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**Geographic information —  
Classification systems —**

**Part 2:  
Land Cover Meta Language (LCML)**

*Information géographique — Systèmes de classification —*

*Partie 2: Métalangage de couverture du sol (LCML)*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19144-2 was prepared jointly by the Food and Agriculture Organization of the United Nations (UNFAO) and Technical Committee ISO/TC 211, *Geographic information/Geomatics* under a cooperative agreement between the two organizations.

ISO 19144 consists of the following parts, under the general title *Geographic information — Classification systems*:

— Part 1: *Classification system structure*

— Part 2: *Land Cover Meta Language (LCML)*

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## Introduction

Efficient assessment of land cover and the ability to monitor change are fundamental to sustainable management of natural resources, environmental protection, food security and successful humanitarian programmes. Such information is also required to help towards raising levels of nutrition, improving agricultural productivity, enhancing the lives of rural populations and contributing to sustainable growth of the world economy. However, in the past, policy-makers and planners have not had access to reliable and comparable land cover data, not only for lower-income countries but also at the regional and global levels.

Access has been limited by two factors: Lack of mapping activities and lack of commonality between systems. The solution has been to carry out separate regional mapping projects using national or regional land cover classification systems. However, it has not been possible to compare or to exchange information between current systems.

The aim of this part of ISO 19144 is to enable the comparison of information from existing classification systems in a meaningful way without replacing them. The aim is to complement the development of future classification systems that can offer more reliable collection methods for particular national or regional purposes by allowing them to be described in a consistent manner.

A critical factor in implementing such global activities is the availability of a common, umbrella land cover classification system structure. This then provides a reliable basis for interaction without replacing the increasing number of national, regional and global land cover mapping and monitoring activities. This enables comparisons of land cover classes to be made regardless of mapping scale, land cover type, data collection method or geographic location.

Another critical factor is the availability of a common reference for land cover classification systems. This part of ISO 19144 provides a metalanguage expressed as a UML model that allows different land cover classification systems to be described.

This part of ISO 19144 establishes a metalanguage for a set of objects and rules (language) to describe land cover features based on physiognomy that can be part of different land cover legends (nomenclature). This provides a framework for comparing different systems and nomenclatures such as Corine, Africover, Anderson (USGS), Global Map and national systems without replacing them. This is not a description of a nomenclature nor is it a description of a specific set of classes.

# Geographic information — Classification systems —

## Part 2: Land Cover Meta Language (LCML)

### 1 Scope

This part of ISO 19144 specifies a Land Cover Meta Language (LCML) expressed as a UML metamodel that allows different land cover classification systems to be described based on the physiognomic aspects. This part of ISO 19144 also specifies the detailed structure of a register for the extension of LCML but does not specify the maintenance of the register. This part of ISO 19144 recognizes that there exist a number of land cover classification systems. It provides a common reference structure for the comparison and integration of data for any generic land cover classification system, but does not intend to replace those classification systems.

### 2 Conformance

#### 2.1 Classes

Three conformance classes are identified in this part of ISO 19144.

#### 2.2 Conformance of a land cover classification system

A land cover classification system, as defined in accordance with the LCML defined in this part of ISO 19144, shall satisfy the conditions specified in the following abstract test suite:

- a) ISO 19144-1 (Annex A) for general conformance of the classification system;
- b) A.2.

#### 2.3 Conformance of a register for the extension of the metalanguage

The register defined in this part of ISO 19144 shall satisfy all of the conditions specified in the following abstract test suites:

- a) ISO 19135 for the general register structure;
- b) A.3.1 for the minimum register content;
- c) A.3.2 for uniqueness of registered metaclass names;
- d) A.3.3 for backward compatibility.

#### 2.4 Conformance of a comparison process of land cover classification systems

The process of comparison of two land cover classification systems shall be done by developing descriptions of the two land cover classification systems, each in accordance with the abstract test suite in A.2, and then identifying the differences in accordance with the abstract test suite in A.4.

### 3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19109:2005, *Geographic information — Rules for application schema*

ISO/TS 19103:2005, *Geographic information — Conceptual schema language*

ISO 19144-1:2009 *Geographic information — Classification systems — Part 1: Classification system structure*

ISO 19135:2005, *Geographic information — Procedures for item registration*

## 4 Terms, definitions, and abbreviations

### 4.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE The technical terms applying to plant physiognomy, and terms from other disciplines used to establish the classifiers in the classification scheme are not defined in this part of ISO 19144.

