user-defined as well as commonly used land use classification systems, containing properly defined a-priori land use classes.

Simultaneous Storage of Data from Different Surveys

The Land Use Database can store a vast number of different types of data as obtained from a large number of studies simultaneously. All data stored are based on a single glossary and can be queried simultaneously.

Query and Data Export

The Land Use Database offers the possibility to extract any sub-set of stored data by a query procedure with a variety of search options. Extracted data can be printed, viewed, and exported to a number of commonly used file formats, e.g. spreadsheet (Lotus-123, Quattro, Symphony, Excel), database (dBASE), or text file formats.

Example Land Use Data Provision

The Land Use Database contains an extensive set of land use data collected during software field tests. These data may help the user to explore the possibilities of the program.

Site Geo-referencing

Sites from where land use data are collected may be geo-referenced by latitude and longitude as well as by UTM coordinates. In addition, land use information can be geo-referenced by administrative areas, map units, and elements of map units. Geo-referencing offers the possibility to map and monitor land use. Apart from location, also plot sizes can be specified. When plot boundaries can not be traced, the user can take a selective representative sample.

Scale Independence

The Land Use Database stores land use descriptions on plot level or as valid for various other spatial units, i.e. based on defined administrative areas, holdings, map units, parcels, or a combination of these. Each such a description is then more or less 'generalised' and valid for 'aggregations' of plots.

Application Independence

The Land Use Database can be used for any type of application that involves collection or use of land use data, e.g.:

- Land use mapping and monitoring
- Land use analysis and modelling
- Land evaluation / Land use planning
- Agricultural research
- Agricultural census and survey
- Farming Systems Analysis

Labour / Gender Specification

The software can accommodate detailed information on the labour inputs for each land use operation, i.e. gender and age class, labour origin, and labour skills.

Origins / Destinations of Inputs and Outputs

The program allows the user to store for any land use operation, the sources / origins of material inputs, implements used, and labour inputs, as well as the destinations of products.

Land Property Indicators

Two parameters, viz. cadastral number and tenancy arrangement, are included in the program to describe the property aspects of parcels from which land use data are collected.

Environmental Issues

Information on land use operations can be specified in great detail in this software. Additionally, detailed information may be stored on observations regarding the land use performance, or its impact on the environment, the knowledge of the user about the land use system, etc.

Survey Preparation Guidance

Since The Land Use Database can store a wide range of land use data, it may serve as a checklist of data to be collected in a land use survey.

Database Links

The Land Use Database has been designed to be compatible with other databases, e.g. a soil/terrain database, a land cover database, a climate database, a household database, or a costs/prices database. The Land Use Database may also be part of a Geographic Information System (GIS).

1.5 Disclaimer regarding Software Status

The development of The Land Use Database is still in progress. Minor flaws and perhaps even (small) bugs may remain in the program. The authors regret that:

- help texts built in the software are still incomplete,
- the glossary is incomplete, and has a focus on agricultural land uses.

2. Conceptual Basis

This chapter discusses the concepts adopted for The Land Use Database. It contains definitions of concepts related to land use, discussions on describing and classifying land use, and the data model of The Land Use Database.

2.1 Land Use Defined

2.1.1 Land and Land Use

Land use is the focal point of this software and is clearly related to land. The terms "land" and "land use" must accordingly be formally defined. The definition of **land**, adopted by The Land Use Database, reads:

> *"Any delineable area of the earth's terrestrial surface, involving all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), near-surface layers and associated ground water and geo-hydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.)."* [9]

Note that the authors consider vegetation, including crops, to be part of land. When crops are present on a field, they are the results of human activities, e.g. of planting maize seeds. Crops constitute thus a land resource that can be used, e.g. harvested.

Numerous definitions of land use exist[10, 11, 12, 13]. In general, they refer to management activities, conducted by man, related to a tract of land or an ecosystem. Some definitions state that land use meets human needs, i.e. that land use has a certain purpose.

For the development of The Land Use Database, the following definition of **land use** was adopted:

> *"A series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources."*

9. FAO, 1994. Integrated Approach to the Planning and Management of Land Resources. Draft report of the UN Secretary-General on the Implementation of Chapter 10 of Agenda 21 (UNCED) to the Commission on Sustainable Development. Third Draft of Task Manager's Report. FAO/AGL, 28 November 1994, Rome. 30 pp.
10. FAO, 1993. Glossary of land use terms. Inter-Departmental Working Group on Land Use Planning. Internal document FAO, Rome.
11. UNEP/FAO, 1994. Report of the UNEP/FAO Expert Meeting on Harmonizing Land Cover and Land Use Classifications; Geneva, 23-25 November 1993. Earthwatch Global Environment Monitoring System. GEMS Report Series No. 25. Nairobi, March 1994.
12. Anderson, J.R., E.E. Hardy, J.T. Roach, and R.E. Witmer, 1976. A Land Use and Land Cover Classification System for use with Remote Sensor Data. US Geological Survey Professional Paper 964. Washington DC.
13. Van Gils, H., H.Huizing, A.Kannegieter, and D. van der Zee, 1991. The Evolution of the ITC System of Rural Land Use and Land Cover Classification (LUCC). ITC Journal 1991(3), pp. 163-167. ITC, Enschede, The Netherlands.

2.1.2 Land Use versus Land Cover

Land use must not be confused with land cover[13]. Land cover is an element of land, whereas land use is not. **Land cover** is defined as:

> *"The vegetation (natural or planted) or man-made constructions (buildings, etc.) which occur on the earth surface. Water, ice, bare rock, sand and similar surfaces also count as land cover."* [9]

The difference between land cover and land use will be illustrated by two examples. The land cover "forest" can be described by direct field observations such as vertical vegetation structure, vegetation height and density. Aspects of the land use of "forest", may be "rubber tapping", "bio-diversity conservation", "recreation", "timber production", or "shifting cultivation". Another example is grassland with grass as land cover: the land use may be "hay production", "grazing", "not used", or "recreation".

These examples indicate that land cover may be determined by direct observation, whereas information on land use requires in principle an interview with the person who controls or carries out the land use.

Remotely sensed data, e.g. from aerial photographs or satellite images, can be correlated with land cover, and used for mapping land cover. Land use, in turn, may be related with actual land cover, so that land use may be mapped with land cover as an intermediate step. "Ground truthing" is required to provide evidence for the surveyed aspects and to describe the actual land uses.

2.2 Describing Land Use

2.2.1 The Land Use System

Precise descriptions of land use are needed for sound analysis of land use performance, notably its feasibility, productivity, sustainability, and environmental impact. The performance of land use can only be determined if land use is described for a known location and a known period of time. This means that spatial and temporal boundaries of the land use must be defined. Actual land use must be described as part of a system.

A **system** is defined as:

> *"A limited part of reality with well-defined boundaries that contains interrelated elements, where the elements within the boundaries have strong functional relations with each other, and limited, weak or non-existent relations with elements in other systems."* [14]

If this definition of a system is adopted, a **land use system** is defined as:

> *"A specific land use, practised during a known period on a known and contiguous area of land with identical characteristics."*

14. De Wit, C.T., 1993. Philosophy and terminology. In: P.A. Leffelaar (Ed.), On system analysis and simulation of ecological processes, with examples in CSMP and FORTRAN. Kluwer Academic Publishers, Dordrecht, pp. 3-9.

To study the performance of land use(s), a land use system must be the basic entity of description. A discussion of the boundaries and elements of land use systems follows hereafter.

2.2.2 Boundaries of a Land Use System

Before attempting to describe a land use system, one must define the boundaries of that system. The spatial boundaries of a land use system confines a tract of land on which one specific use is practised. The temporal boundaries of a land use system are determined by changes in land use.

The spatial boundaries of a land use system are those of a plot. Note that the term "field" is not used in The Land Use Database because it already has several connotations and may therefore cause confusion. A **plot** is defined as:

"A contiguous tract of land, with identical characteristics, under a specific land use."

Note that changes in plot boundaries may coincide with changes in land use, i.e. if the new land use system occupies more or less area of land.

The temporal boundaries of land use systems may be difficult to determine for some long duration land uses, e.g. perennial cropping and shifting cultivation. This is further elaborated in ***Section 2.2.6***.

In some cases, the spatial boundaries of a land use system are difficult to detect, i.e. because spatial changes in land use are gradual, e.g. grazing in communal lands, or firewood collection in a forest. Land use is, in these cases, related to distance to water sources or settlements. It is then recommended to select one or more representative sites, say 100 by 100 m, within the area and to describe the land use of these sites. It is then the surveyor who has to define the boundaries of the land use system for which the description is valid.

The Land Use Database can store both types of plot sizes.

Note that knowledge of the spatial boundaries of land use systems permits geo-referencing of land use as required for land use mapping.

2.2.3 Elements of a Land Use System

To describe a land use system and analyse its performance, individual system elements and their relationships must be identified. The elements of a land use system that were defined during the development of The Land Use Database are shown in **Figure 3**.

Figure 3 shows that land use systems are composed of the two-element land and land use. The latter is divided into land use purpose(s) and operation sequence. See ***Sections 2.2.4, 2.2.5, and 2.2.6*** for descriptions of these elements.

