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Overview of relevant standards for the BonaRes-Program

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Title Overview of relevant standards for the BonaRes-Program

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Abstract Major task of the BonaRes Data Centre is to create a user-friendly data repository to upload, manage and provide soil and soil-related research data in standardized and citable formats for continued use. To meet these requirements, the application of standards for the different stages of research data life is necessary. Such standards concern e.g. the classification and description of soils, field and lab methods, agricultural technology, plant varieties, fertilizers, farming and agricultural business data, data quality control, transfer to data bases, data storage and archiving, and, not least,

the provision of data via geo-data services and a web portal.

This document presents lists and discusses a variety of data standards, regulations, schemas, exchange languages, data journals, thesauri, web services and more for the data life from acquisition to provision. It aims to inform owner, provider and users of soil and agricultural data and to facilitate data integration and data use within the BonaRes data repository.

Keywords BonaRes, standards, research data, data management, data provision, data interoperability, soil science, agricultural science, agronomy

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Contents

0 Introduction

In the scope of the German research initiative BonaRes (*Soil as a sustainable resource for the bioeconomy*) the BonaRes Data Centre developed a repository for soil and soil-related research data and accompanying metadata. Beside data from research projects, the repository is open for other soil-related data, e.g. from national long-term field experiments (LTFE). The BonaRes Data Centre provides DOI, easy access and long-term availability for all uploaded research data. According to the Berlin Declaration on Open Access (2003) and the Initiative "Digitale Information" (Alliance of Science Organizations in Germany, 2013) metadata and research data will not be subject to any restrictions on re-use. Metadata are always available and, after a limited embargo-time, also research data will be provided open for the international research community. Further information is given in the BonaRes Data Guideline (Svoboda and Heinrich, 2017).

The BonaRes Data Centre promotes the availability of soil and soil-related research data and generates the incentives for data-holders to join this endeavor. It sets-up the required infrastructure for providing soil research data in standardized form for users from scientific, regulatory and farming communities.

In order to create a user-friendly data repository, e.g. to provide citable formats for continued use, the use of standards for the different stages of the *data life* are necessary. Such standards concern e.g. the classification and description of soils, field- and lab methods, agricultural technology, plant varieties, fertilizers, farming and agricultural business, data quality control, the transfer to data base, data storage and archiving, and, not least, the provision of data for re-use and publishing.

Since the adaptation of soil properties in response to changing boundary conditions is typically slow, especially LTFE-data are highly attractive for soil science. The BonaRes Data Centre identifies and compiles (decentralized stored) soil and agricultural research data from LTFE in Germany. The recent situation and the aspired goal of LTFE data (Table 1) demonstrate the relevance of data harmonization and standardization within the data repository.

Table 1: Situation of LTFE data in Germany

	Recent situation…	Goal…
Data localization	mostly decentralized	within one data base
Data formats	heterogeneous	standardized
Metadata	sporadic	complete
Data acquisition, used methods	low comparability	high comparability
Data visibility & accessibility	low	high
Data citeability	difficult, diverse	easy, possible by DOI
Data archiving system	unsafe	safe
Data re-use	difficult	easy
Responsibility	local, federal, sparse	central

In 2017 the BonaRes Data Centre begun to collect data from national soil and agricultural research projects, such as collaborative BonaRes projects on soil and agricultural researches. The infrastructure accompanies the entire process of data-life cycle, i.e. primary data generation, storage, provision, publication, and long-term archiving. Research data which were collected under standardized conditions, stored with quality tests, and described with coherent metadata, will be visible and open for any data re-use (e.g. modelling), exchange and review.

The integration of research data of different formats and from various sources is challenging. Providing research data for re-use is associated with additional costs and effort for scientists. A prerequisite for the correct re-use of research data is their good description by standardized metadata. The provision of research data is far from being self-evident. Currently, few possibilities exist to provide data from soil and agricultural research for re-use. Research data management imposes a wide range of technical and organizational requirements. Therefore, the development of a research data repository and their integration into international networks need close cooperation between researchers and data scientists.

In the long term it is planned to consolidate the BonaRes repository into international infrastructures for soil data. This requires data interoperability by internationally accepted and applied standards. Transformation tools may help to translate data from national to international valid systems and formats.

To this document

Tasks of this overview document is to describe, to compare, to review and to recommend standards for measurement, quality control, management and provision of data and assists users in integrating their data into the BonaRes framework. Missing and competitive national and international standards and potential conflicts are stated and outstanding standards for the BonaRes Data Centre are highlighted and summarized to recommendations.

This document is grouped based on the major data life stages:

1. Data acquisition
2. Data management
3. Data provision

In the appendix code lists, glossaries and web links are listed.

1 Data Acquisition

The acquisition of soil-, crop-, agricultural machinery-, farming- and business data are regulated by numerous, sometimes inconsistent, standards, laws, guidelines and conventions. Many regulations are used only in national contexts and need to be transformed to harmonize with international standards or standards from other countries.

In this chapter, standards from field and lab work (e.g. soil mapping, -classification, -quality, and meteorology), agriculture (e.g., crops, tillage tools, field management, and fertilization), business, and personal data (e.g. farm size, attitudes of farmers, income, and property rights) are collected.

1.1 Field Description and Soil Classification

1.1.1 Overview of existing standards

German Soil Survey Guidelines ("*Bodenkundliche Kartieranleitung*"), 5th edition, Ad-hoc-AG Boden (2005, KA5), short: KA5

The first edition (1965) was a nation-wide accepted guideline in administration and research. Still in use in some federal states are also the editions of 1994 (KA4) and 1982 (KA3). The administrative soil surveys of the federal states (*Bundesländer*) often use adaptations and modifications of this guideline. A shortened and simplified version of the German Soil Survey Guidelines has been extracted from KA5 for soil conservation purposes (*Arbeitshilfe Boden*; short: AHB); the Federal Soil Protection and Contaminated Sites Ordinance in Germany refers nonetheless to KA4.

The major part is about describing site, soil profile, layers and horizons, naming horizons and soil's allocation in the German soil system ("*Bodensystematik"*) as well as a classification of the soil material (substrate classification; "*Substratsystematik"*). A large number of parameters, often with partly extensive code lists, and a formalized way to record auxiliary information (form, degree of expression, share, and size) are provided. It is thus one of the most detailed guidelines for soil description in the world. However, a strict data model is not included.

A new edition is awaited (possibly in 2019) with improvements in the soil system and substrate classification, horizon notation, code lists and in the mapping part. The simplification of soil description (AHB) shall be included in the new edition.

DIN 4220:2008-11 - Pedologic Site Assessment - Designation, Classification and Deduction of Soil Parameters

This German standard provides guidelines with several code lists, based on the German Soil Survey Guideline, for pedologic site assessment in various fields, e.g. agriculture, forestry or water economy. It defines rules for procedures of soil survey in the field, classification and deduction of pedologic parameters.

DIN 19682-1ff – Soil Quality - Field Investigation

The DIN 19682 series describes in 9 parts determination and measurement techniques for soil properties which are applicable in the field. Those parts that address description of soil properties (color (1), particle size distribution and soil type (2), soil moisture (5), soil structure (10) and decomposition level of peat soils (12)) are adopted from the German Soil Survey Guideline. The other parts contain analytical methods for field-measurements of the following parameters: water infiltration rate (7), water and air permeability (8 & 9), carbonates, sulfides, ph-value and iron(II)-ions (13). This German standard is often used in international soil studies and can be a helpful supplement for general soil descriptions in the field by **ISO 25177:2008**.

Guidelines Soil Assessment („Arbeitsanleitung neues Feldschätzungsbuch: Bodenschätzung", Bundesministerium der Finanzen, 1996)

Soil assessment (*"Bodenschätzung"*) is the basis for the taxation of arable land in Germany. Soil mapping according to these guidelines is required by law and organized by the German fiscal authorities. Mapping is realized by the description of soil profiles with 1 m depth at intervals of 50 m, resulting in large scale soil information. The guidelines provide a framework for field assessments ("*Bewertungsrahmen*") which combines soil type, soil condition/development and the parent material of which the soil is composed. Soil investigation following this guideline results in a soil value ("*Bodenwertzahl*"). It expresses the relative net income that, under normal and proper management, is determined only by the profitability of the soil. It is the basis for taxation of every plot used as crop- or grassland.

World Reference Base for Soil Resources (IUSS Working Group WRB, 2014)

The WRB was developed by a working group with the participation of IUSS, FAO, and ISRIC. It provides a standard taxonomic soil classification system which allows the accommodation of national systems. It is designed to serve as a common denominator for communication at the international level and as a correlation between existing classification systems. The WRB classification system contains two hierarchical levels: On the level of "Reference Soil Group" (RSG) 32 units are differentiated. On the second level the RSG is described more precisely by the use of "Qualifiers". For every RSG a list with corresponding principal and supplementary Qualifiers is defined. Classification is done by using both levels via diagnostic horizons, materials and features.

FAO Guidelines for Soil Description (FAO, 2006)

The FAO guidelines provide a complete procedure for soil description and for collecting field data necessary for classification according to second edition of the World Reference Base for Soil Resources (IUSS Working Group WRB, 2006). Notes for classification purposes are added to each chapter and explain the relevance of the described feature for classification according to the WRB.

ISO 25177:2008 Soil Quality – Field Soil Description

ISO 25177 traditionally was based on the FAO Guidelines, but was removed from it during the last editions. A current revision process aims at amalgamating the soil scientific soil description with the geotechnical soil description (**ISO 14688**).

This international standard provides rules for describing soil in the field and its environmental context at a given site. Sites may be natural, near natural, urban or industrial. Soil observations can be made on various levels (project site, plot, layer, horizon, specific soil constituents). ISO 25177 can also be used to describe non-soil layers, e.g. artificial material and coarse material. The standard addresses various research fields, e.g. soil science, geotechnical examinations, and investigation on soil contamination. Depending on the specific objective, ISO 25177 can be used in combination with other standards that provide guidelines or requirements for specific aspects of soil observation and measurements. Several parameters are mentioned that have to be observed for soil investigation and partially corresponding code lists are provided (Appendix, Table 15)

DIN 19706, DIN 19707, and DIN 19708 Soil erosion risk and nutrient supply

National standards provide guidelines and determination keys to quantify the risk of soil erosion by water (DIN 19708:2015) and wind (DIN 19706:2013) and the nutrient supply of a soil site (DIN 19707:2004).