#### 4.1.1

##### **abstract test suite**

abstract test module specifying all the requirements to be satisfied for conformance

[ISO 19105:2000, 3.4]

#### 4.1.2

##### **classification**

abstract representation of real world phenomena using **classifiers** (4.1.4)

[ISO 19144-1:2009, 4.1.4]

#### 4.1.3

##### **classification system**

system for assigning objects to classes

[ISO 19144-1:2009, 4.1.5]

#### 4.1.4

##### **classifier**

definition used to assign objects to **legend classes** (4.1.11)

[ISO 19144-1:2009, 4.1.6]

NOTE Classifiers can be algorithmically defined, or defined according to a set of **classification system** (4.1.3) specific rules.

#### 4.1.5

##### **feature**

abstraction of real world phenomena

[ISO 19101:2002, 4.11]

EXAMPLE The phenomenon named “Eiffel Tower” can be classified with other similar phenomena into a feature type named “tower”.

#### 4.1.6

##### **item class**

set of items with common properties

[ISO 19135:2005, 4.1.6]

NOTE Class is used in this context to refer to a set of instances, not the concept abstracted from that set of instances.



**4.1.7****land cover**

observed (bio)physical cover on the Earth's surface

[UNFAO LCCS 2:2005]

NOTE Land cover is distinct from **land use** (4.1.9).

**4.1.8****land cover metalanguage**

logical general model used to describe **land cover** (4.1.7) **features** (4.1.5) from which more specific rules can be described to create a particular **classification system** (4.1.3)

**4.1.9****land use**

arrangements, activities and inputs people undertake in a certain **land cover** (4.1.7) type to maintain it or produce change

[UNFAO LCCS 2:2005]

NOTE The definition of land use in this way establishes a direct link between land cover and the actions of people in their environment. Multiple land uses can coexist at the same location (e.g. forestry and recreation), contrary to land cover classes that are mutually exclusive.

EXAMPLE "Recreation area" is a land use term that can be applicable to different land cover types, e.g. sandy surfaces such as a beach; a built-up area such as a pleasure park; woodlands etc.

**4.1.10****legend**

application of a **classification** (4.1.2) in a specific area using a defined mapping scale and specific data set

[UNFAO LCCS 2:2005]

**4.1.11****legend class**

class resultant from the application of a **classification** (4.1.2) process

[ISO 19144-1:2009, 4.1.16]

NOTE In order to avoid confusion with respect to the term "class", the result of a classification process will be termed a "legend class". This use of the term "class" is distinct from the term "class" as used in UML modelling.

**4.1.12****physiognomy**

general appearance of an object or terrain, without reference to its underlying or scientific characteristics

**4.1.13****register**

set of files containing identifiers assigned to items with descriptions of the associated items

[ISO 19135:2005, 4.1.9]

**4.1.14****registry**

information system on which a **register** (4.1.13) is maintained

[ISO 19135:2005, 4.1.13]

**4.2 Abbreviations**

CEC Commission of the European Communities

CORINE	Coordination of Information on the Environment, EU
LCCS	Land Cover Classification System
LCML	Land Cover Meta Language
LC	Prefix used to identify classes in the Land Cover Meta Language
TDS	Total Dissolved Solids
UML	Unified Modelling Language
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFAO	United Nations Food and Agriculture Organization
UNFAO LCCS	UNFAO Land Cover Classification System

## 5 Notation

The conceptual schema specified in this part of ISO 19144 is described using the Unified Modelling Language (UML), following the guidance of ISO/TS 19103.

Several model elements used in this schema are defined in other ISO geographic information standards. By convention within ISO/TC 211, names of UML classes, with the exception of basic data type classes, include a two letter prefix that identifies the standard and the UML package in which the class is defined. UML classes defined in this part of ISO 19144 have the two letter prefix of LC. Examples in this part of ISO 19144 have the two letter prefix EL. The classes in the meta model in Annex B use the prefix LM. Table 1 lists the other standards and packages in which UML classes used in this part of ISO 19144 have been defined.

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**Table 1 — Sources of externally defined UML classes**

Prefix	Standard	Package
CL	19144-1	Classification System Structure
RE	19135	Procedures for registration

In accordance with the ISO/IEC Directives, Part 2, the decimal sign used in the body of the text in this part of ISO 19144 is a comma. However, in the UML models in figures, and in strings of Object Constraint Language text taken from the model as quoted in curly brackets " {} ", the decimal sign used is a period.