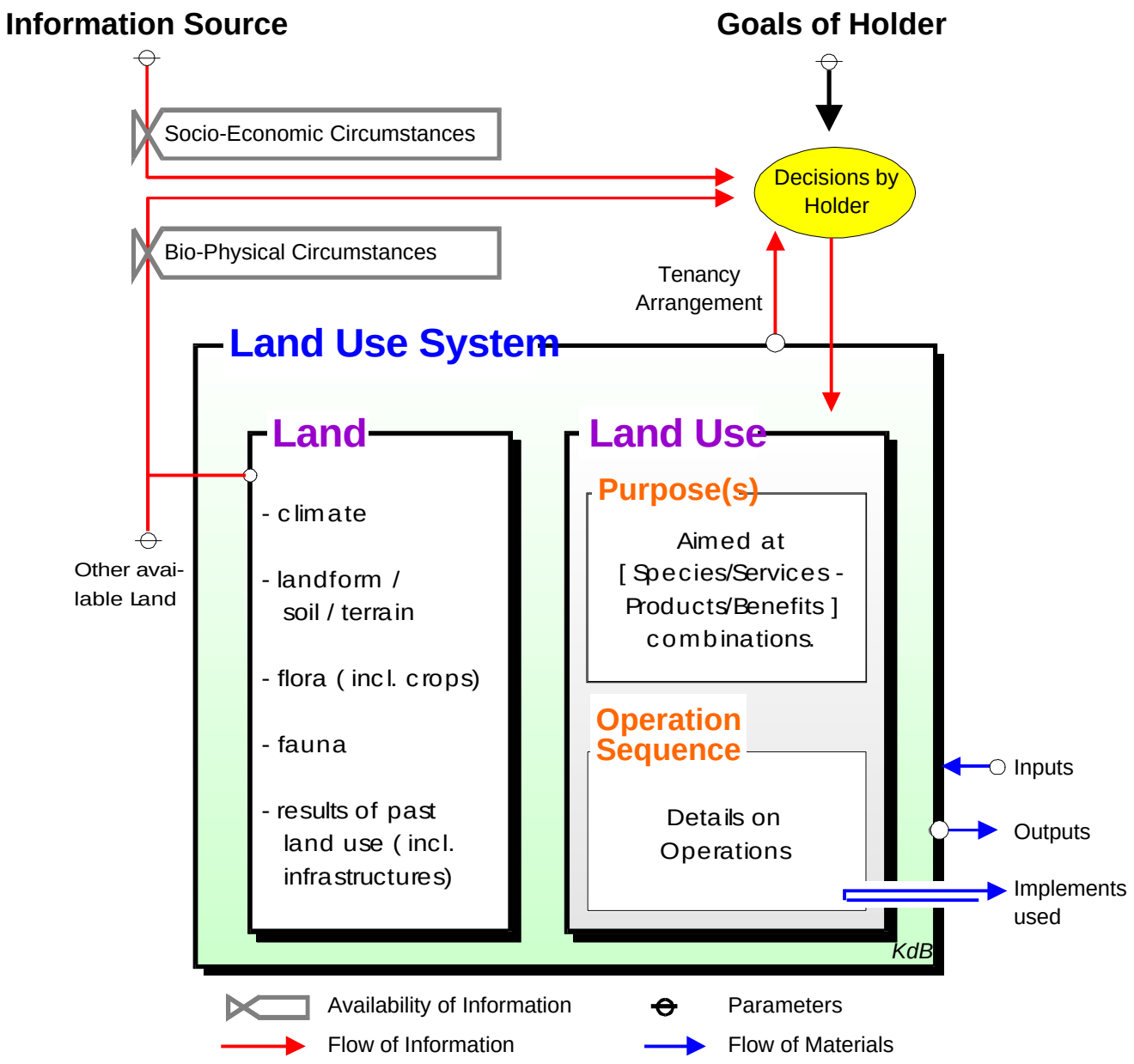

Figure 3. **Elements and External Relationships of a Land Use System. Flows of Information within the Land Use System are not shown.**

Earlier concepts coined in the FAO Guidelines for Land Evaluation plus their drawbacks are explained below.

The definition of a **land use system** suggested in ***Section 2.2.1*** differs from the one given by the FAO[15] which is:

> *"A specified land utilization type practised on a given land unit, and associated with inputs, outputs and possibly land improvements."*

By the FAO, for practical reasons, the land use system (LUS) has been divided into two parts: the Land Unit (LU), and the Land Utilization Type (LUT).

The **land unit** represents the supply side in the land use system, and is defined as:

> *"An area of land possessing specified land qualities and land characteristics, which can be demarcated on a map."* [15]

The **land utilization type** represents the demand side of a land use system, and is defined as:

> *"A kind of land use described or defined in a degree of detail greater than that of a major kind of land use", i.e.: "of which specific data on management, economics and technical inputs are given."* [15]

The Land Utilization Type concept has flaws:

- it is neither a precise nor a formalized description of land use,
- it reflects neither an actual land use system, nor a defined land use class,
- a description of land use in broad qualitative terms has limited value for a sound quantitative analysis, and
- the flexible but not formalised guidelines to describe land use leaves authors often confused.

In short:

> "**A land utilization type is a simplified, idealized description of land use which is not practised by any farmer in reality, because continuous adaptations of the LUT occur according to time, place, judgement or inclination.**" [16]

On the above grounds, the land use system concept of the FAO Guidelines was adopted in a modified form during the development of The Land Use Database.

15. FAO, 1984. Guidelines: Land Evaluation for Rainfed Agriculture. Soils Bulletin 52. FAO, Rome.
16. UNEP/FAO, 1994. Report on the UNEP/FAO Expert Meeting on Harmonizing Land Cover and Land Use Classifications. Geneva, 23-24 November 1993. GEMS Report Series No 25. Nairobi. (Quote of Dr.Purnell).

2.2.4 Land

"Land" is an element of land use systems (see **Figure 3** and the definition given); most of its characteristics are not included in The Land Use Database. Land refers to the compounded properties of climate, soil, terrain, flora and fauna (including crops, weeds, diseases, livestock, wildlife, and pests) and the results of past land use (notably infrastructure).

Although aspects of land are very important for precise analysis of the performance of a land use system, The Land Use Database was not designed for storage of land characteristics. Databases containing land information, e.g. on soil, land cover, or climate, may be linked with The Land Use Database in order to carry out land use systems analysis.
Nonetheless, some aspects of land can be stored in The Land Use Database. It concerns notably infrastructure and selected observations.

Infrastructure is defined as:

> *"Permanent installations constructed to assist economic activity such as roads, irrigation or drainage works, buildings and communication systems."* [17]

Infrastructure present in or around a plot may be used in the context of a particular land use. In The Land Use Database, information on such infrastructure can be stored.

An **observation** is defined as:

> *"A description/measurement of a condition that may influence the performance of a land use system, that states its impact on the environment, or that reflects the knowledge of the land user about the land use system."*

Examples of observations are "water shortage during crop establishment", and "known limitations of the rooting depth by crops". Observations can be made at any moment during the existence of the land use system; the land user often makes them and information about it is obtained through interviews. Observations frequently provide important information on temporal aspects of the land use system that is not stored in databases containing static or generalised land characteristics.

The Land Use Database allows storage of observations regarding a land use system and their (estimated/possible) effects on production.

2.2.5 Land Use Purposes versus Goals of the Holder

Land Use Purposes

Land use always has one or more purposes. A **land use purpose** is defined as:

> *"The product or benefit aimed at through land use."*

Products are material/tangible results of a land use system and may originate from plants in a land use system, e.g. grains from maize or straw from wheat.

17. FAO, 1993. Guidelines for Land-Use Planning. FAO Development Series 1. FAO, Rome.

Benefits are immaterial/intangible results of a land use system and may originate from species and through services, e.g. shade provided by trees, soil protection by cover crops, pleasure by recreation, or bio-diversity conservation through protection.

Land use purposes can be stored in The Land Use Database by so called [Species/Service-Product/Benefit] combinations, e.g. [buckwheat - grain] or [recreation - pleasure]. The quantities achieved by an actual land use system can also be specified.

Be aware that one land use system may have more than one purpose. For example, intercropping of maize and cow-peas can provide fodder, grain and pulses in one operation sequence. If more than one purpose is aimed at by one land use, it is called a **multi-purpose land use**, defined as:

> *"A land use in which more products and/or benefits are aimed at."*

The Land Use Database offers the possibility to define more than one purpose for a single land use system, i.e. more than one [Species/Service-Product/Benefit] combination.

Goals of the Holder

The purpose of the land use must not be confused with the goals of the holder (**Figure 3**). A **holder** is defined as:

> *"A civil or juridical person who exercises management control over the (agricultural) holding operation and takes major decisions regarding resource use."* [18]

The purpose of land use is expressed in general terms by the products and/or benefits aimed at in a land use system. The goals of the holder, on the other hand, are specified with reference to holding level. Goals can be "food production" or "income generation".

The decision regarding a particular land use option (purpose) is taken on the basis of the goals of the holder and on bio-physical and socio-economic possibilities and constraints (circumstances) plus the tenancy arrangement of the land use system (**Figure 3**). This decision is normally taken at the holder's level.

The bio-physical component of a land use system relates to the bio-physical performance of that system; it includes land characteristics which condition the feasibility or productivity of the land use. When information on them is known or available they are likely to influence the holder's decision on the land use.

Information on land characteristics can not be stored in The Land Use Database, apart from infrastructural items, and specific observations on aspects of the land which affect the performance of the system, e.g. a hail storm that damaged crops.

The socio-economic component of a land use system includes the decision making process plus socio-economic circumstances that influence the holder's decision to reserve a plot for a specific land use. This includes political and institutional aspects. Circumstances that may be relevant are: labour availability, presence of a market, costs of inputs, and product prices.

18. FAO, 1986. Programme for the 1990 World Census of Agriculture. FAO Statistical Development Series 2. FAO, Rome.

These circumstances determine if a certain land use system is feasible in economic terms, and therefore, when known to the holder, influence his decisions regarding land use.

The Land Use Database does not store information on the socio-economic circumstances of land use systems. Databases that include this type of information may be linked to The Land Use Database.

2.2.6 Operation Sequence

In the course of a land use a series of operations is carried out which is termed as **operation sequence** (**Figure 4**), and defined as:

> *"A series of operations on land, carried out by humans, in order to realize set land use purpose(s)."* [19]

In the present context, an **operation** then refers to:

> *"A distinct and intended management action carried out by humans on land."*

The type, timing and sequence of operations is very important for a thorough analysis of the performance, e.g. productivity and sustainability, of a land use system. Temporal aspects of land use must also be considered in the analysis of the temporal variation in labour demands, fertilizer requirements, cash flow, etc.

Detailed descriptions of an operation includes amongst others the type and quantity of implements used, the type, quality and quantity of material inputs applied and labour inputs used, the main power source used, and details on products/benefits achieved.

The Land Use Database can store detailed information on individual operations.

It was stated in ***Section 2.2.2*** that the temporal boundaries of a land use system are affected by a change in land use, i.e. a change in operation sequence. Evidently, the start and end of an operation sequence must be defined. Currently, there are no strict guidelines for determining the temporal boundaries.

Possible criteria to use are the growing season (e.g. for annual cropping), or a fixed period of one year (e.g. for perennial cropping), or the dates when plot boundaries changed. The duration of the operation sequence is also determined by the objectives of the study. For example: if the objective is to study the first crop of a crop sequence, the part of the operation sequence covered will not exceed the growing period of this first crop.