1.1.2 Conflicts and solutions (transformation and derivation tools)

National conflicts

The Soil Survey Guidelines in its 5th edition (KA5) is currently the valid basis for soil description in Germany. However, some administrative soil surveys of the federal states use modifications of these guidelines. Even prior editions of 1994 (KA4) and 1982 (KA3) are still applied. Harmonization of data acquired according to different editions of KA can be realized by the use of a transformation tool developed by the Geological Survey of Lower Saxony BGR (see Chapter 2.3).

DIN 4220 is based on KA5, but deviates in some detail and in particular regarding some site assessment parameters. DIN 4220 is often applied in the context of geotechnical investigation. KA5 has a more expanded scope of application and community of users than DIN 4220. Thus, DIN 4220 as a national standard for soil description in the field has less importance than the German Soil Survey Guidelines.

The substrate classification of soil assessment deviates clearly from that given in the German Soil Survey Guidelines. Mineral soil types are determined by the fractions of sand, loam and clay. Silt is not represented as a grain fraction, contrary to other established substrate classification systems, so that comparison with other soil data is difficult. However, soil assessment data are valuable for various soil scientific issues regarding their high spatial resolution (scale 1:5.000) and comprehensive availability for agricultural area.

The German version of ISO 25177 is not intended to compete with the German Soil Survey Guidelines or with its deducted standards (e.g. DIN 4220) nor to replace them. It rather should facilitate soil survey work abroad, especially in Europe. In principle, soil description is feasible according to ISO 25177 also for soils occurring in Germany. But for most national purposes the application of the German Soil Survey Guidelines is recommended or even mandatory, according to national law.

Table 2: Selected national standards in the field of soil description and classification

Standard	**Contents**
***Germany**: 2. bundesweite Bodenzustandserhebung Wald (BZE Wald II, Arbeitsanleitung), (Wellbrock, 2006)*	investigation of state and changes of forest soils, vegetation, treetops and forest nutrition at about 2000 sites
***Germany**: Forstliche Standortsaufnahme. (Arbeitskreis Standortkartierung, 2016)*	national standard in the field of forest site survey, suited for functional use in the field, mentions federal state-specific differences
USA*: USDA-NRCS Field Book for Describing and Sampling Soils and US Soil Taxonomy (Schoeneberger et al. 2012)*	summarizes the present science and type of describing and documenting soils and soilscapes in the USA. Intended to be used by professionals who describe soils for various purposes, includes key descriptors, conventions, and concepts from soil science and geomorphology, support for understanding soil descriptions and data of soil surveys and soil scientific research
***UK**: English and Welsh Soil Survey Field Handbook (Hodgson, 1997)*	technical guideline for describing soil profiles
***France**: Guide pour la description des sols (Baize and Jabiol 1995)*	description of soils and their environment, one part deals with interpretation of soil observations in terms of e.g. pedogenesis and soil. The classic French soil classification system (Classification des sols, Commission de Pédologie et de Cartographie des Sols CPCS 1967) seems to be still in use, in particular in tropical and subtropical areas with French colonization history
***France**: Référentiel Pédologique. (Baize and Girard 2009)*	soil classification of the reference system type that is applicable world-wide. In contrast to WRB, the system is open, i.e. classes can be added if the user may them deem necessary
***Australia**: Soil and Land Survey Field Handbook. (National Committee for Soil and Terrain, 2009)*	follows a more landscape-oriented approach with extensive parts on landform, vegetation and land surface description. Includes short substrate classification, the soil description part resembles the English & Welsh handbook

International conflicts

There are significant differences between WRB and German soil classification. Main criteria for the latter are type and vertical order of genetic horizons in soil profiles. In contrast the WRB system uses diagnostic horizons, features and materials that are described independently from each other. The WRB-nomenclature of soil types is based on 32 Reference Soil Groups (RSG) with prefix- and suffix qualifiers. A simple translation of the German soil name into the WRB-name is not feasible for a wide range of soil types due to the deviant approaches. Moreover, WRB uses analytical parameters for classification, which are either not available for many soil profiles or are analyzed with different methods than those intended by WRB.

1.1.3 Recommendations for the BonaRes Program

Numerous standards for soil description exist that might be of subordinated importance for the BonaRes Program due to their special approach or field of application (Table 2). Besides, BonaRes focuses primarily on German soil data. Therefore, the current edition of the German Soil Survey Guidelines (KA5), as the most common national standard for soil description and classification, is strongly recommended. Foreign national standards without or with minor international aspects are less important for BonaRes.

1.2 Soil Sampling

1.2.1 Overview of existing standards

Standardized soil sampling methods used to be described in the ISO 10381 series which has been technically and structurally revised and replaced by the **ISO 18400-1ff** series. ISO 18400 is currently in development and has, in contrast to its precursor, a modular structure. Examples are the framework for a sampling plan (ISO 18400-101:2015), safety aspects (ISO 18400-103:2015) and quality control/assurance (ISO 18400-106:2015).

The **ISO 15903:2000** regulates the format and recording of soil information, including recommendations on sample design and -transport with the aim to "achieve a high degree of harmonization in reporting results". Further definitions of field sampling methods can be found in the standard group "Geotechnical investigation and testing". Examples are **ISO 22475-1:2006** (Sampling of soil and ground water), **ISO 22476-2:2005** (Sampling by hydraulic hammer), and **ISO 17628:2015** (Determination of thermal conductivity). Besides soil sampling, the sampling of grains, cereals and cereals products is described in **ISO 24333:2009.** German standards for soil sampling are part of the Handbook of Soil Investigation (Handbuch der Bodenuntersuchung, Blume et al., 2016). Selection of sampling locations, sample preparation, treatment and transportation are described in this compilation (see also Chapter 1.3).

1.2.2 Conflicts and solutions

1.2.3 Recommendations for the BonaRes Program

Standards as given by national method books should be used, such as the Handbook of Soil Investigation („Handbuch der Bodenuntersuchung", Blume et al. 2016), VDLUFA Method book "The investigation of soils" ("Die Untersuchung von Böden", VDLUFA, 2016), "Methods of Soil Analysis" (SSSA) and, if exist, ISO, EN or DIN standards. Table 3 lists further elected methods which are relevant for the BonaRes Program.

Data that was acquired according to national standards should, if possible, be translated into international standards to enhance their usability in international context.

It is recommended to use accepted or standardized sampling depths, such as 0−20 cm for Ap horizon = topsoil, or 0−5, 5−15, 15−30, 30−60, and 60−100 cm based on the GlobalSoilMap specifications.

Table 3: Soil quality analysis as regulated by national or international standards

Soil quality parameter	**Standard**
air permeability	DIN 19682-9:2011
Al-oxides/hydroxides extraction (oxalate acid)	ISO 12782-3:2012
ammonium	ISO/TS 14256-1:2003, -2:2005
carbon (TOC)	ISO 14235:1998, ISO 10694:1995, EN 15936:2012, DIN 18128:2002
carbonate	ISO 10693:1995, DIN 19682-13:2009
cation exchange capacity (CEC)	ISO 11260:1994
color	DIN 19682-1:2007
compression stress	ISO 17892-5:2014
DNA extraction	ISO 11063:2012
dry bulk density	ISO 11272:1998, ISO 17892-2:2015
dry matter fraction	EN 15934:2012
ecotoxicological characterization	ISO 15799:2003
electrical conductivity	ISO 11265:1994
(trace) element contents (total, dissolution)	ISO 14869-1:2001, -2:2002
(DTPA solution)	ISO 14870:2001
(Aqua Regia extraction)	ISO 11466:1995, ISO 11047:2003
(X-ray fluorescence)	ISO 13196:2013, DIN EN 15309:2007
(ICP-AES -spectroscopy)	ISO 22036:2008
(dilute nitric acid)	ISO 17586:2016
(ammonium nitrate)	ISO 19730:2008
exchangeable acidity	ISO 14254:2001
Fe-oxides/hydroxides extraction/ions	ISO 12782-1:2012, -2:2012, DIN 19682-13:2009
humic substances extraction	ISO 12782-4:2012, -5:2012
hydraulic conductivity	ISO 11275:2004, DIN 19682-8:2012
infiltration rate	DIN 19682-7:2015
microbial abundance and activity	ISO 17155:2012
biomass	ISO 14240-1:2011, -2:2011
diversity	ISO/TS 29843-1:2014, -2:2014
nitrate, nitrite	ISO/TS 14256-1:2003
nitrification (potential)	ISO 15685:2012
nitrogen (mineral, nitrate and ammonium)	DIN 19746:2005
(nitrate, ammonium, solute)	ISO 14255:1998
(total)	ISO 11261:1995, ISO 13878:1998, ISO 25663:1984
nutrient supply condition	DIN 19707:2004

pH	ISO 10390:2005, DIN 19682-13:2009, ASTM-E1910
particle density	ISO 17892-3:2015
phosphorus	ISO 11263:1996
pore water pressure	ISO 11276:1995
sampling of soil invertebrates	ISO 23611 (1-6)
shear strength	ISO 17892-6:2014
soil structure	DIN 19682-10:2014
soil texture	ISO 11277:1998, ISO 17892-4:2014, DIN 18123:2011, DIN 19682-2:2014, DIN 66115:1983
soil water content/soil moisture	ISO 11461:2001, ISO 17892-1:2014, DIN 18121-2:2012, DIN 19682-5:2007, DIN 19745:2006
sulfide	DIN 19682-13:2009
sulfur (total)	ISO 15178:2000
thermal conductivity	ISO 17628:2015
water retention	ISO 11274:1998

1.3 Laboratory Methods

1.3.1 Overview of existing standards

Soil sample pretreatment for laboratory analysis are defined by **ISO 11464:2006** and **DIN 19747:2009**. The national standard **DIN 32645:2008-11** contains statistical approaches and calibration features for chemical analysis and describes limits of detection and determination under statistical replication conditions. Alternative methods on detection limits and calibration can be found within the international standard **ISO 11843-1 ff** series (see below). In Tables 3 and 4 important standards for soil quality analysis are listed.

Laboratory Methods for Soil Testing ("Labormethoden-Dokumentation", Utermann et al., 2001)

It contains preferred analytical procedures for investigation of the most important soil parameters. This selection was discussed and agreed with the Geological Surveys of the Federal States in Germany. It was designed as a method database containing descriptions of analytical procedures, references to existing standards and method codes that link methods with analytical results in the laboratory database of the Federal Institute for Geosciences and Natural Resources (BGR). Information about the application range of analytical methods, plausibility of analytical results, restrictions, and common sources of errors are given in this documentation of laboratory methods.