## 6 Context

The purpose of this part of ISO 19144 is to define a common reference structure for the comparison and integration of data for any generic land cover classification system. The approach has been to define a Land Cover Meta Language (LCML) expressed as a UML model that allows different land cover classification systems to be described. This approach provides a rigorous logical framework for the description of any land cover classification system. This will improve the harmonization and integration of spatial data sets defined using different land cover classifications and the legends or nomenclatures developed from these systems and allow them to be compared and integrated.

This part of ISO 19144 defines a LCML for a land cover classification system<sup>1)</sup>. It recognizes that there exist a number of land cover classification systems and nomenclatures in a number of countries and regions, and that these systems are well established and cannot be easily changed. In fact, portions of these systems are

1) The LCML is derived from the concepts in the land cover classification system (UNFAO LCCS version 3) established by the Food and Agricultural Organization (FAO) of the United Nations [34], [35]. The UNFAO LCCS classification system is one particular classification system for land cover based on plant physiognomy and does not exclude other classification systems being established for land cover for other purposes.

set in law in some nations with respect to land use legislation. For example, the definition of wetland is of great importance in some nations because there is environmental legislation in many nations to protect wetlands. Yet the definition of wetland varies between jurisdictions, and there is a need to be able to compare this and other types of land cover object. A wide acceptance of an approach to handling the description of land cover depends upon its flexibility to accommodate nomenclatures derived from different systems.

The approach taken in this part of ISO 19144 is to avoid specific limitations such as fixed value ranges for attributes and the use of specific definitions for classifiers to increase the acceptability to the international community. The LCML defined in this part of ISO 19144 avoids complex definitions, prefixed ranges of values and specific detailed classification rules. It acts as a method to bring the land cover community together to create a common understanding of land cover nomenclatures with the aim to produce global regional and national data sets able to be reconciled at different scales and detail level and geographic places.

One example of a land cover classification system is the UNFAO Land Cover Classification System.<sup>[34]</sup> The purpose of the UNFAO LCCS, which is standardized by the UNFAO, is to give to the international community one possible system to classify land cover with a parametric approach that is compliant with the metamodel defined in this part of ISO 19144. Other land cover classification systems can also be defined by other regional or national bodies. The UNFAO LCCS is described as a set of classifiers and rules expressed in terms of the LCML. Any other national or multi-national land cover classification system can also be described in terms of the LCML. Examples of different national or regional classification systems are given in C.10 to C.15.

The LCML complies with the general structure for classification systems defined in ISO 19144-1 in that a land cover classification system described in the LCML can be created so as to comply with ISO 19144-1. The structure used to represent the classified data can be that of a discrete coverage as described in ISO 19123. The classifiers described in accordance with the LCML can be maintained in a register, compliant with ISO 19135 and with ISO 19144-1; that is, the classes described using the metalanguage defined in this part of ISO 19144 can populate a register for classifiers as described in ISO 19144-1. Registration within this part of ISO 19144 is used in a very different way. It is used to allow for extension of the LCML.

The LCML provides a general framework of rules from which more exclusive conditions can be derived to create specific classification systems. It is a language based on physiognomy and stratification of both biotic and abiotic materials. The system can be used to specify any land cover feature anywhere in the world, using a set of independent diagnostic criteria that allow correlation with existing classifications and legends.

Land cover metalanguage descriptor objects are defined by a combination of a set of land cover metalanguage-elements. These land cover metalanguage-elements are divided in two categories: “basic metalanguage-elements”, the elements that constitute the main physiognomic aspects of biotic and abiotic cover features, e.g. for biotic features trees, shrubs, herbaceous vegetation, and “metalanguage-element properties” that further define the physiognomic/structural aspect of the basic objects.

Further definition of the land cover classes can be achieved by adding the metalanguage-element characteristics. The characteristics are of two types: land cover element characteristics and land cover class characteristics. “LC\_ClassCharacteristics” and “LC\_ElementCharacteristics” are defined as optional descriptive elements not directly related to the physiognomic/structural characterization of the land cover metalanguage-element. “LC\_ElementCharacteristics” can be applied to a single basic metalanguage-element. “LC\_ClassCharacteristics” relate to a whole land cover class, defined as the combination of single or multiple strata of single or multiple basic meta-elements. The definition of these characteristics in this part of ISO 19144 is informative, not normative, i.e. other sets of characteristics can be established and used with the LCML basic elements. These characteristics do not in any way prescribe how a land cover classification system is to be established. When used they can assist in better defining a land cover class and therefore make it easier to compare classes between land cover classification systems.