Since formal guidelines on defining the temporal boundaries of a land use system are still lacking, a discussion of rotation schemes is not included here.

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19. Adapted from:
    - Sims, D., 1993. Definition of Land Use Types and Production Systems in Relation to the AD 2000 Agricultural Census. Census Paper 27/5/93, FAO, Rome.
    - Stomph, T.J., L.O. Fresco and H. van Keulen, 1994. Land Use System Evaluation: Concepts and Methodology. Agricultural Systems 44: 243-255.

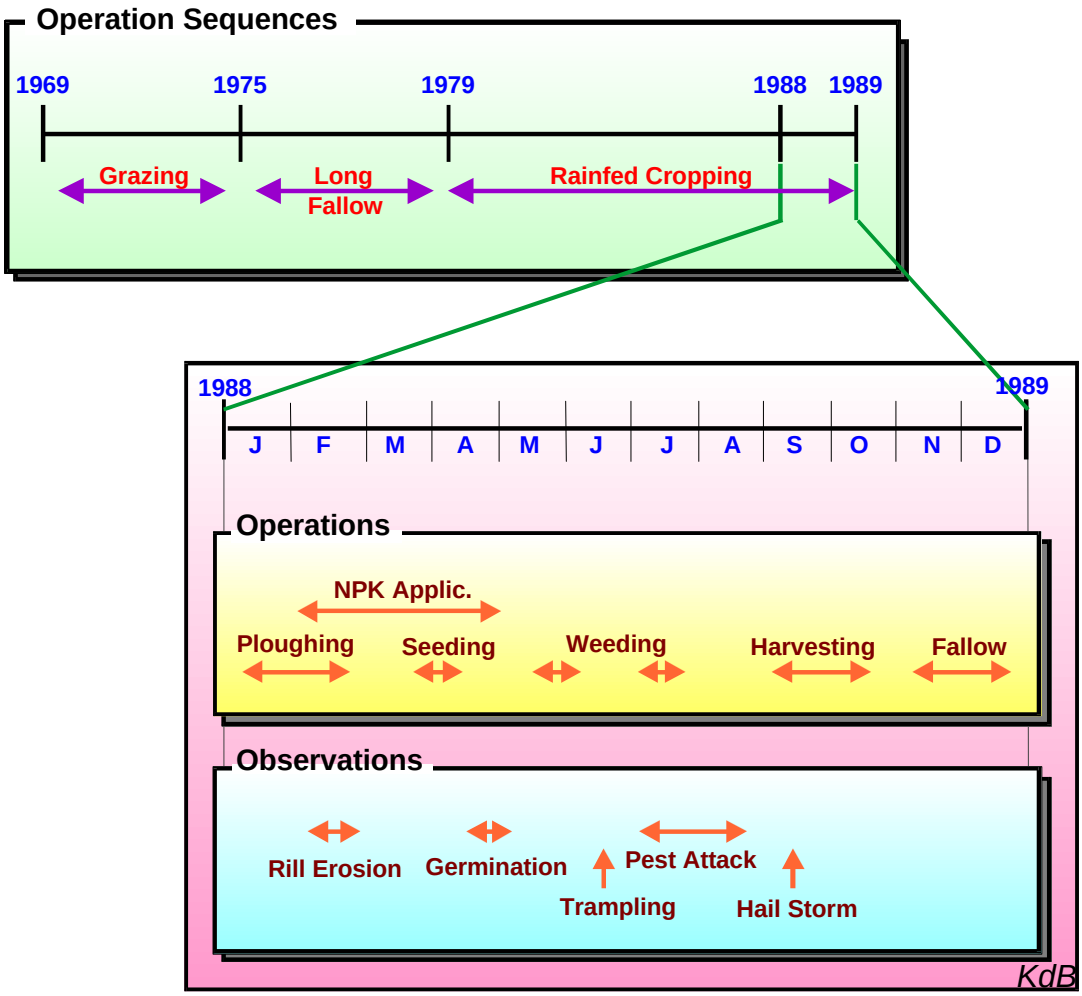

Figure 4. **Examples of:**
- **A-priori Land Use Class Names reflecting Operation Sequences.**
- **Individual Operations as part of an Operation Sequence.**
- **Observations on the Performance of a Land Use System.**

2.2.7 Land Use and Livestock Production Systems as Part of a Farm System

Land Use Systems

Land use systems are at least described at the level of a plot. Several plots may constitute one parcel (**Figure 5**). For the development of The Land Use Database the following definition of a **parcel** was adopted; it is based on a FAO definition [20]:

> *"A contiguous piece of land with uniform (identical) tenure and physical characteristics. It is entirely surrounded by land with other tenure and/or physical characteristics, or by infrastructure."*

20. FAO, 1992. FARMAP. The FAO Farm Analysis Package, Reference manual. FAO, Rome.

Several parcels may constitute part of a **farm** or **agricultural holding** (**Figure 5**), which is defined as:

> *"An economic unit of agricultural production under single management comprising all livestock kept and all land used wholly or partly for agricultural production purposes, without regard to title, legal form, or size."* [21]

Within the context of an agricultural holding, a **farm system** is practised, which is defined as:

> *"A decision making unit, comprising the farm household, cropping and livestock systems, that produces crop and animal products for consumption and/or sale."* [22]

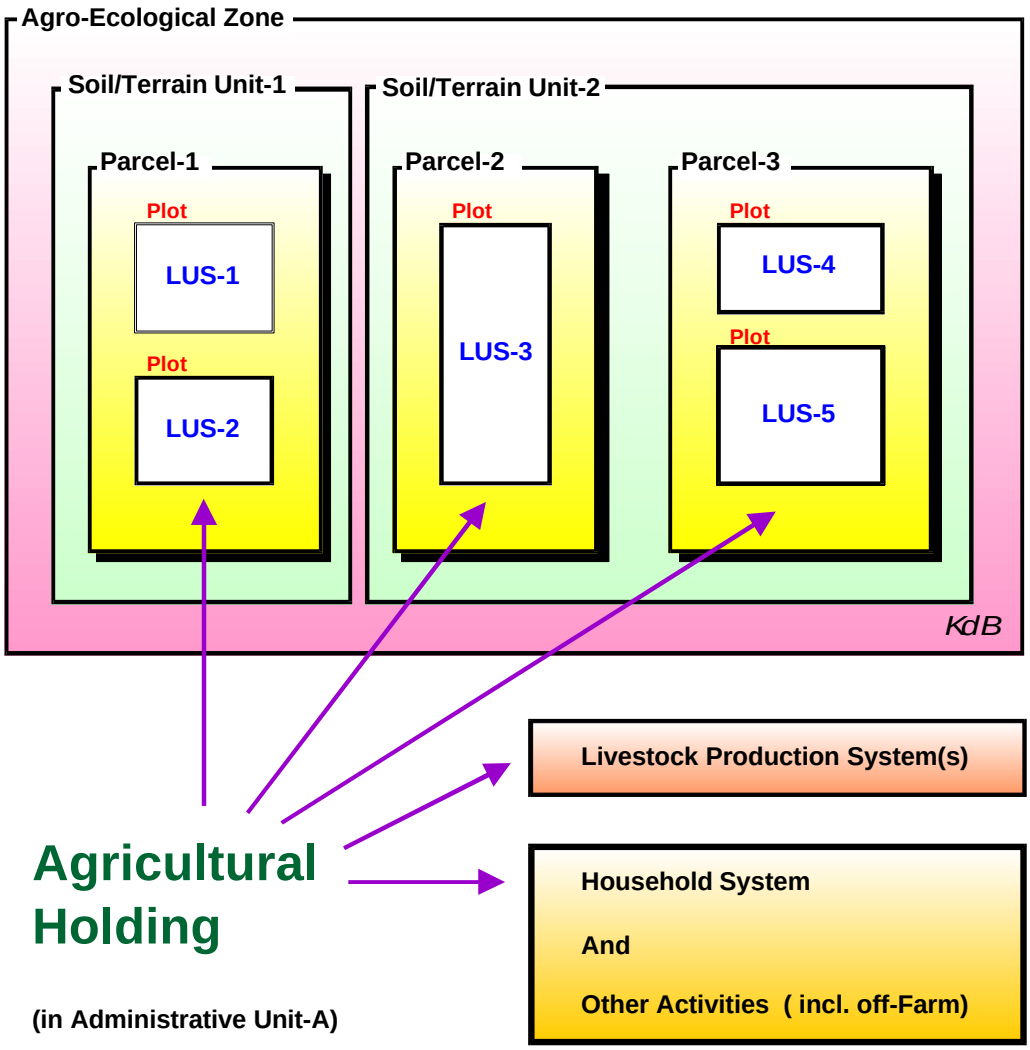

Figure 5. Elements of an Agricultural Holding; Example of its Spatial Pattern.

21. FAO, 1986. Programme for the 1990 World Census of Agriculture. FAO Statistical Development Series 2. FAO, Rome.
22. Fresco, L.O., H.Huizing, H.van Keulen, H.Luning and R.Schipper, 1994. Land Evaluation and Farming Systems Analysis for Land Use Planning; LEFSA. FAO Guidelines: Working Document. FAO, Rome, ITC, Enschede, WAU, Wageningen.

Holdings and land use systems can also be non-agricultural, e.g. a nature reserve, a recreational area, etc.

Farm systems are sometimes mistaken as being equal to land use systems, e.g. shifting cultivation is often used to label a farm system, but in really it is a land use system whose operation sequence covers a short period of cultivation followed by a long fallow period. So shifting cultivation is practised within a farm system.

Selected information on the farm system can be stored in The Land Use Database, notably the name, size, and location of the holding, the tenancy status of the parcel(s), the sources of materials, labour inputs and implements used, and the destinations of the product achieved (**Figure 3**).

For each holding various parcels, and for each parcel various land use descriptions can be entered into The Land Use Database.

Livestock Production Systems

Land use systems are also often confused with **livestock production systems**, which are defined as:

> *"Systems comprising pastures and herds and auxiliary feed sources transforming plant biomass into animal products."* [22]

and **livestock** is defined as:

> *"All animals kept or reared in captivity on the holding mainly for agricultural purposes."* [21]

Livestock is often related to a certain tract of land for a relatively short period. In that case, livestock production systems can not be considered as part of a single land use system. However, the grazing of livestock is and must be considered as an operation that takes place on a plot as part of an operation sequence. Grazing is therefore part of the land use system while the livestock production system is not.