VDLUFA Method Book "The Investigation of Soils" (Methodenbuch "Die Untersuchung von Böden", VDLUFA, 2016)

Loose-leaf collection with seven supplements (1991-2016). One of the main issues of VDLUFA (Association of German Agricultural Analytic and Research Institutes) is to establish uniform methods and evaluation principles in agricultural research. The methods book treats analysis on soil quality for agricultural issues, including methods which are not (yet) described in international ISO standards. The methods include the taking of samples, determination of total contents, and characterization of organic matter, soil physical analyses and field methods (Table 4).

Handbook of Soil Investigation (Handbuch der Bodenuntersuchung, Blume et al., 2016)

Loose-leaf collection with relevant standards (12,195 pages, 15 folders, in German) for soil description and investigation as well soil assessment. These standards cover the whole range of soil investigation: selection of sampling locations, sample preparation, treatment and transportation, extraction and fractionation techniques, analytical measurements, and evaluation methods. Many of these standards are enshrined in German legislation. More than 300 standards of the Handbook of Soil investigation are cited in the Federal Soil Protection and Contaminated Sites Ordinance.

Table 4: Soil quality analysis as regulated by the VDLUFA method book (VDLUFA, 2016)

Parameter	**Chapter**
Chemical analyses (Section A)	
Ammonium	A 6.1.2, 8.2
boron (plant available)	A 7.1
carbonate (total, demand)	A 5.3, 5.2
CEC (potential)	A 9.1
copper (plant available)	A 7.3
heavy metals, Aqua Regia	A 2.4.3.1
humic substances, extraction, fractionation	A 4.4.2
magnesium (plant available)	A 6.2.4.1
manganese (plant available)	A 7.2
Mercury	A 2.5.1
molybdenum (plant available)	A 7.4
Nickel	A 3.4.1
nitrogen (total), Kjehldahl	A 2.2.1
nitrogen (plant available) nitrate, mineral-bound	A 6.1.1, 6.1.4.1
pH	A 5.1.1
phosphorus (total)	A 2.4.2.1,
phosphorus (plant available)	A 6.2.1.1, 6.2.1.2, 6.2.3.1
potassium (total)	A 8.1
potassium (plant available)	A 6.2.1.2, 6.2.1.7
radio nuclides	A 12.2
Salinity	A 10.1.1
sodium (plant available)	A 6.2.5
soil organic matter (total)	A 4.1
strontium (^{90}Sr)	A 12.1
sulfur (plant available)	A 6.3.1
zinc (plant available)	A 7.5
Physical analyses (Section C)	
bulk density	C 1.3
compression stress	C 7.3
load capacity	C 7.4
permeability air/water	C 6.1 / 5.11
pore size distribution	C 4.3
sediment density	C 1.2
soil texture	C 2.2
soil water content	C 1.1

Handbook of Forestal Analytics (Handbuch Forstliche Analytik, HFA), GAFA (2005, suppl.1–5, 2014)

Loose-leaf collection with 5 supplements containing harmonized analytical methods for the resources soil/humus, plant and water in forest context, starting from sample preparation up to determination of physical and chemical parameters. Moreover the handbook provides a customized method coding system that was developed in order to enable complex documentation of analytical methods in a database and to make them evaluable and interoperable. Analytical methods and method codification are applied for the National Forest Soil Inventory in Germany and for Environmental monitoring in Europe. Several methods are based on accepted national and international standards (DIN, EN, ISO), which is tagged in the handbook. If there are deviations from certain standards, these are marked as well.

1.3.2 Conflicts and solutions

Soil analytical methods which are described within VDLUFA method book are considered to be national standards. In Germany the VDLUFA method books for soil analyses are established as standard field and lab methods for soil quality analyses on national scale and compete with existing other national standards and ISO standards. Numerous soil analytical laboratories in Germany use these methods for a long time to ensure comparability of national data. However national standards may complicate data transfer to international data bases and reduce comparability of data sets in international contexts.

The future challenge will be to develop transfer procedures for soil quality methods and results within different countries. The establishment of an international IT-infrastructure on soil and agricultural data could be an important step on this process.

1.3.3 Recommendations for the BonaRes Program

It is recommended to use standards as given by national method books such as the Handbook of Soil Investigation („Handbuch der Bodenuntersuchung“, Blume et al. 2016), VDLUFA Method Books volumes I and II.1 (“Die Untersuchung von Böden” and “Düngemittel”, VDLUFA, 2016), “Methods of Soil Analysis” (SSSA) or, if exist, ISO, EN or DIN standards.

Soil data users may require basic information, such as pH and bulk density according to well established standard methods in soil science. It is therefore recommended to collect these parameters for each soil sample.

The BonaRes Data Centre will use acknowledged coding systems for field- and laboratory methods to enhance methods documentation, data comparability and interoperability.

The BonaRes Data Centre gives support to find and use derivation tools (if any exist) to transfer data that was acquired according to national standards into international standards (see Chapter 2.3).

1.4 Soil Management

1.4.1 Overview of existing standards

The regulation of soil management is less ruled by ISO standards but more by laws, policies, commitments, and recommendations. However, most soil management practices strongly depend on local soil characteristics and changing biological and physico-chemical conditions as well as variable meteorological phases. In this context, flexible management activities by farmers including a frame for open regulations are provided by lawmakers and agricultural agencies.

Good Agricultural Practice (GAP)

GAP for soil management are national and international commitments and principles to reduce soil erosion and prevent soil functions such as soil fertility as a contribution to assure food security (FAO, 2003). GAP was implemented in numerous national and international agricultural policies and laws.

Common Agricultural Policy (CAP)

This EU-Policy was established in 1992 and revised in 2013. Today the key objectives of the CAP are an enhanced competiveness, an improved sustainability and greater effectiveness of the agricultural sector in Europe. Since 2015 crop diversification rules, the maintenance of permanent grassland and areas set apart for ecological purposes are integrated in the first pillar of the agricultural policy as obligatory measures.

Federal Soil Protection Act (BBodSchG, 1998) and the Federal Soil Protection and Contaminated Sites Ordinance (BBodSchV, 1999), Germany

This law and regulation set general legal requirements for agriculture and soil management to tackle degradation threats to soil, e.g. for weather- and site adapted tillage operations. Both, the BBodSchG and BBodSchV do not go into detail but are frameworks for more detailed policies.

Association for Technologies and Structures in Agriculture (KTBL), Germany

The handbook „Operation Planning Agriculture 2014/15“ (KTBL, 2014) provides methodical information on soil management questions. For soil management sequences, key parameters for economic success and costs per unit agricultural products are listed. The Pocket Book Agriculture (KTBL, 2015) provides, beside others, information on agricultural machines, prices for services and machines, and fertilizers, in numerous tables. Soil tillage tools and cropping systems in national contexts are provided. For example, no-till and non-turning cultivation are described in the “Definition of Soil Tillage and Management Systems”.

WOCAT (World Overview of Conservation Approaches and Technologies)

WOCAT is a global network. It supports decision-making processes for best management practices and sustainable land management and aims to unite the efforts in knowledge management and decision support for up-scaling sustainable land management among the different stakeholders.

NRSC (Natural Resources Conservation Service)

This service provides numerous technical guidelines and conservation practice standards for soil and water conservation in agriculture. Examples are Terraces (Code 600), Grassed Waterways (Code 412), and No-Till

Soil Protection Review, UK

The review was introduced in 2010 as part of the Good Agricultural and Environmental Conditions (GAEC 2010). The rule aims to maintain soil structure and organic matter and to prevent soil erosion and compaction.

Further regulations

Numerous laws and standards are defined by organizations and can be found in national and international records, e.g. for the US standard ASAE ASABE S578 provide rules for yield monitoring. Responsible for agricultural standards are e.g. the United States Department of Agriculture-National Agricultural Library (USDA-NAL), and in international contexts the FAO (AIMS, Agricultural Information Management Standards).

1.4.2 Conflicts and solutions

Some LTFE in Germany were set-up within the former German Democratic Republic (GDR). In the GDR, so called *"TGL standards"* were applied for agricultural field experiments such as plant production (TGL 21168/12), experiment design (TGL 21168/02) and physical soil analysis (TGL 31222/01). Although TGL standards have expired in 1990, most legacy data from LTFE in the former GDR were acquired by these standards. Even though these standards have expired, their former applications must be documented as metadata.

1.4.3 Recommendations for the BonaRes Program

Soil management such as crop rotation and catch crops does not follow strict ISO standards. Therefore, it is recommended to document the policies, laws or guidelines followed, such as: Good agricultural practice (GAP) (FAO, 2003), Common Agricultural Policy (CAP) EU-Policy, German Federal Soil Protection Act (BBodSchG, 1998), Association for Technologies and Structures in Agriculture (KTBL), Germany, WOCAT for best management practices and NRCS for technical conservation practices.

1.5 Agricultural Tools and Machineries

1.5.1 Overview of existing standards

Numerous tillage tools for sowing preparation and soil loosening equipment are defined in rulebooks and standards. In Table 5 the most important national and international standards on agricultural tools and machineries are compiled.