The metalanguage generates mutually exclusive land cover classes, with specific rules to deal with the all functional elements of the language (basic metalanguage-elements and properties) and the different strata.

All land covers can be accommodated in this highly flexible approach. The metalanguage can be used to describe different land cover classification systems in terms of the same basic metalanguage-elements, thus contributing towards data harmonization and standardization. Data defined using different nomenclatures can be used together with or fused with other data described according to a classification scheme which is also expressed in the metalanguage. By standardizing the principles and structure of a metalanguage, it is possible

to interwork with other application areas or other nomenclatures within an application area. This is similar to interworking between other geographic information systems that comply to the same feature cataloguing methodology but use different feature catalogues, although in this case the concept of features are constrained to that of a classification system that partitions the attribute space (range) of a discrete coverage. Different nomenclatures, which are legends of classes defined in accordance with the LCML system, can be used within multiple product specifications. Nomenclatures defined in accordance with the LCML are in compliance with the general feature model defined in ISO 19109. This point is covered in more detail in Annex B.

## 7 Conceptual basis

### 7.1 Definition adopted for land cover

The common integrated approach adopted in this part of ISO 19144 defines land cover as the observed (bio) physical cover on the earth's surface. Land cover is considered to be a geographically explicit feature that other disciplines may use as a geographical reference (e.g. for land use, climatic or ecological studies).

### 7.2 LCML approach to class definition

#### 7.2.1 LCML basic principle

A given land cover class in a land cover classification system is described by a land cover metalanguage object that has been formed by the combination of a set of independent land cover metalanguage-elements. The unique combination of the metalanguage-elements describes the land cover class. Two land cover classes (from different land cover classification systems) can be compared by looking at the list of metalanguage-elements that are combined to describe each class.

#### 7.2.2 Land cover classification system design criteria

Land cover classes shall be defined by a set of land cover metalanguage-elements as represented by the class LC\_Element and its subtypes. Further definition of the land cover classes may be achieved by adding land cover metalanguage characteristics. "LC\_ClassCharacteristic" and "LC\_ElementCharacteristic" are defined as descriptive elements not directly related to the physiognomic/structural characterization of the land cover object.

Due to the heterogeneity of land cover metalanguage objects, certain design criteria have been applied.

All vegetated classes are derived from a consistent physiognomic structural conceptual approach that combines the basic metalanguage-elements for growth form with their physiognomic properties Cover and Height and arrange them in strata. At any level specific characteristics can be added.

The non-vegetated metaclasses have a specular approach.

The basic elements of each of the two class groups constitute the main physiognomic aspects of biotic and abiotic cover features. For instance, for biotic classes, trees, shrubs, herbaceous vegetation etc., the "properties" that further define the physiognomic/structural aspect of the basic objects are mainly the horizontal and vertical arrangement of the basic metalanguage-element cover and height. All these elements (or part of them) can be arranged in one or more layers or strata.

Further definition of the land cover classes may be achieved by adding land cover characteristics. Land cover characteristics are defined as descriptive elements not directly related to the physiognomic/structural characterization of the class. Land cover element characteristics relate to the basic metalanguage-element itself. Land cover class characteristics relate to the whole final Land Cover metaclass, defined as the combination of single or multiple strata of single or multiple basic meta-elements.

This results in a land cover class defined by specific rules that govern the place and the functional position of all elements of the language as basic metalanguage-elements and their properties, (land cover characteristics) and the different strata composition.

### 7.2.3 General rules for classification

The factors governing the concepts of classification of Vegetated and Non-Vegetated metaclass groups are:

- the definition of “**appearance**” or physiognomic aspect of the basic meta-elements LC\_Vegetation and LC\_AbioticSurface
- the definition of the **layering** or **strata** of vegetated and/or abiotic metaelements.

The two main aspects are described in 7.2.4 to 7.2.6.

### 7.2.4 Land cover metalanguage-elements

The description of each of the land cover metalanguage-elements, the subtypes of LC\_Element, is given in the glossary of land cover elements in Annex D. This description is informative in that it provides meaning to the subtypes of LC\_Element, but it does not in any way provide definitions for classes in a particular land cover classification system. The relationship between each of the land cover metalanguage-elements is given in the UML model in Clause 8. These are arranged by physiognomic aspect. The model also shows how the land cover elements may be combined to form strata and how these may be combined to form land cover metaclasses.