The spatial boundaries of a land use system are defined by the plot boundaries; for a livestock production system a herd, flock, etc may determine them. The spatial boundaries of a herd can expand over relatively large and non-homogeneous areas, e.g. transhumance systems.

For confined livestock production, i.e. when livestock remains in permanent enclosures, a plot does indicate the boundaries of both the land use system and the livestock production system. In theory the two systems can thus be treated as one single system, e.g. a pond for fish production, a shed for poultry production, stables with cattle kept at zero grazing for milk production.

Information on livestock production systems that are not confined to one plot cannot be stored in The Land Use Database, but information on grazing can be stored as an operation of which the period, duration, intensity, etc. can be specified.

2.2.8 Land Use Descriptions at Various Scales

Actual land use system descriptions are minimally valid for a single plot. However, many studies of land use require land use information for larger units (at a smaller scale), e.g. for an administrative area (village, province, country), map unit, and/or holding. There are two possibilities:

Grouping of land use system descriptions

Descriptions of land use systems can be grouped, e.g. by map unit, holding, region, etc., i.e. by units with smaller scale. For example, land use information is collected for several plots in a parcel; the individual land use descriptions are then grouped by parcel (**Figure 6**: top part). The same procedure may be applied to group land use descriptions by holding, map unit, administrative area, or a combination of these.

Generalised description of land use systems

A single generalised description of several plot-specific land use systems consists of a description of their common properties. That description is in general terms and valid for all locations involved (aggregated plots; **Figure 6**: bottom part). For example, a generalised description is given of all like-wise land uses of a holding, a map unit, an administrative area, or a combination of these.

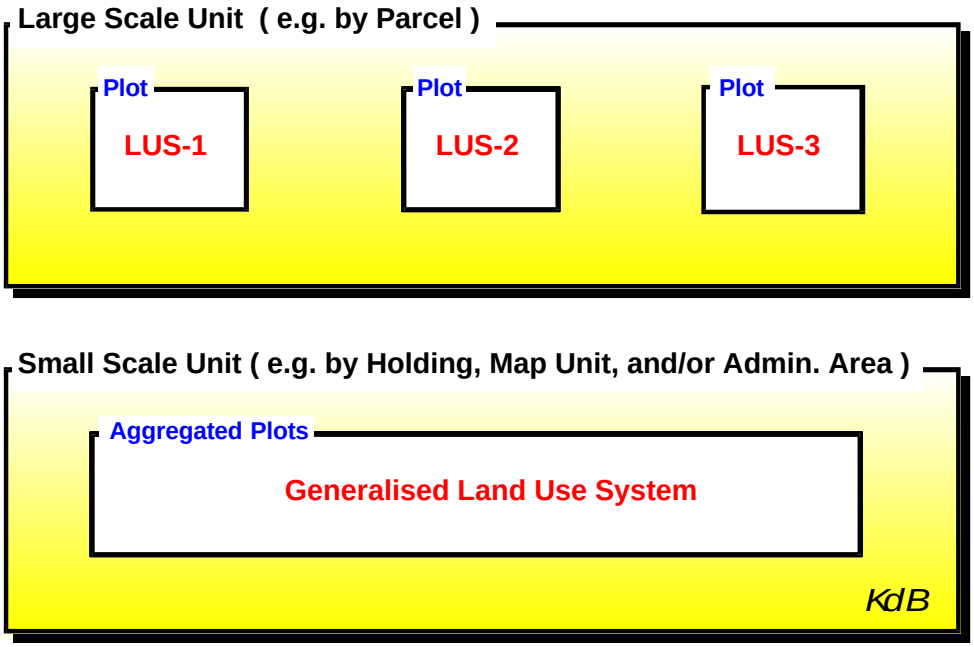

Figure 6. Top: Grouping of Land Use System Descriptions.
Bottom: Generalised Land Use System Description at Smaller Scale.

The Land Use Database allows the user to group descriptions of land use systems, by storing land use data in a hierarchical structure. It also offers the possibility to store generalized, smaller scale, land use system descriptions.

2.3 Classifying Land Use

2.3.1 Why Classifying Land Use?

There is an enormous variation in land use worldwide. Operation sequences and land use purposes may vary considerably between plots. To map land use, to report land use statistics, and to carry out land use planning, common characteristics of the variety of land uses must be identified.

Common land use characteristics can be prepared in two ways:

by generalizing descriptions of actual land use systems.

> Generalisation of land use systems descriptions implies that the resulting description is only valid for a certain area during a given period, e.g. land use names/descriptions in map legends (***see Section 2.2.8***).

by classification of land use descriptions

> Classification of land use descriptions, on the other hand, results in descriptions that are not limited to a certain area or time frame.

The following sections cover the subject of land use classification. **Land use classification** can be defined as:

> *"The process of defining land use classes on the basis of selected diagnostic criteria."*

A **land use class** is defined as:

> *"A generalised land use description, defined by diagnostic criteria derived from the land use purpose(s) and operation sequence followed, and without any specific location or period indications."*

2.3.2 How to Classify Land Use?

Classification of land use must be based on well-defined diagnostic criteria. These will be referred to as classifiers. Unfortunally classifiers are often omitted from land use classification reports, i.e. names of classes are given only.

A land use class is free of temporal and spatial dimensions. It is a universally applicable land use description. Therefore, land use classes must not be defined in terms of land characteristics like the use of cover terminology.

A **land characteristic** is defined as:

> *"A property of land, that can be measured or estimated, and that is used to distinguish land units from each other."* [22]

In case land charcteristics are used, it is no longer possible to determine the suitability of a certain piece of land for a certain land use, to monitor land use changes, or to study why on a certain piece of land a specific use occurs. In spite of this, land characteristics are often added as classifiers, resulting in land use (system) classes such as "not used bare soil" or "protected tropical forest".

The productivity of a land use system is occasionally used to define land use classes, which is incorrect as productivity reflects the performance of a land use system that includes the element 'land'.

Land use classes must exclusively be based on classifiers derived from the land use elements of a land use system (**Figure 3**), thus parameters that express the purpose and operation sequence of the land use system may function as classifiers.

In The Land Use Database, three types of classifiers can be applied to define land use classes (**Figure 7**):

- Purpose classifiers that specify the aimed at [Species/Service-Product/Benefit] combinations. For each land use class at least one combination must be specified. Each combination may be defined to a certain degree of detail. For lower level classes **no** new products or benefits can be added, but existing ones can be further specified or, if required, they can be split into several new combinations.

- Operation sequence classifiers that specify elements of individual operations or combinations of elements of several operations. For lower level classes new classifiers can be added; used classifiers can only be specified at a similar or further level of detail.

- Context classifiers that specify the circumstances of a land use system. They are not an inherent part of the purpose or operation sequence. It is basically incorrect to use context aspects as classifiers. They are included in The Land Use Database as a compromise because they are frequently used in existing classification systems.

Context classifiers can be grouped into three types:

- Origins of inputs/implements and destinations of outputs. For land use system descriptions this information can be stored in The Land Use Database. This type of classifier is used when a classification system includes "market orientation".

- Tenancy arrangements. For land use system descriptions, this parameter can be stored in The Land Use Database.

- Others, referring to for instance 'capital intensity', 'holder attitude', and 'goals of holder'. This information cannot be specified in The Land Use Database when describing land use systems.

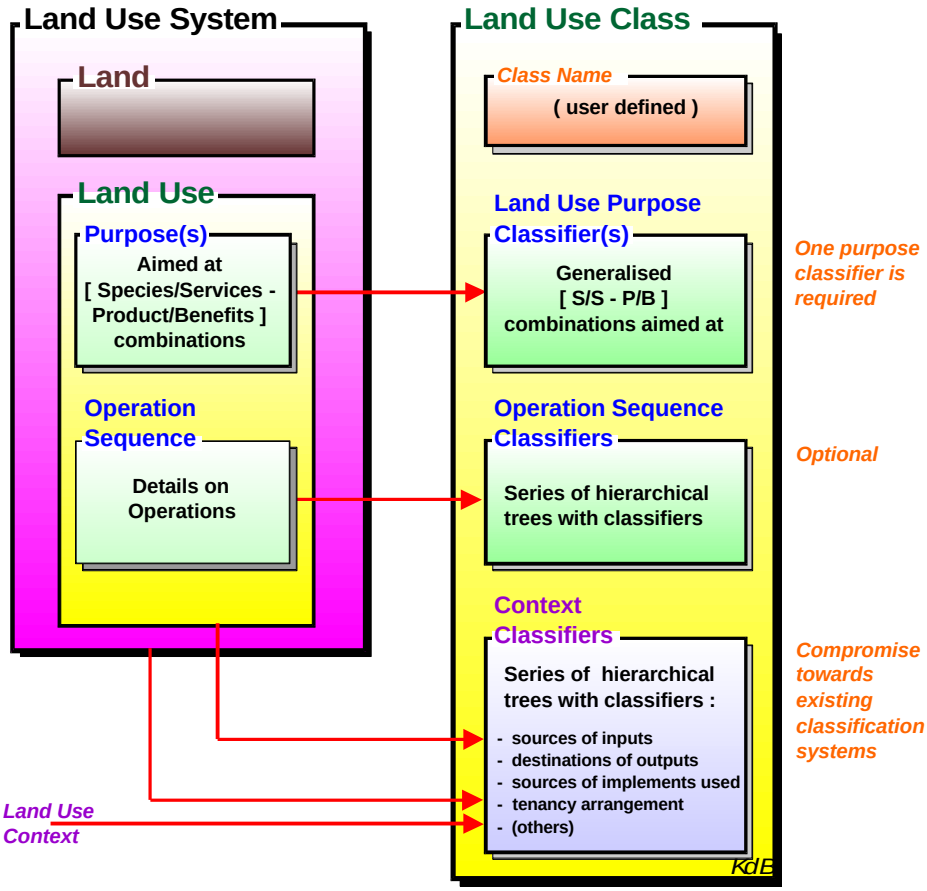

Figure 7. Classifiers of a Land Use Class and their Relationship with a Land Use System.