Table 5: Standards on tillage tools and agricultural machines

Content	**Standard**
Tools and Equipment	
Cultivator Blades (fixing dimensions)	ISO 8945:1989
Cultivator Tines and Shovels (fixing dimensions)	ISO 5680:1979
Disks	ISO 5679:1979
Harvester	DIN 11389:1988
Hoe blades	ISO 4197:1989
Pesticides and herbicides (granulated, equipment) *(spraying)*	ISO 8524:1984 ISO 5682-1:1996
Plough	ISO 8910:1993
S-tines	ISO 8947:1993 ISO 5678:1993
Seed drills	ISO 7256 (1-2)
Shallow tillage (dimensions, attachment points)	ISO 6880:1983
Sowing and planting (equipment)	ISO 17962:2015 ISO 4002 (1-2)
Sprayers	ISO 10627-2:1996
Turf and seeding	DIN 18917:2002
Machines	
Machines, self-propelled - assessment of stability	ISO 16231:2013 (1-2)
Machines, safety (-6 sprayer, -9 seed drills, -10 rotary tedders, -12 rotary disc)	ISO 4254 (1-12)
Machines operations	VDI 6101:2014
Tractors, mounted rotary cultivators, motor hoes drive wheel	EN 709:1997
Tractors, rear-mounted power take-off types	ISO 500:2014-1
Tractors, remote control hydr. cylinders for trailed implements	ISO 2057:1981
Tractors, connection via three-point linkage	ISO 2332:2009 ISO 730:2009
Tractors, operators manual	ISO 3600:2015

Tractors, safety	ISO 26322-1:2008
Tractor-mounted sensor interface – specifications	ISO 11786:1995
Tractors, track widths	ISO 4004:1983
Tyres: definitions	ISO/DIS 4223-1:2016
Tyres: dimensions (-1) load ratings (-2) *dimensions and designation* *dimensions, load ratings and reference speeds*	ISO/DIS 4251:2013 ISO 7867-1:2005 ISO 8664:2005(E)
Wheels and tyres, radial construction *measuring conditions*	DIN 7807:1995 DIN 70020-5:1986
Wheels and castors, test methods	EN 12527:1998
Weigh-in-Motion of road vehicles	DIN 8113:2009
Working width (sawing, planting, fertilizing)	ISO 6720:1989

1.5.2 Conflicts and solutions

1.5.3 Recommendations for the BonaRes Program

Standards for tractors and machineries in agriculture are developed by the ISO/TC 23. We recommend to record and document used tools, equipment and machines during field measurements, assigned to e.g. ISO standards, and to provide this information as metadata. This information should be compared and connected to the agroXML-schema.

1.6 Field Crops, Fertilization and Plant Protection

1.6.1 Overview of existing standards

Cross-compliance (Council of the European Union, 2009)

Cross-compliance mechanisms link payments to farmers with requirements on plant, animal and soil protection.

Water Framework Directive (Council of the European Union, 2000)

The directive addresses, beside others, the water pollution by nitrates from agriculture, and is thus a legal framework for agricultural activities on crop protection and fertilization.

EU Regulation No. 2003/2003 (European Parliament and of the Council relating to fertilizers)

The regulation treats all issues which are connected with fertilizers. In Annex IV numerous methods of samplings and laboratory analysis of fertilizers are given.

European Plant Protection Organization (EPPO)

The EPPO global database provides numerous free available code lists and standards and guidelines on pest risk, plant protection products, risk assessment and diagnostic.

Directive for agricultural value analyses and variety trials (Bundessortenamt, 2000)

In Germany several professional, qualitative assessment methods ("*Boniturmethoden*") exist. The Federal Plant Variety Office provides descriptive variety lists e.g. for cereals, maize, oil and fiber plants (Bundessortenamt, 2015). Beside the value analysis ("*Bonitur*") on different field crops it additionally provides recommendations on sowing dates, amounts and periods and densities, plant maintenance, fertilization, and soil and plant sampling for lab analyses. The State Offices of Germany regularly published recommendations for numerous agricultural products, e.g. maize, pasture grass and soy beans.

VDLUFA method books, manure and fertilizing regulations

Similar to soil management, crops, crop protection and fertilizing are predominantly regulated by national directives. While the legal fertilizing regulation in Germany (DüV, Bundesministerium der Justiz und für Verbraucherschutz, 2006) only treats nitrogen and phosphorus, VDLUFA method book volumes II.1 and II.2 (2016) deal with all other relevant soil nutrients.

Plant Protection Act, Germany

It regulates the protection of field crops and agricultural products against harmful organisms and the prevention of health damages for plants, animals, natural systems and humans from the agriculture (Bundesministeriums der Justiz und für Verbraucherschutz, 2012).

Further standards

- For the investigation of the yield structure the determination of the mass of 1000 grains is a common approach, which is defined in **ISO 520:2010**.
- The determination mass per hectoliter (bulk density or "*Schüttdichte*") of grain is described in **ISO 7971 (1-3)** .
- The determination of components of grain which does not belong to the good cultivated grain (="*Besatz*") is regulated in **DIN EN 15587:2014**.
- **DIN 18916:2016-06** Regulates activities on agricultural plant and soil works including mulch (which inhibits evapotranspiration) and measures against wildlife.
- **VDI 3957-1:2014** Describes biomonitoring as a method to determine and assess air pollutants effects on plants.
- Seed saving, reproduction and certification ("*Saatgut Nachbau und Zertifizierung*").

1.6.2 Conflicts and solutions

1.6.3 Recommendations for the BonaRes Program

Field crops and agricultural activities, such as pest management and fertilization, are often regulated in directives and method books, rather than in ISO standards. Similar to agricultural machineries, all activities should be recorded during field measurements, assigned to e.g. regulations and provided as metadata. Specific code lists are given in the Appendix (Chapter 4.1).

1.7 Accompanying Disciplines

Beside soil and agricultural data, accompanying data from different research fields concern the BonaRes Program.

1.7.1 Overview of existing standards

Land use classification

The **CORINE Land Cover** provides a EU-wide unique and comparable data set of land cover with 44 land use classes, out of which 37 classes are relevant for Germany. Mapping of the land cover and land use was performed on the basis of satellite remote sensing images on a scale of 1:100.000.

The German land survey authorities provide topographic data and maps. Their contents are reported in the feature type catalogue of the Official Topographical Cartographic Information System (**ATKIS**), where topographical appearances are classified in categories with land use information. ATKIS data are available in different scales (from 1:1.000.000 up to 1:25.000). Because of the higher spatial resolution, compared to e.g., CORINE Land Cover, the feature types catalogue comprises more land use classes (around 130 feature types).

Meteorology

The German **DIN 1319-1:1995-01ff** series defines basics in meteorological measurement techniques e.g. terms of measuring equipment (Parts 1 and 2) and measurement uncertainties (3 and 4). On international scale the **EN ISO 20988:2007** provides a detailed guideline to estimate measurement uncertainties for meteorological data. It includes statistical operations on systematic data deviations, calibration, ring trials, drift controls, and evaluation on variances. In particular the standard helps to evaluate and validate air quality data. **ISO 9169:2006** defines the performance characteristics of an automatic meteorological system. Meteorological measurements are described in guidelines **VDI 3786ff** including an extensive glossary and instructions on data aggregation for archiving (1) and air temperature (3).

Vegetation

Phenology stages are given within the BBCH code list. The Braun-Blanquet-Scale, as part of the Relevé Method, defines approaches of vegetation survey.

1.7.2 Conflicts and solutions

Meteorological raw-data are often available in time series with different temporal distributions. The conversion into convertible data and the supply for further processing is challenging.

1.7.3 Recommendations for the BonaRes Program

1.8 Business- and Personal Data

There are different types of data describing characteristics of farming businesses and actors involved in agricultural activities (e.g., farmers and other land users, planners of land use, representatives of interest groups, politicians in the agricultural sector, and consumers of agricultural products). These types of data include surveys, official and other statistics, interviews, workshops with experts' judgements, focus groups, and other. They can be provided in different forms such as text, numbers, audios, or videos. The data can be distinguished between different statuses, i.e., raw data, result data, and syntax data. Thus, standards vary over different data types and statuses.

This chapter focus on standards for raw data from surveys, statistical analysis and interviews as the most common data collected, evaluated and delivered from the BonaRes Module-A projects.

1.8.1 Overview of existing standards

Certification and labels for organic farming (Council of the European Council of the European Union, 2007)

In the European Union the Council Regulation No 824/2007 on organic production aims to ensure an "effective functioning of the internal market, guaranteeing fair competition", and "protecting consumer interests". It lists rules e.g. for livestock production, fertility management and soil protection.

Demographic Standards 2010 (DESTATIS)

This is a collection of Quality Reports about methods, definitions and standards for statistical information, including anonymization, table design, classification of professions, demographic standards, and macro and micro data statistics.

Joint recommendation by ADM, ASI and the German Federal Statistical Office provide survey versions. GESIS provides the **ZIS Version 14.00**, 2010, which is a collection of social science items and scales.

Education, status and prestige

- ISCED-International Standard Classification of Education by the UNESCO (1997/2011):
- SIOPS/ISEI/EGP Occupational Status (Ganzeboom and Treiman, 2003)
- ESeC – European socio-economic classification (User Guide)
- KldB – Classification of occupational status in Germany (Federal Labor Office 2010)

More information about statistical data, DESTATIS, in German

- Classification of professions, thesaurus (LINK)
- Statistical reporting, macro and micro data (LINK)
- Table design (LINK)
- Anonymization (LINK 1, LINK 2)

Guidelines for focus groups:

- Guideline for conducting a focus group (2005)
- AIMRO (Association of Irish Market Research Organizations, 2009)
- Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups (Tong et al. 2007)

Table 6: Standards and guidelines for methodological approaches

Content	**Standard**
Bio-based products - Life cycle assessment	EN 16760:2015
Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling)	ISO 14021:2016
Environmental management - Eco-efficiency assessment of product systems- Principles, requirements and guidelines	ISO 14045:2012
Environmental management - Environmental communication- Guidelines & Examples	ISO 14063:2006
Environmental management - Environmental performance evaluation - Guidelines	ISO 14031:2013
Environmental management - Life cycle assessment- Illustrative examples on how to apply ISO 14044 to impact assessment situations	ISO/TR 14047:2012
Environmental management - Life cycle assessment- Requirements & Guidelines (refers to the environmental aspects and potential environmental impacts e.g. resource use and impact of emissions over the product life cycle from raw material acquisition through production, use, waste treatment, recycling to final disposal)	ISO 14044:2006
Environmental management - Life cycle assessment- Principles & Framework	ISO 14040:2006
Evaluation of sustainability	VDI 4605:2016-02
Guidance on social responsibility	ISO 26000:2010
Resource efficiency - Methodical principles and strategies and - Raw Materials	VDI 4800-1:2016 VDI 4800-2:2016
Stakeholder Engagement - Guidelines for decision making processes dealing with climate change (REGKLAM project)	DIN SPEC 35810:2014
Sustainable management in small and medium-sized enterprises - Guidance notes for sustainable management	VDI 4070-1:2016
Sustainability criteria for bioenergy	ISO/DIS 13065:2014

Further Guidelines

- ecoinvent provides high quality environmental assessment, life cycle assessment and product chains in database
- Guideline Foresight (JRC)
- Sustainability Reporting Guidelines: GRI (Global Reporting Initiative)
- EC 2015: Better Regulations Guidelines e.g. on impact assessment

1.8.2 Conflicts and solutions

1.8.3 Recommendations for the BonaRes Program

Different national and international standards for the collection of business and personal data were identified and compiled. So far an evaluation was not conducted.