### 7.2.5 Layering

Several vegetated or non-vegetated basic metalanguage-elements may be combined to form a layer or stratum and these strata may be combined to form a metalanguage descriptor object. There is no limit to the number of strata and to the number of metalanguage-elements (vegetated and/or abiotic) forming the strata. One or more layers can be further characterized by their temporal or vertical relationship.

### 7.2.6 Packages

The UML model of each of the land cover metalanguage-elements is given in Clause 8. The metalanguage objects are organized into several packages. The package LC\_LandCoverClassStructure describes the high level structure of the model. The packages LC\_Vegetation and LC\_Abiotic define the basic LC\_Element metalanguage objects for vegetation and non-vegetation (abiotic) surfaces. The optional characteristics at the class level and at the element level given in LC\_ClassCharacteristics and LC\_ElementCharacteristics further refine the metalanguage objects. The metalanguage value types given in LC\_ValueTypes define the allowable basic numerical types with constraints. The LC\_Registers package includes the definition of the registers which may be used to extend the LCML. This is represented in Figure 1.

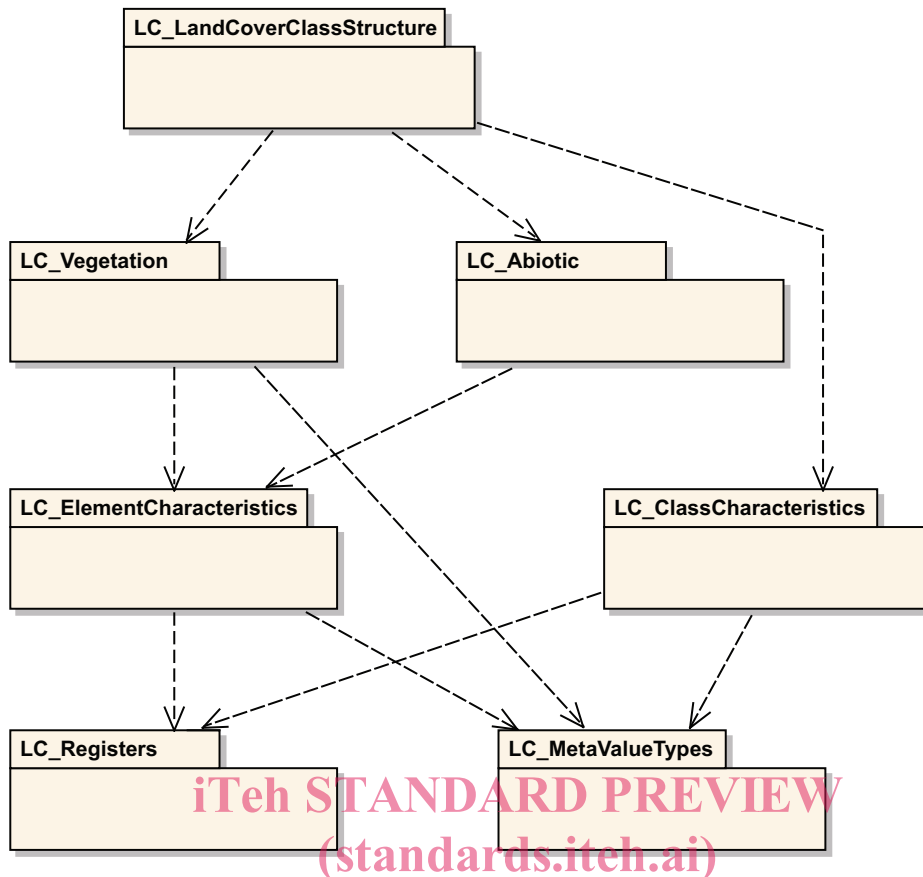


Figure 1 — LCML packages

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## 8 LCML objects

### 8.1 Introduction to LCML objects

The LCML is a metalanguage which may be used to describe a wide variety of land cover classification systems. The LCML operates by describing each class in a land cover classification system in terms of a set of basic elements that when combined describe each aspect of the land cover classification system class. That is, each class in a land cover classification system may be modelled using the basic element objects defined in the LCML. These elements are all subtypes of the object LC\_Element, so any particular land cover classification system class can be described as a combination of a set of LC\_Element subtype A+B+Q+Y etc. Two different land cover classification system classes (from different land cover classification systems) can be compared by examining the LC\_Element subtypes of which it is composed. If one class from one system is composed of, for example LC\_Element subtype A+B+Q+Y and another of LC\_Element subtype A+B+Y then one can determine that the difference is the “Q” element. Being able to compare land cover classification systems in this detailed manner is important for establishing mappings so that data sets can be generated by the fusion of data from different sources.