2.3.3 Land Use Classification Systems

Definitions of land use classes may be arranged to form a **land use classification system** (**Figure 8**) which is defined as:

> *"A structured collection of land use class definitions."*

Most land use classification systems are hierarchically structured (**Figure 8**). A classification system is based on two rules:

- At each level the defined land use classes must be mutually exclusive.
- Classes at a lower level must be a further specification of a class at a higher level.

The second feature states that lower level classes are logical sub-divisions, which implies that classifiers used at one particular level are always valid for classes at a lower level. For example, if a classifier of the highest class states that a product is 'vegetative', the product of

underlying classes must be 'vegetative' too, or a further specification of this, e.g. tubers, leaves, etc. It cannot change into an animal product or an immaterial/intangible benefit.

In The Land Use Database, the user can specify land use classification systems. The software secures the hierarchical structure requirements of land use classes.

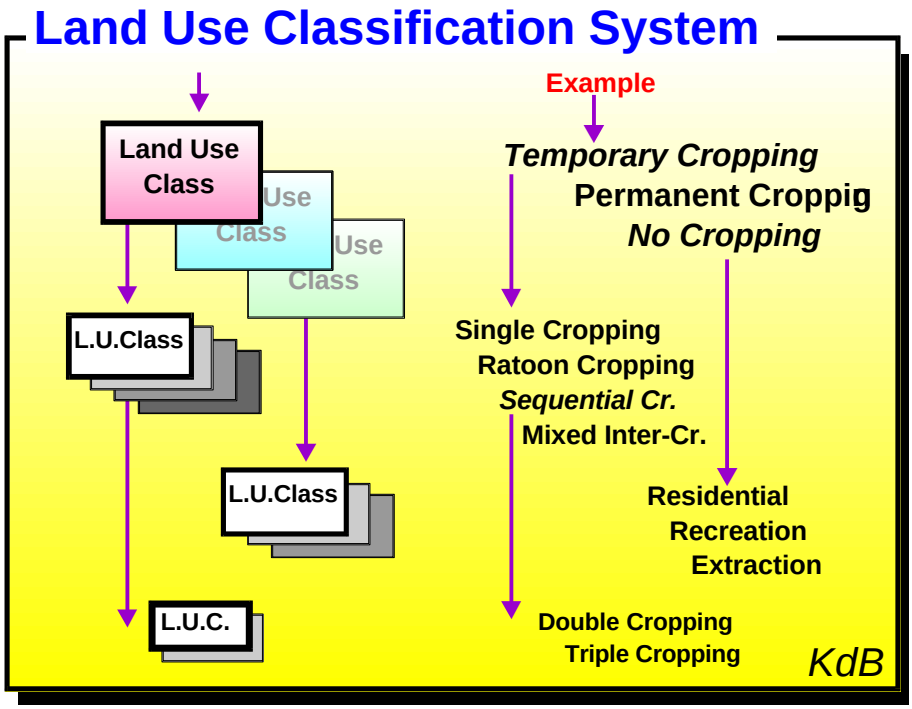

Figure 8. Example of a Land Use Classification System.

2.3.4 A-priori versus A-posteriori Classification

Land use classification can be a-priori or a-posteriori.

A-priori classification involves the preparation of land use classes before the actual collection of data. So, the classifiers are not based on collected land use information. This approach is generally used by international organisations, such as the FAO, or individual governments, to accomodate information on land use in an existing framework. The main advantage of a-priori systems is that classes are standardized. Any well-known national or international land use classification system can be adopted for any survey. An a-priori land use classification system can also be designed based on the study objectives.

An a-posteriori classification system is based on classifiers defined on the basis of an analysis of the collected data. The advantage of this method is that classifiers can be defined that meets the study objectives. If several study objectives are formulated, several a-posteriori classification systems may be prepared. A-posteriori classification is flexible and is of particular use after analysis of land use information.

In The Land Use Database, a-priori land use classification systems can be specified and stored. One a-priori land use class must be specified for each entered land use system description; it serves as a filter of possible [Species/Service - Product/Benefit] combinations for that land use system (*see Section 2.4.2*).

The name of a land use class may add information to the land use system description. For example, if the operation sequence for a field planted with sugar-cane is described for the first ratoon only, the class name can reveal that the land use is permanent cropping; this information can not be extracted from the collected operation sequence data.

In the current version of The Land Use Database, it is not possible to define a-posteriori land use classes and to perform an a-posteriori classification of stored land use descriptions. Land use data stored in The Land Use Database can be retrieved through query procedures and exported in various formats for subsequent analysis in other software.

2.3.5 One Universal Classification System or Harmonizing Classifiers?

The growing demand for global assessment of land use generated a need for a universal classification approach. Many attempts to develop a universal classification of land use have been made; the first one known to the authors was published in 1949[23], and the last in 1994[24].

It is still debated whether a universal classification is realistic since different land use studies may require different classification systems depending on their objectives and study area. For example: when remotely sensed images are used to map land use, classifiers strongly correlated with land cover will be used, and if a land use study relates to farming system analysis, classification will rather be based on the land use purpose(s), labour inputs, etc.

The study objectives will thus determine at which level a classifier is used, e.g. 'irrigated' can be a classifier at the highest level, used at any lower level, or simply not used at all.

If one universal classification system is not considered feasible, the problem remains that many different classification systems exist as a result of the use of different classifiers at different levels. Therefore, a standardization of land use classifiers is required to allow comparison of land use classes that originated from different classification systems. This will preserve the possibility to prepare user-defined classification systems and facilitate comparison of classification systems.

23. IGU, 1949. Report of the Commission to study the possibility of a "World Land Use Survey". International Geographical Union.
24. UNEP/FAO, 1994. Report on the UNEP/FAO Expert Meeting on Harmonizing Land Cover and Land Use Classifications. Geneva, 23-24 November 1993. GEMS Report Series No 25. Nairobi 1994.

2.4 Data Model

2.4.1 Relational Database

A database stores information in database files, which can be relational in structure. A **database file** is defined as:

"A structured collection of information stored in one computer file."

If information is stored at different levels, e.g. more inputs are used for one operation and more operations are carried out for one land use, then information must be structured in a relational model. A **relational database** is thus a particular type of database and is defined as:

"A collection of database files which are linked to each other by index keys."

A relational database has special advantages regarding accessibility of stored data and efficiency in data storage. In The Land Use Database the relational structure concept was used to develop the data model. Each of the files of a relational database can be seen as a table. Each table is linked to another table.

In **Figure 9** three tables of The Land Use Database are shown as an example, together with their links. Each table contains rows and columns. The file names indicate the table contents. Each column has a field name, which describes the parameter for which values are stored in the column. Each row of the table is called a record. A record contains related information. A record is subdivided into fields, each containing a single parameter value.

Records in different tables that belong to the same set of collected land use information must be linked with each other in order to reflect that they belong together. The three example tables in **Figure 9** are linked to each other through **index-keys**. The index-key that establishes the link between the first two tables is a combination of three fields, i.e. '*Administrative Area*', '*Project*', and '*Number*'. The parameter values of these three fields are combined into a single field in the second table, e.g. '*Zimbabwe FAO 1*'. In the first table, these fields must always form a unique combination.

All the records belonging to one set of collected land use information, i.e all records that are linked through index-keys, comprise one data set.

2.4.2 Data Model of The Land Use Database

The Land Use Database contains two groups of relational database files (***see also Section 1.3***). The first group is called Land Use Data and contains collected land use system information, either primary or secondary. The second is called Land Use Classes and contains information on a-priori land use classes, i.e. both class names and classifiers used to define the classes. A third database consists of a single file and is referred to as Glossary. It contains parameter values used in Land Use data and Land Use Classes. All three databases are linked to each other. The file structure of the databases and their internal and external links is presented in **Figure 10**.

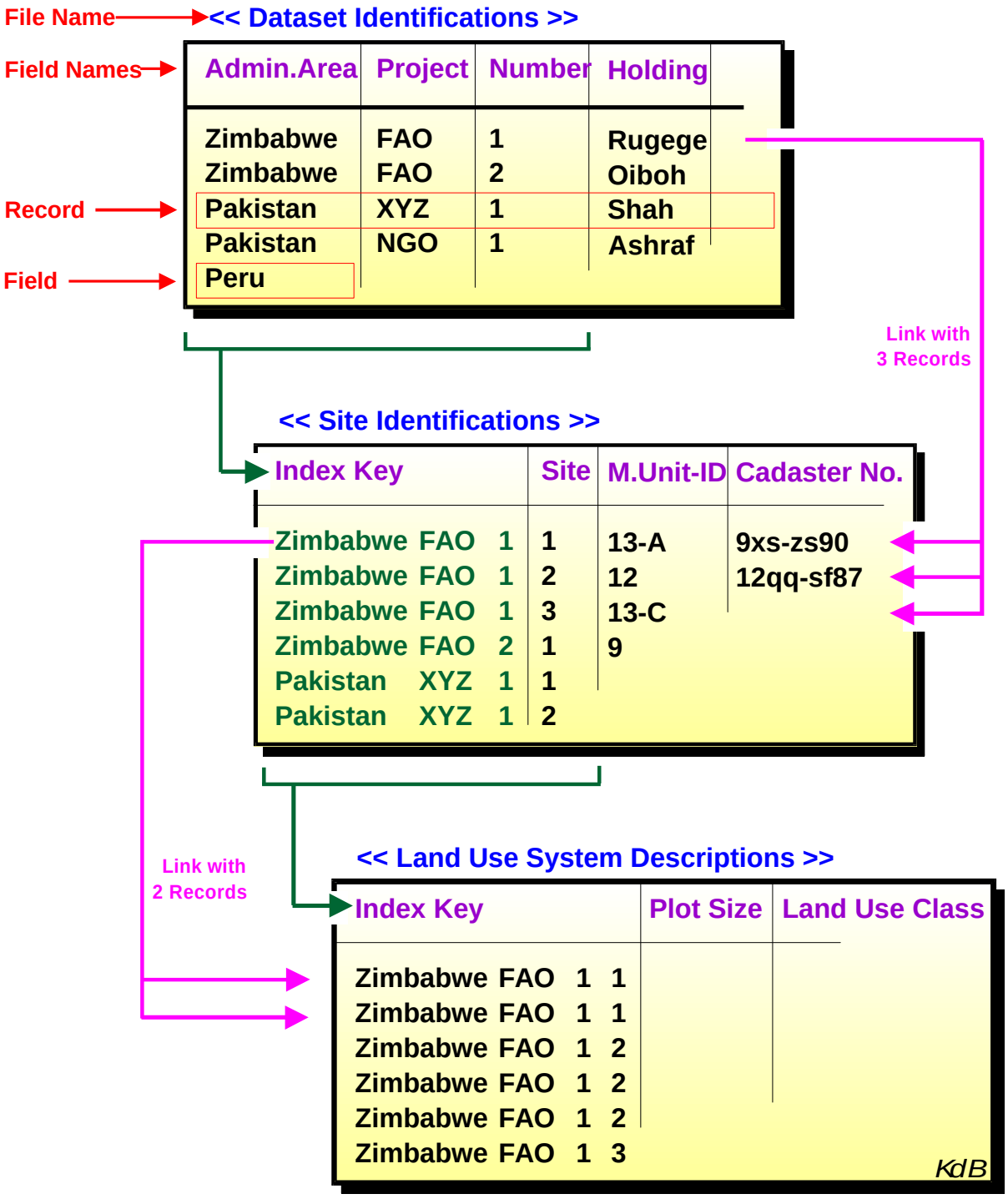

Figure 9. Example of Three Relational Database Files, showing the Links between Database Files through Index Keys:
- more sites (parcels) are defined for individual holdings, and
- more plots are defined for individual sites (parcels).