2 Data Management

The topic *data management* includes methodical standards to describe, document and evaluate research data which were recorded by standardized methods as described in Chapter 1. Assuring the data quality by supervised or unsupervised procedures e.g. data completeness, normal distribution, integrity, and removal of outliers, is prerequisite for the data storage, -exchange, -processing and -evaluation. Descriptive data should be checked on misspellings, synonyms and inconsistencies to enable clear data allocation and combination of different data sets.

After research data are collected, tested, described, and maybe pre-processed (e.g. pedotransfer-functions, biological models, upscaling) data are prepared to be transferred into a data base. At this point internal data base management becomes relevant. Data (base) management includes e.g. rules on the data structure, languages and formats used. These need to meet the requirements on later data applications such as archiving, evaluation, re-use, and publishing. An example for national agricultural data management is the PIAF system (**P**lanning, **I**nformation and **A**nalysis for **F**ield trials).

This chapter provides an overview of standards with general requirements on data quality, -structure and -formats, and -types, as well as geographic reference systems, units and dimensions.

2.1 General Conventions

2.1.1 Overview of existing standards

In Table 7 an overview lists standards with general and geographic data conventions and requirements e.g. on geographic reference systems, units and dimensions.

Table 7: Data conventions (Standard for general and geographic data)

Content	Standard
Data General	
Alphabet (Latin) -8-bit single-byte coded graphic character set	ISO/IEC 8859-1:1998
ASCII (American Standard Code for Information Interchange), 7-bit	ISO/IEC 646:1991
Countries/regions	ISO 3166-1:2013
Dates and times representation (interchange formats)	ISO 8601:2004
Languages	E DIN 2335:2014
Meteorological parameter e.g. air pressure (kPa), relative humidity (%) and wind velocity (m/s)	ISO 4226:2007
SI-units, Unit names, Unit symbols	EN ISO 80000-1:2013 DIN 1301-1:2010 DIN 1313:1998
Territorial units	NUTS (EUROSTAT statistics)
Universal coded character set	ISO/IEC 10646:2014
Geographic Data	
Application schema (rules)	ISO/DIS 19109:2013
Conformance	EN ISO 19105:2005
Coverage standards	EN ISO 19123:2007
Data product specifications	EN ISO 19131:2008
Encoding	EN ISO 19118:2011
Feature cataloguing	ISO/DIS 19110:2013
Filter encoding	EN ISO 19143:2012
Imagery and Gridded data	ISO/TR 19121:2000
Item Registration	EN ISO 19135:2015
Observation and measurements	EN ISO 19156:2013
Point location by coordinates	EN ISO 6709:2009
Positioning service	EN ISO 19116:2006
Profiles	EN ISO 19106:2006
Reference Model and System	EN ISO 19101-1:2014 DIN 18709-6:2016
Simple Feature Access	EN ISO 19125-2:2006
Spatial referencing by coordinates (geodetic reference systems)	WGS84 ETRS89 GRS80
Spatial referencing by geographic identifier	EN ISO 19112:2005
Spatial schema	EN ISO 19107:2005
Temporal schema	EN ISO 19108:2005

2.1.2 Conflicts and solutions

2.1.3 Recommendations for the BonaRes Program

The standards of general conventions listed in Table 7 should be considered and used in the different stages of data management by the BonaRes Data Centre. In detail:

- General conventions, e.g. SI-Units and Dimensions (EN ISO 80000-1:2013), Latin alphabet (ISO/IEC 8859-1:1998), interchange formats dates and times (ISO 8601:2004) and languages (E DIN 2335:2014-07) should be used.
- Geographic data should follow the regulations as described in series ISO 19100ff.
- A SQL-based relational database management system (RDBMS) will be used to manage research data in BonaRes.
- One of the various hierarchical models should be used, depending on the specific data structure. For spatial data most common is the spatial hierarchy (time stamp).
- The transfer of research data into the BonaRes repository will be enabled for all widely used data formats such as asc, csv, xlsx, and accdb.
- Common Coordinate systems are the WGS84, ETRS89 (EN ISO 19111:2007) and GRS80 (International Association of Geodesy, 1980). The technical directive of the German Federal Ministry of the Interior (Bundesministerium des Inneren, 2017) gives valuable specification on geodetic reference systems, geo-object catalogues and quality features. Coordinate transformation in further processing steps.
- **EN ISO 19156:2013** defines a conceptual schema for observations and features involved in sampling. It is used in INSPIRE and provides models for the exchange of information describing observation acts and their results, both within and between different scientific and technical communities. A common set of sampling feature types is defined that is classified primarily by topological dimension, as well as samples for ex-situ observations. The schema includes relationships between sampling features (sub-sampling, derived samples).

2.2 Data Quality and Statistics

2.2.1 Overview of existing standards

In this chapter quality assurance is provided by standardized methods of data acquisition, e.g. in laboratories. Data bases with scientific data should provide statements on data quality features. Data base clients, in particular modeler, need to get information on the quality level of a data set and information on completeness and consistency. Therefore, quality checks should be carried out when research data are uploaded to the data base.

Helpful features of data quality analysis are statistical data checks. Workflows including statistical test algorithms, accuracy of estimation, number of replication, outlier test, Gaussian normal distribution, systematic errors, and peakedness (single or multiple) are relevant for data quality evaluation and systematic data error identification. Data assessment needs also additional information on the quality criteria of the data set.

Quality management system and Measurement management systems

The quality management system (QMS) is closely coupled to **ISO 9000ff** and **ISO 10000ff** series (e.g. ISO 9000:2015, ISO 9001:2015, ISO 9004:2009, ISO 10005:2005, ISO 10006:2003) and **DIN 55350-100:2017** which are mainly focusing on the management aspect to achieve costumer's satisfaction. The **DIN 55350** series describes concepts and definitions in quality and statistics.

Examples

ISO 9001:2015 contains the general requirements for the competence to carry out tests and / or calibrations, including sampling. It refers to tests and calibrations that are based on specified in normative documents methods of methods that are not defined in normative documents, and those that were developed in the laboratory (ISO/IEC 17025: (2005) (2005) (2005) (2005) (2005) (2005) (2005) (2005) (2005)2005). ISO 9001 specifies requirements for a QMS.

ISO 9004:2009 gives guidance on a wider range of objectives of a QMS, for long-term success and improved performance. These standards can be applied to support organizations to develop a coherent quality management system. Guidelines for technical subjects in support of QMS are provided by e.g. ISO 10005, ISO 10006, ISO 10007, ISO 10014, and ISO 19011.

ISO 10012:2003 defines measurement processes and emphasizes the requirement of suitable equipment for an effective measurement management system. It aims to control risks of wrong data and results. Other management systems are given in the ISO 14001ff (Environmental management systems) and ISO 50001 (Energy management system).

ISO 19157:2014 - Data quality

Information about the quality of available geo-data is vital to the process of selecting a data set because the value of data is directly related to its quality. ISO 19157 provides:

- a classification schema for data quality and data errors, which are categorized into different elements, depending on their nature,
- principles how geo-data can be described and guidance on assessing the quality of actual datasets, and
- a framework of procedures for determining and evaluating data quality that is applicable to digital geographic datasets.

ISO 11843-1:2004ff series - Capability of detection

This norm has five parts including terms (1), linear calibration of data (2), determination of the critical value for the response variable (3), comparing the minimum detectable value with a given value (4) and linear and non-linear calibration cases (5).

ISO 3534-1/-2:2006 Statistics and terms

Define statistical terms and terms used in probability. They provide also rules on probability calculations, random sampling, correlations, and estimation functions.

Table 8: National standards on statistic evaluation and tests

Content	**Standard**
Methods for the examination of water, waste water and sludge (describes statistical data evaluation and treatments)	DIN 38402-1:2011-09
Stochastics, probability theory, concepts, signs, terms, symbols, formula	DIN 13303-1:1982 DIN 13303-2:1982
Chemical analysis – Decision limit, detection limit and determination limit under repeatability conditions – Terms, methods, evaluation	DIN 32645:2008-11
Limit of detection and limit of determination (quantitation) as processing parameters. Estimation in an interlaboratory test under reproducibility conditions; Terms, meaning, proceeding (are used for statistical evaluation of chemical analysis. Define e.g. detection limits under repeatability conditions)	DIN 32646:2003-12
Statistical evaluation (provides continuous features e.g. frequency distributions, random sample, frequency distribution, tests on normal distribution, and outlier)	DIN 53804-1:2002-04

DIN 66270:1998 - Software document evaluation, Quality characteristics

The German standard defines requirements of documents according to its identification, content (completeness, adequacy, correctness, and consistency), and representation (comprehensibility and clarity).

2.2.2 Conflicts and solutions

2.2.3 Recommendations for the BonaRes Program

Data quality assurance must be achieved by validation checks (such as errors, gaps, outliers, and plausibility), syntactical checks, and data integrity.

2.3 Data Transformation

Often data are obtained by national standard methods or classified by national systems and need to be transferred into international classification systems. Gaps in data-sets could preclude the direct use within models and thus require gap-filling methods.

2.3.1 Overview of existing standards and tools

Transformation tool for the 5th edition of the German Soil Survey Guidelines (KA5)

The revision of the guidelines KA5 resulted in a modified data encoding and classification of soils. For the transformation of soil data from a previous towards the following edition of the German Soil Survey Guidelines a software tool has been developed by the Federal Institute for Geosciences and Natural Resources (BGR) in cooperation with the Geological Surveys of the German federal states. It enables the translation of horizon symbols and derivation of soil systematic units based on the horizon data, as well as translation of substrate types and substrate systematic units. This software tool is available for the transformation of data recorded according to the 3rd edition of the German Soil Survey Guideline (KA3) towards its 4th edition (KA4) and KA4 towards KA5. The function for derivation of soil systematic units according to the German soil classification is only implemented in the last-mentioned version (KA4/KA5). A free download for both versions is provided on the homepage of BGR.

Conformity key for KA5

BGR developed a quality assurance tool for soil data according to the KA5. With this database application users can check their soil data for conformity according to the rules of the KA5. Complex algorithms test soil and substrate types as well as horizon symbols. The enumeration of horizons and depth information is tested for validity, and missing profile or horizon datasets are identified. Correction of errors can be performed by the user and KA5-compliant data can be exported. This application helps to improve data quality of either newly acquired data or already existing databases.