The LCML described in this part of ISO 19144 is one of many possible metalanguages. Any set of basic elements that fully describe a topic area could be chosen as the basic vocabulary to establish a metalanguage. It is possible to establish other metalanguages based on different criteria. However, in order to do a comparison and to integrate data from different land cover systems it is necessary to standardize one metalanguage. This avoids the need to standardize classification systems.

### 8.2 Relation to ISO 19144-1 Classification system structure

The LCML metalanguage is used to describe a land cover classification system which is itself a UML model of classes that is then used to generate a legend (or nomenclature).

A classification system consists of a set of Land Cover Classes<sup>2)</sup> that are established to exhaustively represent a particular aspect of the reality. The totality or a subset of these classes may be selected to describe a particular geographic area establishing a legend or nomenclature. A land cover classification system is general in that its classification scheme classes do not address a specific geographic area or collection scale, whereas a legend or nomenclature is established specifically for a geographic area. The relationship between a classification system and legend is described in ISO 19144-1. There are two separate semantic levels of abstraction involved. A legend (or nomenclature) is concrete in that it defines legend classes, instances of which can exist within a particular geographic area. A classification system is a semantic level of abstraction above a legend that characterizes the functional relationship of a set (finite or infinite) of possible classes and defines their descriptive criteria. The LCML metalanguage is another semantic level of abstraction higher. The metalanguage provides the structure so that a classification system may be described.

The initial (root) class of the LCML is the LC\_LandCoverClassificationSystemMetaLanguage object. This object is composed of all the land cover elements used to describe the classes that make up a classification system as given by LC\_LandCoverClassificationSystem. LC\_LandCoverClassificationSystemMetaLanguage object is an aggregation of the land cover descriptor objects LC\_LandCoverDescriptor. The LC\_LandCoverDescriptor object describes the LC\_LandCoverClass, which is a subtype of CL\_LegendClass as defined in ISO 19144-1. The LC\_LandCoverDescriptor object is the link to the more general classification system structure in ISO 19144-1. An application schema for a land cover classification system described in conformance with this part of ISO 19144 and established in conformance with ISO 19109 shall include the classification system structures defined in ISO 19144-1.

### 8.3 Composition of a LC\_LandCover object

The LC\_LandCover objects are composed of classification system elements LC\_Element. These elements may be organized into strata (or layers) through the LC\_Stratum object. Specific rules apply to the composition of a stratum and the relationship of elements in different stratum. The LC\_Elements in a stratum may also be organized so as to describe a horizontal pattern through the class LC\_HorizontalPattern.

The LC\_Element metalanguage object is an abstract UML class that is a generalization of a large number of subtypes. These subtypes form the basic elements of the LCML metalanguage model. A classification system, described in terms of the metalanguage, consists of land cover classes formed as instantiations of the LCML metalanguage model subelements in various combinations.

The structure of the LCML is represented in UML. The definitions of each of the land cover basic element classes, the subtypes of LC\_Element, are contained in an associated glossary. The glossary is informative in that it is used as a guide for matching classes in a land cover classification system with a set of descriptive elements from the metalanguage, but it does not dictate the definitions of the classes in any land cover classification system. The definitions and their inheritance and other relationships are also contained in a register. This makes the LCML extensible since additional basic elements may be defined as required. Registration is described in Clause 9.

2) The term *class* has several meanings in this part of ISO 19144. The UML modelling language uses the term *class* as a construct in an object oriented programming or data modelling paradigm, as the template for an object. That is, a UML *class* describes the properties associated with the instances of the *class* called objects. The term *class* is also used in this part of ISO 19144 to represent a construct in a classification scheme. A classification scheme consists of a set of classes subdividing the concepts within a given topic area. There is an unavoidable conflict with the terminology when a modelling language such as UML is used to describe a classification scheme metalanguage such as the LCML. The term *class* is used in normal practice in both modelling and classification and it is unreasonable for either modelling or classification to avoid the term. Adjectives have been used in this document where possible to reduce this confusion, for example UML classes can be called "UML classes" and classification scheme classes can be called "classification classes" or "legend classes". At times a UML class describes a classification class and it is possible to dispense with the adjective since both meanings of *class* are equivalent in the context. The conflict results from the fact that there is a deep relationship between data modelling and classification as used in other domains. There is a similar related potential conflict with the associated terms of attribute and object. Adjectives have been used where possible, but at times it is necessary to derive the meaning from the context.