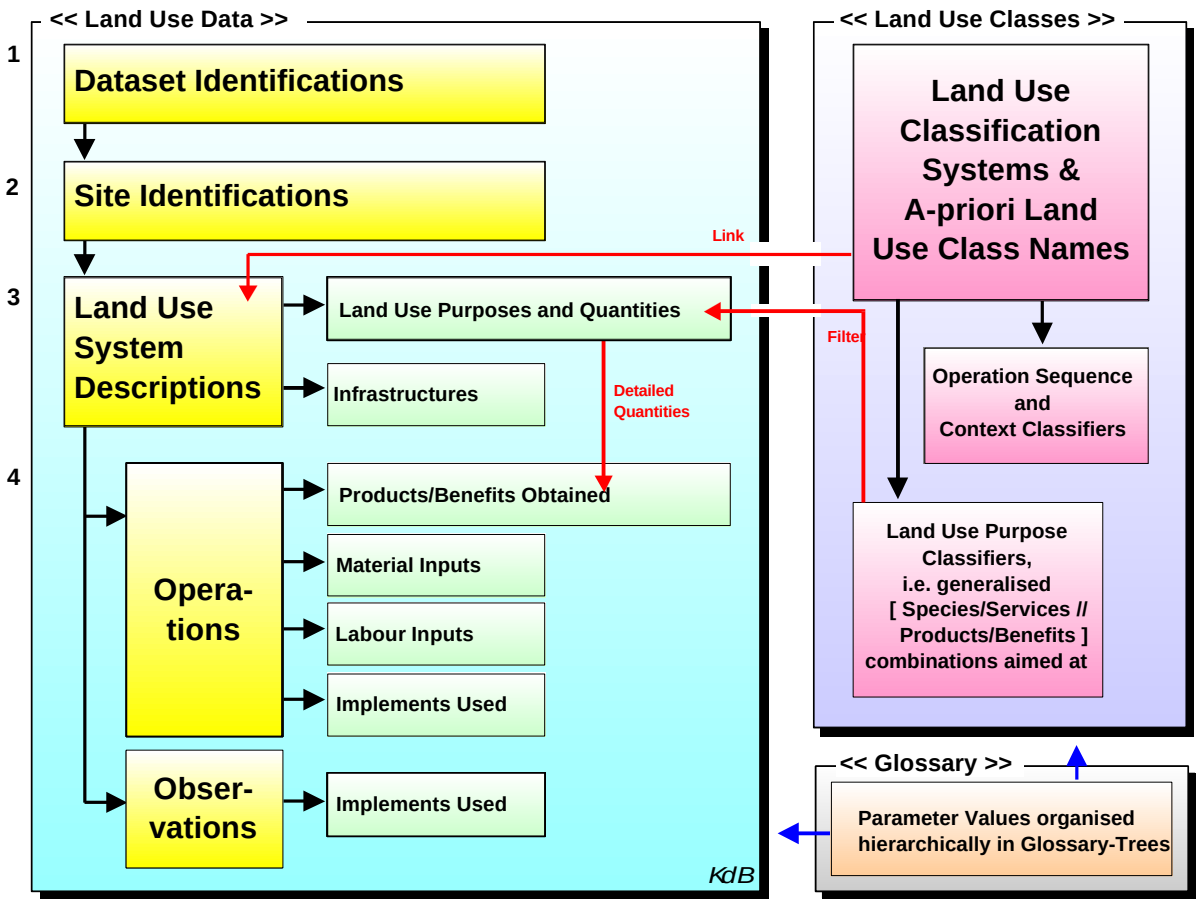

Figure 10. Data Model of The Land Use Database. Each square represents one database file, links between the Glossary File and Other Files are not depicted.

"Land Use Data" has a hierarchical structure with 4 levels:

1.	Dataset Identifications:	-	Admin. Area	(compulsory)
		-	Project Number	(compulsory)
		-	Dataset Number	(compulsory)
		-	Holder's Name	(optional)
		-	*Etc.*	*(optional)*
2.	Site Identifications:	-	Plot Aggregation	(compulsory)
		-	Map Unit	(optional)
		-	*Etc.*	*(optional)*
3.	Land Use System Descriptions:	-	Plot Coordinates	(optional)
		-	Land Use Class Name	(compulsory)
		-	*Etc.*	*(optional)*
4.	Operations and Observations:	-	*Etc.*	

The combination of fields specified at the first three levels defines the structure of a dataset plus the scale and level of generalisation of included land use system descriptions; some examples:

- Holding-X (1) has several parcels (2), with 1 to 3 land uses (3) each.
  (structure: 1:x:x; generalisation: no)

- Province-Y (1) has 5 Map Units (2), with 4 to 7 generalised land uses (3).
  (structure: 1:x:x; generalisation: yes)

- On plot-Q land use-X is practised (3); the plot is located in Map Unit-Y (2) and in Admin.Area-Z (1).
  (structure: 1:1:1; generalisation: no)

- On plot-Q land use-X is practised (3); the plot is located in Admin.Area-Z (1).
  (structure: 1:1:1; generalisation: no)

- Holding-X in Village-Y (1) practises two generalised land use types (3); plots where he carries out these land uses are aggregated (2).
  (structure: 1:1:x; generalisation: yes)

The third level, i.e. the 'Land use System Descriptions' file, is linked with Land Use Classes; see 'link' in **Figure 10**. The [Species/Service-Product/Benefit] specifications of the selected class act as a filter when defining parameters in the 'Land Use Purposes and Quantities' file; see 'filter' in **Figure 10**.

For example, when for a land use system description a class is selected with as purpose [cereals-grain], then any cereal for any type of grain as produce can be specified as land use purpose, e.g. [bread wheat cv.102 - un-milled grain]. Normally, the specification of a land use class purpose is generalised, while the land use system purpose description is specific.

The total quantity of a product obtained through a land use must be specified in the 'Land Use Purposes and Quantities' file. At level 4, this produce can be split over several operations (harvests); see: 'detailed quantities' in **Figure 10**.

For example: If the total achieved produce is 7000-7500 kg/ha of un-milled wheat grain, then it is possible to specify that in May 500 kg/ha is harversted by hand and in June 6500-7000 kg/ha is harvested by combine.

The Glossary file is linked to all other database files (not shown in detail in **Figure 10**). Accordingly, for applicable parameters, values must be selected from the Glossary file. The codes of the selected glossary items are successively stored. One glossary item can thus be used as often as required. Through this re-use of items, data consistency is achieved. The selection procedure avoids typing errors and spelling differences (e.g. 'mais', 'maize', and 'maiz').

The hierarchical organisation of glossary items offers the possibility to specify parameter values to the required level of detail (from general to more specific). Each glossary item can be well documented. Using less specific glossary items, land use systems can be described

in general terms. During querying, conditions can be built by using less or more detailed terms too.

23 Glossary trees are supplied with the software (fixed number). Each one is independent from the others; each one containes related terms, e.g. data units, administrative areas, and implements.

On the next four pages (**Figure 11**), a questionnaire form is printed which follows the concepts of The Land Use Database. All available parameters for the four levels (**Figure 10**) are shown in **Figure 11**. In **Figure 12** a form to enter specifications for an a-priori land use class is shown. In ***Chapters 5 and 6*** further details of the used data model are provided.