Derivation tool - KA5 (2005) to WRB (2007)

The BGR devised a software tool to derivate international common soil notations (WRB 2006, update 2007) from soil data, which were acquired according to the German Soil Survey Guideline. However, criteria for the determination of distinct diagnostic and naming elements of the WRB classification system are very complex. For each of these elements a graphic algorithm has been developed that refers directly to parameters of the KA5-nomenclature and selective laboratory values. Feasible input data (arrays of KA5- and laboratory parameters) are interrogated in order of decreasing reliability. If

less appropriate arrays have to be used for derivation of WRB-names, this is documented in a report for the user in order to prove the results' quality. The application is currently in further development: The next edition is aimed to derive soil notation according to WRB 2014.

Transformation tool for Soil Assessment data

A software tool for the transformation of Soil Assessment data ("*Bodenschaetzungsdaten*") into the nomenclature of the German Soil Survey Guideline (4th edition) has been developed by the Geological Survey of Lower Saxony (LBEG). It is also used by some other federal states. This software tool enables transformation of certain soil features (substrate type, soil color, humus content) into KA4-nomenclature. Horizon symbols and soil types are derived on basis of the transformed features. For further information see Bartsch et al. (2003) and Engel and Mithöfer (2003).

Other transfer functions

A taxotransfer scheme allows to estimate missing soil properties based on taxon information (Batjes, 2016). Such a tool was developed for the SOTER database and is used to fill gaps by a defined procedure (Batjes, 2003).

2.3.2 Conflicts and solutions

2.3.3 Recommendations for the BonaRes Program

A data transformation is the process of reorganizing or restructuring data from the source format into destination data in order to enhance data usability. For this purpose the application of certain transformation tools, e.g. for soil classification, is recommended.

2.4 Data Exchange and Formats

2.4.1 Overview of existing standards

ISO 28258:2013 Soil quality - Digital Exchange of soil-related data (SoilML)

This standard provides a generic, conceptual schema for soil-related data and the structural framework for the interoperable exchange of individually defined data. It contains a data model (following the rules of Unified Modeling Language UML) with (feature-) types that are generally applicable types with the aim of covering most of the individual, country or data provider specific types. Essential feature types included in the model are, e.g., Plot, Profile, Horizon or Layer. These feature types are defined in a feature catalogue, which is non-extensible. Provider-specific feature types are only allowed to be used, if a taxonomic subtype relationship to at least one of the generic feature types defined in the catalogue is explicitly stated. ISO 28258 encodes soil data using eXtended Markup Language (XML) that is encoded according to the structure given in an XML schema definition file (XSD). The XSD file for SoilML data files is called "*soilml.xsd"*.

Currently ISO 28258 is in revision. An amendment with editorial and conceptual modifications, such as renaming of feature types and improvement of the UML-data model, is planned for 2017.

INSPIRE Data Specification on Soil (INSPIRE Thematic Working Group Soil, 2013)

INSPIRE is not only about data interoperability, but aims at data harmonization. In the INSPIRE data model real soil objects were designed as feature types, and not features created to represent real objects. Thus soil maps were not introduced in the model (handled as metadata, see following section). The INSPIRE model can be extended regarding the parameters for describing features. Extensible parameter lists and code lists are kept in registries.

The INSPIRE data model differentiates between observed and derived soil profiles. An observed profile is directly linked to a soil plot, whereas a derived soil profile describes a soil body without a connection to a certain plot. Soil-related information can be provided as vector data by using the *SoilDerivedObject* feature type, information structured as raster data is supplied by using the *SoilThemeCoverage*.

SoTerML (Soil and Terrain Markup Language)

For the exchange of soil and terrain data between various sources an XML schema was developed within the European FP7 project 'e-SOTER'. It comprises the existing SOTER database conceptual modelling, the WRB and FAO soil data structures and classifications. With this approach it covers major soil and terrain databases as the European Soil Database (ESD). The principles of SoTerML are generic, so that they should be applicable to other geo-scientific domains and not only to soil data (Pourabdollah et al., 2012).

GlobalSoilMap

The GlobalSoilMap initiative supports generating and providing standardized soil data for the world. The GlobalSoilMap Specification provides an internationally agreed set of attributes and terminologies for soil data. It is the basis for the generic soil information model GSMML. Global soil map data is published as GSMML compliant data service. (Wilson et al., 2014)

OGC standards

The OGC (Open Geospatial Consortium) develops open standards for different stages of geo-data management within a consensus process. All OGC standards are based on XML language.

- **GML** (Geography Markup Language, EN ISO 19136:2009) is an XML grammar developed to express geographic features. GML is not only an open exchange format for geographic transactions on the internet, it also serves as a modeling language for geographic systems. The conceptual modelling framework of GML includes spatial and non-spatial properties of geographic features. A GML document is described using a GML schema. This enables the user to describe generic geographic data sets. Specialized extensions of GML are developed to provide community-specific application schemas in order to facilitate data exchange in a certain subject. The current version GML 3.3 was published in 2012 and extends the previous version with additional schema components and requirements.
- **Observations and Measurements – XML Implementation** This standard specifies an XML implementation for the OGC and ISO Observations and Measurements conceptual model. The XML schemas defined in this standard are specified for observations and for features involved in sampling when making observations. Aim is to enable exchange of information describing observation activities and their results within and between scientific and technical communities.
- **WaterML** is a standard information model for representation and exchange of hydrological observation data. It aims to serve as an interoperable exchange format for transport of data sets across information systems. The current version WaterML2.0 is implemented as an application schema of GML 3.2.1 by the use if the OGC Observation & Measurement standards.

XMI (XML Metadata Interchange, OMG)

XMI enables the metadata information exchange between software development tools. Based on XML-format, data can easily be produced, processed, stored and exchanged via internet.

GeoSciML

Data transfer standard for geological data. GeoSciML is XML based and provides solution for the exchange of geoscientific information, e.g. features from geological maps.

AgroXML and ISO-XML

Communication and data transmission between sensors and tools are indispensable in modern agricultural sector. On international level, the **ISO 11783-1ff** series provides an uniform communication language between agricultural machinery, e.g. operating supplies like fertilizers and pesticides, and office software. Applications and hardware (e.g. standardized plugs) that operate with ISO 11783ff are referred to as "ISOBUS". It focuses on the exchange of mobile and spatial data between both systems. Within this standard the language ISO-XML is defined.

While ISO-XML mainly addresses communication between farm machineries and -orders, the data exchange language AgroXML has also an interface via farm management information systems to external partners. AgroXML was developed by a German consortium of agricultural software providers and industry under the leadership of the KTBL.

To enable consistent frameworks for data standards and the integration of spatial data into web services, both languages be bound for integration into GML specification (Toth and Kucas, 2016).

UML (Unified Modeling Language, ISO/IEC 19501:2005)

UML is the dominant graphical language for object-oriented modeling with a semantic specification, geographic notation, interchange format, and a repository query interface.

Other data formats of accompanying disciplines

Beside soil- and agricultural data, other common data formats are widely used such as:

GRIB (GRIdded Binary) format for meteorological data as well as historical and forecast weather data

JSON and GeoJSON are JavaScript notations to represent Simple-Feature-Access-Specifications e.g. for data exchange. It is used to transform and safe structured data

NetCDF is a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data.

GeoRSS (Geographically Encoded Objects for RSS feeds) is a geotagged RSS feed which describes the locations of a web feed, blog or any news. It is available in XML or GML format and provides meta information of a web content like authors, date, title, narrative description, hypertext link and, at least, one location per feed.

Table 9: Further standards on data exchange and languages

Content	Standard
Bibliographic data (sharing, access)	MARCXML
Conceptual schema language	ISO 19103:2015(E)
Data interchange between information systems in agriculture	BS ISO 11788 (1-3)
Format for information exchange (bibliographic information)	ISO 2709:2008
Functional standards	ISO/TR 19120:2001
Keyhole Markup Language (KML), KML 2.2	OGC standard, Google
Language to transform XML documents into other formats	XSLT
Query language, developed by W3C	XPath
Shapefile	ESRI (quasi-standard)
Statistical data and metadata exchange (SDMX)	ISO 17369:2013

2.4.2 Conflicts and solutions

ISO 28258 vs. INSPIRE DS Soil

The most significant difference between both models for soil-related data is, that the INSPIRE model provides two subtypes for the soil profile feature type (observed and derived soil profile), which are missing in the ISO model. There is only one type of soil profile in the ISO model that can be used in both ways, in so far as a connection between soil profile and plot information is provided or the soil profile is directly linked to a soil mapping unit representing geometry in a soil map. Furthermore the INSPIRE model allows to specify from which observed soil profiles a derived soil profile was made what is not feasible in ISO. Feature types for providing soil information as raster data are not included in the ISO model. On the other hand ISO provides feature types for project information and soil samples that are missing in INSPIRE.

These differences are due to the diverging approaches. INSPIRE focuses on data products and their use, as well as the delivery of data to the users. ISO aims to data exchange in a wide range, even for scientific use. Both models need extension by the data provider regarding definition of parameters, which is rather simple with ISO, whereas there are more formal procedures in INSPIRE.

Relation between OGC and ISO standards

In the field of data exchange formats OGC and ISO developed standards in cooperation. As a result, these standards are double branded or divided into different parts with regard to contents. These standards do not compete with each other and have a broad acceptance.

- The XML encoding of the OGC standard GML is consistent with **EN ISO 19118:2011** and, more specifically, with **EN ISO 19136:2009** in terms of transport and storage of geographic information. The basic concepts used by GML to model geographic information are drawn from the **EN ISO 19101ff** series and the OpenGIS Abstract Specification. Current version GML 3.3 is backwards compatible with the previous version 3.2, which is identical to EN ISO 19136:2009.
- Observations and Measurements Implementation Standard is published in two parts: the conceptual model (in UML) is published as **EN ISO 19156:2013**, the XML implementation as an independent document by OGC.

2.4.3 Recommendations for the BonaRes Program

Standardized mobile data communication, especially for agricultural machinery should be included. Most prominent standard is the ISOBUS (**ISO 11783**).

Data interoperability is important. Therefore XML/GML standards are strongly recommended to facilitate data exchange.

2.5 Data Archiving

Research data which are replaced by new data and no longer actively used need to be stored permanently on separate storage devices with long durability. To enable long-term search and access to archived data standard digital archival systems should be used.