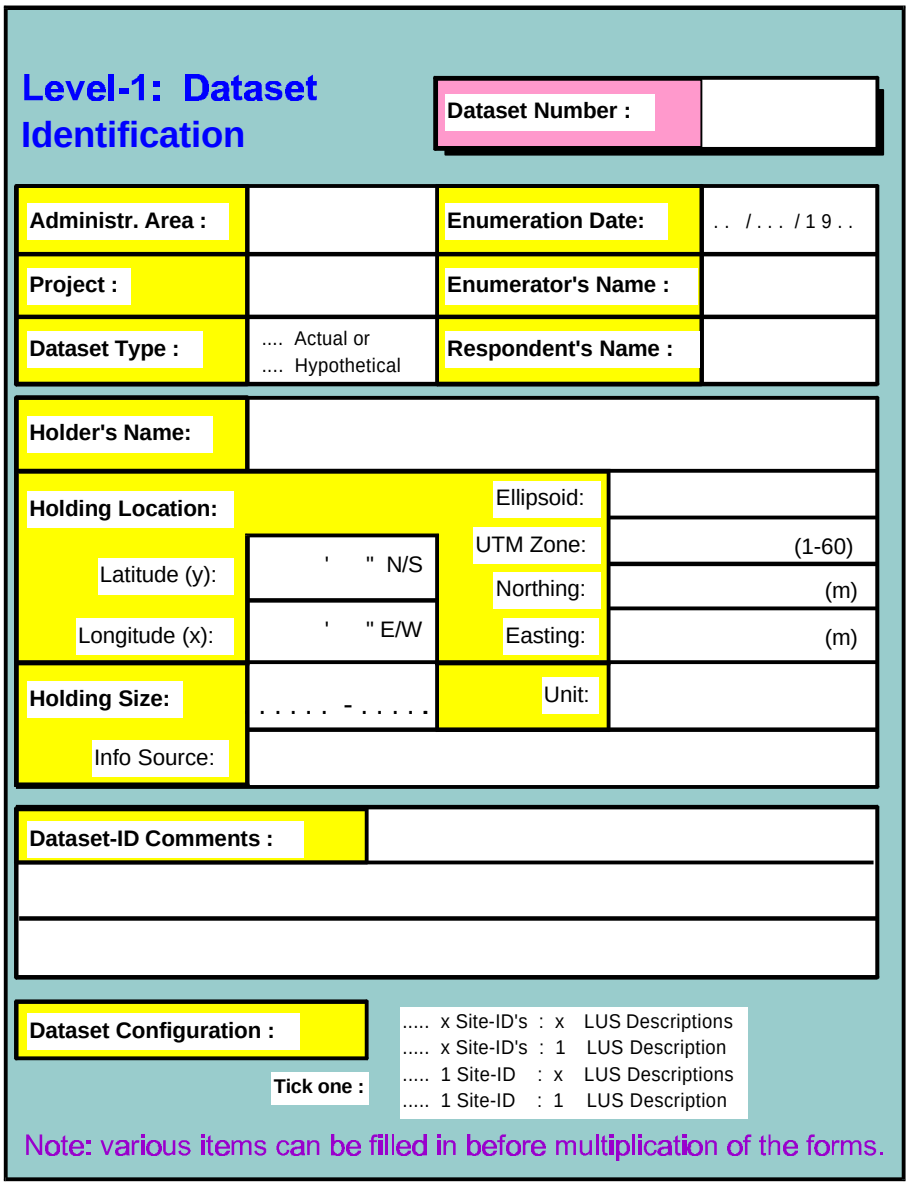

Figure 11. Sample Questionnaire Form that follows the concepts used in The Land Use Database; Level 1: Dataset Identification.

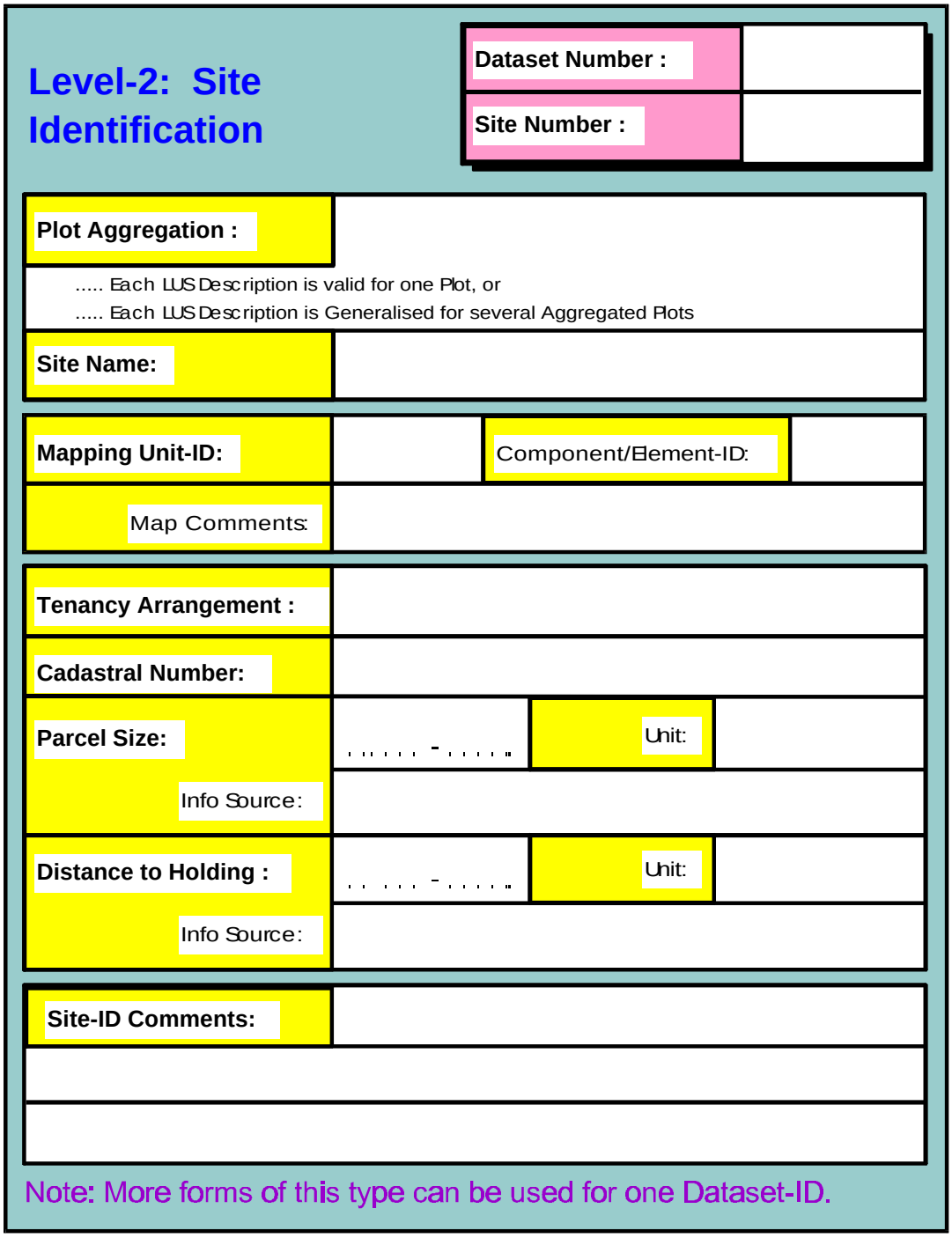

Figure 11. Continuation. Level-2: Site Identification.

Level-3: Land Use System Description

Dataset Number :	
Site Number :	
Land Use System No:	

Plot Location:		**Ellipsoid:**	
Latitude (y):	' " N/S	UTM Zone:	(1-60)
Longitude (x):	' " E/W	Northing:	(m)
		Easting:	(m)
Plot Size:		Unit:	
Info Source:			
Boundaries:	..... **Based on Actual Plot Boundaries, or** ..... **Based on Enumerator-defined Boundaries**		

Infrastuctures	**(at start of Operation Sequence) (many possible)**		
Infrastructure:			
Quantity:	. . . . . -	Unit:	
Info Source:			
Infrastructure:			
Quantity:	. . . . . -	Unit:	
Info Source:			

Soil Sample-ID:	

Land Use System Comments:	

Note: More forms of this type can be used for one Site-ID.
Note: Use additional forms if more infrastructure or Crop Data need to be specified.

Figure 11. Continuation. Level-3: Land Use System Description (part 1).

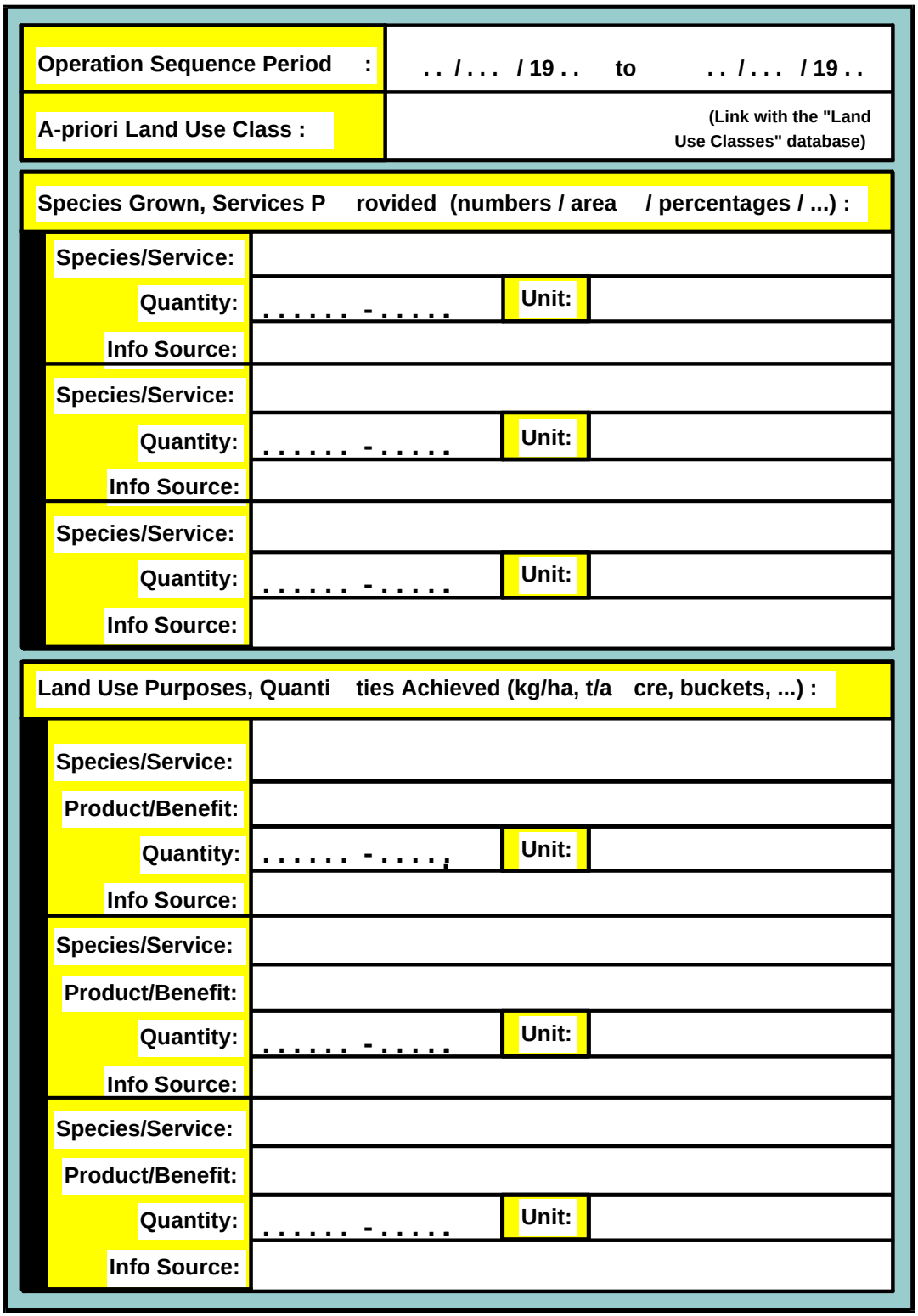

Figure 11. Continuation; Level-3: Land Use System Description (part 2).

Level-4: Operation Data

Dataset Number :	
Site Number :	
Land Use System No:	
Operation No:	

Operation Name:					
- Species Involved:	(leave blank if the operation is crop a-specific)				
%-of Plot Involved:	. . . . - . . . . %	(leave blank if the operation concerns the whole P			
Operation Period:	. . / . . . / 19 . . to . . / . . . / 19 . .				
Periodicity:	Y / N	Description:			
Operation Duration:	……-……	Unit:		Info Source:	
Task Time:	……-……	Unit:		Info Source:	

Labour Inputs:					
Gender @ Age Class:		Skill:			
No. of Persons:	. . . . . -	Info Source:			
Task Time:	. . . . . -	Unit:		Info Source:	
Labour Origin:					
Gender @ Age Class:		Skill:			
No. of Persons:	. . . . . -	Info Source:			
Task Time:	. . . . . -	Unit:		Info Source:	
Labour Origin:					

Operation Comments:	

Note: More forms of this type can be used for one LUS Description.
Note: Use additional forms if more Labour orMaterial Implements Used, or Products/Benefits need to be specified.

Figure 11. Continuation; Level-4: Operations Data (part 1).

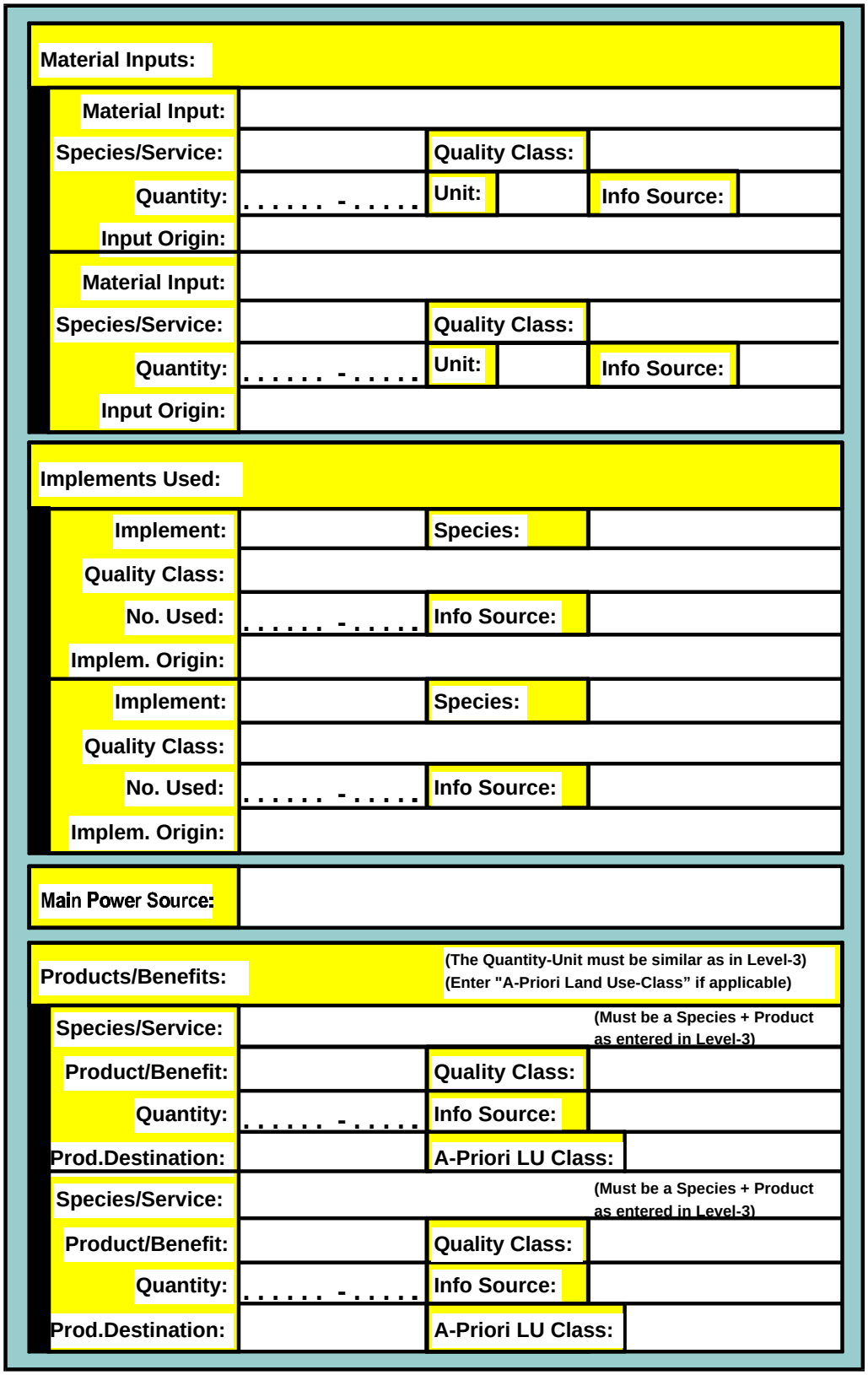

Figure 11. Continuation; Level-4 Operation Data (part 2).

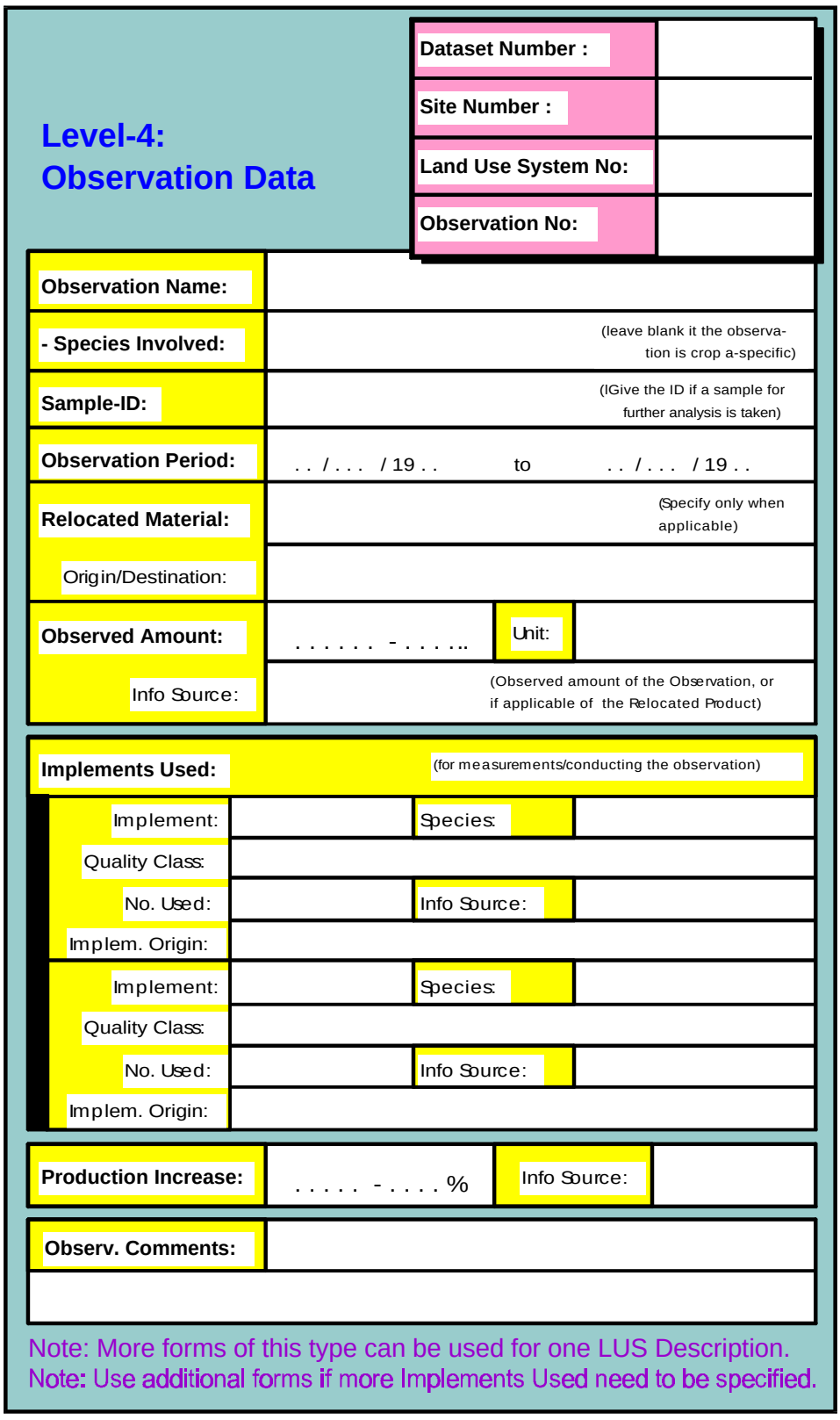

Figure 11. Continuation; Level-4 Observation Data.

A-Priori Land Use Class

Classification System :	
Code of Higher Class :	
Code of this Class :	

Land Use Class Name:	

Land Use Purpose Classifiers :

Species/Service:	e.g: crops; cereals; unspecified
Product/Benefit:	e.g.: crop produce; grain
Species/Service:	e.g: crops; cereals; unspecified
Product/Benefit:	e.g.: crop produce; fodder
Species/Service:	
Product/Benefit:	
Species/Service:	
Product/Benefit:	

Operation Sequence Classifiers:

Crop Production:	e.g.: temporary cropping;multiple; relay
Power Source for Tillage:	
Weeding:	
. . . . . :	

Context Classifiers :

Market Orientation:	
Capital Intensity:	
Tenancy Arrangement:	
. . . . .	

Note: Use additional forms if more Land Use Purpose Classifiers or Operation Sequence / Context Classifiers need to be specified.

Figure 12. Sample Form to specify Land Use Class Information.