2.5.1 Overview of existing standards

DIN 31644:2012-04 - Digital Archives

This standard describes criteria for trustworthy digital archives in general and pre-conditions for the establishment and operation of digital archives. The German standard contains information on archival packages, data identification (e.g. DOI), and descriptive, technical and structural metadata. Users of this standard are encouraged to work through the task list within its takeover project. For practical assistance, a control list is annexed.

ISO 14721:2012 - Open archival information system, OAIS

OAIS provides frameworks for archival concepts, long-term digital information preservation, terminologies and concepts for describing and comparing archive architectures.

ISO 16363:2012 - Audit and certification of trustworthy digital repositories

The ISO sets out comprehensive metrics for what an archive must do, based on OAIS. Primary Trustworthy Digital Repository Authorization Body (ISO-PTAB).

ISO 16919:2014 Space data and information transfer systems

This standard specifies the requirements for bodies providing audit and certification of candidate trustworthy digital repositories.

2.5.2 Conflicts and solutions (transformation and derivation tools)

2.5.3 Recommendations for the BonaRes Program

According to the project „nestor" (=**N**etwork of **E**xpertise in Long-Term **Stor**age of Digital Resources) the results will be involved into the archiving process of research data in BonaRes.

3 Data Provision

Structured research data, reasonably described by standardized metadata facilitates its provision and increase its visibility. Open metadata, free and widely accepted geo data protocols and accepted licenses facilitate data queries and access for user.

This chapter provides an overview of metadata standards, possibilities for data publication, accepted licenses and thesauri and ontologies as applied in soil and agricultural science.

3.1 Metadata

3.1.1 Overview of existing standards

Standards only dealing with metadata for diverse purposes and are published by ISO. Metadata for geographic information are regulated in **ISO 19115-1ff** series (Geographic information - Metadata). ISO 19115-1:2014 and -2:2009 contain many code lists on identification information, geometry types and other relevant topics.

Requirements for metadata related to geographic information services are defined in **ISO/DIS 19119:2015**. A technical guideline for encoding of metadata using a XML-schema is provided by **ISO/TS 19139:2007** (XML schema implementation). Regulations for metadata are also part of other standards that relate to soil data, for example INSPIRE DS Soil or **ISO 28258:2013**.

The German Infrastructure for Spatial Information (GDI-DE) requires the application of ISO 19115, 19119 and 19139 in the context of INSPIRE for acquisition and support of metadata. For such purposes the Drafting Team Metadata and European Commission Joint Research Centre published a technical guideline with INSPIRE implementing rules for metadata (JRC, 2007).

The Digital Curation Centre (DCC) provides a list of common metadata standards.

INSPIRE Data Specification on Soil

The INSPIRE directive contains metadata elements on dataset-level that should be applied for documenting metadata for an entire dataset or a dataset series. Metadata can also be stored on object-level. This means that metadata can be described for each individual spatial object. Due to the product-oriented approach of INSPIRE, metadata provide not only information on data quality and validity, but also on conditions for accessibility, use of data, access restriction (including reasons) and charges.

DataCite

The DataCite was developed to provide easy access to scientific data over internet. It provides domain agnostic services which belongs to the concept of a long term or *persistent* identifier. DataCite is using *Digital Object Identifiers* (DOIs) to register a resource associated with metadata. The objective of DataCite is to increase the acceptance of research data as legitimate, citable contributions to the scientific record and to archive data for future study. Besides a wide range of metadata elements, DataCite provides the opportunity to acknowledge contributions of disciplinary work. To enable an accurate and consistent identification of a resource (e.g. for citation) the metadata scheme offers a list of essential metadata properties. The da|ra is the DOI registration agency for social and economic research data. The recent Metadata Scheme is 4.0 (Group, 2016).

Dublin Core Metadata Element Set (Version 1.1)

This set is a vocabulary of fifteen properties to describe a resource. It is maintained by the Dublin Core Metadata Initiative (DCMI). The Dublin Core metadata elements formally endorsed in **ISO 15836:2009**, **ANSI/NISO Z39.85-2012** and **RFC 5013** (Kunze and Baker, 2007).

METS (Metadata Encoding & Transmission Standard)

This is a standard for coding and management of metadata from digital or analogue sources of different formats (picture, text, audio, video…). Precondition are beside others sections for the presentation of the internal structure of a digital object, group related files, technical metadata, and information about the source. METS documents can link and integrate different metadata (e.g. from PREMIS, Dublin CORE or MARC).

PREMIS (PREservation Metadata: Implementation Strategies)

Initiative for the development and maintenance of internationally recognized long-term archiving metadata standards. PREMIS aims to develop recommendations, suggestions and best practices for implementing preservation metadata, further development of the standards, as well as the connection to other standards.

DDI (Data Documentation Initiative)

Open standard (metadata model) to describe social and economic research data and survey data. Basic concept is the description of the complete Data Life Cycle with XML.

GESIS (Leibniz-Institute for the Social Sciences)

In line with DDI, presentation of detailed metadata and standards for surveys and interviews, e.g., in the following technical reports: Zenk-Möltgen and Habbel 2012, Jensen and Schweers 2014.

Business Association ADM (Arbeitskreis Deutscher Markt- und Sozialforschungsinstitute e.V.)

Represents the interests of private-sector market and social research agencies in Germany and provides guidelines, quality standards and the ICC/ESOMAR Codex e.g. about telephone, online and personal surveys, about focus group discussion, qualitative interviews and ethical standards in data collection.

Quali-Service (University of Bremen)

Emerging data service center for qualitative primary data (focus on interviews) and provision of reports about metadata standards, e.g., Betancort Cabrera and Haake 2013.

3.1.2 Conflicts and solutions

INSPIRE vs. ISO Metadata

The problematic issue of metadata and data is, that almost any piece of data can be metadata in a more specific context. In the application schema of ISO 28258 any piece of information that can be handled as data should at least be handled as data, but can additionally be handled as metadata. According to ISO 28258 information e.g. on projects or soil maps can be described as data (in the form of features) or metadata. In line with INSPIRE this information is metadata of a dataset.

After reviewing INSPIRE metadata schema for dataset and services, GDI-DE, DataCite and Dublin Core metadata standards, a new metadata schema has been planned to propose. The new schema has blended with INSPIRE and DataCite while few relevant elements within these two standards have been found.

3.1.3 Recommendations for the BonaRes Program

Preconditions for metadata are to be easy to understand and allow repeatability. Therefore a metadata schema has been created by combining elements of both schemes INSPIRE (EU) and DataCite (DOI) since few relevant elements within these two standards have been found.

3.2 Geo Data Services

Geo data service provides access to a geo database by local area network (LAN) or the internet using ArcGIS server or open source GIS servers, i.e., geo server to view, search and queries into database. Open Geospatial Consortium (OGC) regulates rules and standards for geo data services. So called "OGC services" are listed in this chapter. They are widely accepted and applied by geo data providers and users. Requirements, types and structure of services are defined in **ISO/DIS 19119:2015** and **ISO 19133:2007** (data types, operations and implementation).

3.2.1 Overview of existing standards

All OGC standards on web services (OWS) and supporting documents are available to the public at no cost, e.g.:

WMS (Web Map Service)

WMS offer geo-registered map images in different format (e.g., JPEG, PNG) from distributed geo database system through GIS servers. It is basically a HTTP/HTTPS link, which provides different request types, two of which are required by any WMS server: GetCapabilities and GetMap, defines a certain geographic location and layer(s) to be managed. Request types that WMS optionally support include: *GetFeatureInfo*, *DescribeLayer* and *GetLegendGraphic* (OpenGeoSpatial). Rules and applications of WMS are provided by **EN ISO 19128:2008**.

WFS (Web Feature Service)

WFS allow any usage that might work with web services to get geographic features from one or more distributed spatial information system or a map itself. Similar to WMS (mapping output as an image), WFS deal with create, update, delete and query functions of feature instances from regarding database. WFS serve eight general operations: *Capabilities, DescribeFeatureType, DescribeFilterModel, Feature, FeatureWithLock, Property, LockFeature* and *Transaction*. Rules and applications of WFS are provided by **EN ISO 19142:2010**.

WCAS (Web Catalogue Service, also known as **CSW,** Catalogue Services for the Web)

CSW service provides options to publish and searching capabilities of metadata about geospatial data, services, and related information objects. Request types that CSW services offers include: *GetCapabilities, DescribeByRecord, GetRecords, GetRecordById, GetDomain, Harvest*, and *Transac-*

tion. Requests can encode the parameters in three different ways: GET with URL parameters, POST with form-encoded payload and POST with XML payload.

WCS (Web Coverage Service)

WCS returns the original data with its descriptions along with actual semantics. This service allows access into coverage data for client-side rendering. WCS also offers clients to get information of a certain portions based on constraints and certain criteria, similar to WFS and WMS service (OGC Networks).

WMTS (Web Map Tile Service)

WMTS makes detailed rendering of a raster data or a large volume of vector data in tiles which supports Key-Value-Pair (KV, process oriented) encoding interfaces, REST (Representational state transfer) encoding and SOAP encoding.

TJS (Table Joining Service)

The TJS standard joins attribute data with its associated geospatial framework. Attribute data can be stored in one network and mapped with geographic data into another network which contains geometries for the attribute data. TJS provides simple web-based services for searching, accessing and using attribute data from different sources which can generate database, perform analysis and populate maps.

WMC (Web Map Context)

The OGC XML file standard WMC describes meta-information of a WMS (e.g., the URL, different layers within the service, bounding box rectangle, coordinate system) in XML file, stores and loads XML schema which belongs to it.

WPS (Web Processing Service)

WPS service defines how to implement a geoprocessing service, geographic calculations or models as a service. It offers simple web-based standardized method of finding, accessing and using of geoprocessing services, at the same time also direct requests and responses of those services. WPS uses HTTP GET, HTTP POST, SOAP and XML as a mechanism for describing the data and for interoperability.

3.2.2 Conflicts and solutions

3.2.3 Recommendations for the BonaRes Program

All OGC standards are free and widely distributed geo data services and are also indisputably accepted in the geo-data community. Therefore within the BonaRes Program these standards will be used.

3.3 Data Publication

3.3.1 Overview of existing standards

A review of efficient and enhanced publishing, dissemination, sharing and re-use of bio-diversity data are given by Chavan and Penev (2011). Data publication in data journals are classified as "**p**ure" publish data papers only and journals classified as "**m**ixed" publish both.

TRAC integrated SCM & Project Management provides a list of Data Journals.

Selected overview of journals and data publisher:

Geoscience Data Journal (Wiley)

Open Access with scientific peer-review. Important standards for this Journal: Linked data must be stored in an approved repository and assigned with DOI.

Earth System Science Data (Copernicus Publications)

International, interdisciplinary journal for the publication of articles on original research data (sets). Important standards for this Journal: Dataset with persistent identifier; OAI-PMH; Metadata in Dublin Core format (oai-dc), full-text XML

Ecological Archives / Data Papers: (Ecologigal Society of America, ESA)

Supplemental to articles of the ESA. Data is registered in official Data Registry of the ESA. Data are fully peer reviewed, technical review of data and metadata. Data ingest as text format. Important standards for this Journal: Metadata following (Michener et al., 1997)

Hindawi publishing (Hindawi Publishing Corporation)

Peer-reviewed, open access, all areas of geosciences. Important standards for this Journal: Content is archived in Portico, LOCKSS.

GigaScience / BioMed Central

Open access and Open-Data

Journal of Physical and Chemical Research Data / AIP Publishing LLC

Published by the American Institute of Physics (AIP) for the National Institute of Standards and Technology (NIST); reviews of measurement techniques, critical data evaluation. Important standards for this Journal: Standard Reference Data Act (Public Law 90-396); Article and supplemented material with DOI.

Biodiversity Data Journal (Pensoft)

This journal is community peer-reviewed and Open-Access. It is in accordance with the Data Publishing Policies and Guidelines of Pensoft Publishers. Important standards for this Journal: related data must have DOI or other persistent identifier, XML.

F1000 Research (F1000 Research Ltd, Science Navigation Group)

Data articles are citable and authors are credited when data are reused. Important standards for this Journal: CC0, no explicit standards but guidelines for different datasets, Metadata of date linked to the journal should be, when possible, in standardized machine readable formats (DataCite).

Mostly DataCite as well as DOI were important standards used in these Journals. The most important Persistent Identifier (PI) used is the DOI.

CODATA Data Science Journal (Ubiquity Press)

Journal of Open Research Software (Software Sustainability Institute)

PANGAEA (Data publisher for earth & environmental science)

Data Publication in repositories

An overview and recommendations of over 1200 repositories available are published by re3data.org (full scale resource of registered repositories across subject areas).

Important PI systems in chronological order (Hakala2010):

Handle, 1994; Persistent URL (PURL), 1995; Uniform Resource Name (URN), 1997; Archival Resource Keys (ARK), 2001; Extensible Resource Identifier (XRI), 2005; digital object identifier (DOI) 2000 – 2012. DOI is the implementation of the Handle (1994) system.

DOI is specified by the American national standard **ANSI/NISO Z39.84-2005** and managed by the DOI Foundation. DOI became the standard **ISO 26324:2012** (Information and documentation - Digital object identifier system). In the DOI system the object is identified unambiguously to its institution

(prefix). There is no limit of the length of either suffix or prefix. Metadata can be associated with the object.

3.3.2 Conflicts and solutions

While the expression of DOI as URN is possible, conversions from DOI into other systems, such as XRI or ARK, are difficult or impossible, respectively. In contrast to URN, DOI goes beyond identifying an electronic manifestation of a resource. The DOI-prefix also identifies the location of access.

It is already decided that the BonaRes Program will use and provide the DOI system. The BonaRes Data Centre is partner of the TIB and thus qualified for DOI certification. All DOI, provided by BonaRes, have the prefix: *10.20387*.

3.3.3 Recommendations for the BonaRes Program

It is already decided that the BonaRes Program will use and provide the DOI system. The BonaRes Data Centre is partner of the TIB and thus qualified for DOI registration. All DOI, provided by BonaRes, have the prefix: *10.20387*.

3.4 Licenses

3.4.1 Overview of existing standards

License information for research data and metadata is important because it informs users what they allowed to do with data and metadata. Without an explicit license, reuse is restricted. Licenses should not be created individually but existing licenses should be used.

Creative Commons (CC)

Creative Commons is a global nonprofit organization that enables sharing and reuse of creativity and knowledge through the provision of free legal tools. Current version is 4.0.

Open Data Commons (ODC)

Open Data Commons is a project of the Open Knowledge Foundation with the aim to provide legal solutions for open data: Open Database License (ODbL) and Attribution License

Datenlizenz Deutschland (Data License Germany)

Was created by federal and state governments in Germany during the work at the Open Data Portal and has been specially developed for administrative data. Current version is 2.0.

GeoLizenz

This license was developed by the German GeoBusiness Commission (GIW-Kommission), which was founded by the Federal Ministry for Economic Affairs and Energy. The license is intended for geo data, metadata and geo data services.

GNU General Public License

GNU is intended to guarantee freedom to share and change all versions of a program and to make sure it remains free software for all its users.

Open Software License (OSL-3.0)

OSL applies to any original work of authorship whose owner has placed the following licensing notice adjacent to the copyright notice for the Original Work: “Licensed under the Open Software License version 3.0”.

3.4.2 Conflicts and solutions

3.4.3 Recommendations for the BonaRes Program

The BonaRes Centre strongly recommends the Creative Commons (CC) for licensing each data (research- and metadata) to be stored. Metadata is always unrestricted. The standard license for all research data stored in the BonaRes Data Centre is CC-BY that facilitates maximum distribution and usage of data.

3.5 Thesauri and Ontologies

The use of thesauri, ontologies and glossaries with standardized, generally accepted and clearly assigned vocabularies, codes and definitions are necessary for smooth data integration and to allow an accurate exchange, query and reproduction of information. In the Appendix of this document the most relevant code lists and glossaries are compiled.

3.5.1 Overview of existing standards

ISO 25964 - Information and documentation – Thesauri & interoperability with other vocabularies

-1:2011 Thesauri for information retrieval

This is part one of an international standard for thesauri, that is published in two parts. It provides recommendations for the development and maintenance of thesauri intended for information retrieval applications. It is applicable to vocabularies about all types of information resources including knowledge bases and portals, bibliographic databases, text, etc. It provides a data model and recommended format for the import and export of thesaurus data and can be applied for monolingual and multilingual thesauri. Based on the data model it includes also an XML schema for data exchange.

-2:2013 Interoperability with other vocabularies

Provides guidelines for high quality information retrieval across networked resources that have been indexed with different vocabularies or Knowledge Organization Systems (KOS). It helps to set up mappings between different concepts (classification schema, taxonomies, subject heading schemas, ontologies, name authority lists, terminologies and synonym rings).

SKOS – Simple Knowledge Organization System

Is a W3C recommendation for the representation of thesauri, classification etc. or any other controlled vocabulary. It gives guidelines to facilitate publication and use of vocabularies as Linked Data. SKOS is part of the Semantic Web standards built upon RDF and RDFS. SKOS was formal released in 2009 by W3C as a new standard that connects different KOS and the linked data community. It defines classes and properties to present common features of a standard thesaurus.

ORCID

A persistent digital identifier that distinguishes researchers from each other.

RDF – Resource Description Framework

Is a family of W3C specifications that is applied as a general method for conceptual description or modeling of information that is implemented in web resources.

ISO/IEC 13250-2:2006 - Information technology – Topic Maps

Regulates the representation and interchange of knowledge, especially for information retrieval. Topics Maps enable the linkage of multiple indexes from different sources. The standard defines the abstract structure and interpretation of Topic Maps, rules for merging them and a set of fundamental subject identifiers. The purpose of the data model is to define the interpretation of the Topic Maps interchange syntax, and to serve as a foundation for the definition of supporting standards for canonicalization, querying, constraints, etc.

Overview of existing thesauri in agricultural and environmental science

AGROVOC

Is a multilingual vocabulary developed by the FAO to define terms and translate them to more than 20 languages. It is published as an RDF/SKOWS-XL concept schema and as Linked Data. It is aligned with 16 vocabularies related to agriculture and has a SPARQL endpoint. It is edited through VocBench, a web-based editing tool for editing thesauri.

AGRIS (International System for Agricultural Science and Technology)

Is a global public domain database published by the FAO with more than 8 million records on agricultural science and technology. The AGRIS Search system allows scientists, researchers and students to perform sophisticated searches using keywords from the AGROVOC thesaurus, specific journal titles or names of countries, institutions, and authors.

GCMD (Global Change Master Directory)

This directory was developed by NASA and can be implemented as thesaurus into a data base. Keywords are provided in different scientific disciplines such as agriculture, atmosphere and hydrology.

GEMET (General Multilingual Environmental Thesaurus)

Was developed by the European Environmental Information and Observation Network (EIONET). It summarizes different structured vocabularies and aims to define a common terminology for environmental terms in the European context. It is available in more than 27 languages and consists of more than 6000 records.

VocBench

Is an open source, web-based multilingual vocabulary editing and workflow tool. It was originally developed and released by the FAO and the Artificial Intelligence Research Group of the University of Rome Tor Vergata to manage AGROVOC, but now hosts a still expanding set of vocabularies.

EUROVOC

Multilingual thesaurus maintained by the Publications Office of the European Union for indexing of documents of European institutions. Available in 24 languages.

Open Tree of Life

Was funded by the NSF, describes and visualizes the biological taxonomic classification system and can be used to allocate taxonomic species names and classes.

ISO 11074:2015 - Soil quality, Vocabulary

Summarizes all relevant terms of soil science in a glossary and is available in a trilingual edition. It defines a list of terms used in the preparation of other standards in the field of soil quality. The terms are classified under the following main headings: general terms, description of soil, sampling and assessment of soils, remediation, and soil ecotoxicology.

EPPO Plant Protection Thesaurus

Includes pest-specific information, names (multi-lingual) and codes for plants, animals and microorganisms

Overview of existing ontologies

QUDT (Quantities, Units, Dimensions and Data Types Ontologies)

This ontology is under development by the NASA and provides first unified model of quantities, dimensions, units, and conversion factors. Each unit has its own URI, and can thus be used as unique unit-identifier for data-sets.

Semantic Sensor Network Ontology

Developed by the W3C Semantic Sensor Networks Incubator Group. This ontology describes sensors and observations, and related concepts (W3C Semantic Sensor Network Incubator Group, 2009). It provides numerous suggestions on the management of sensor data including metadata of sensor description (e.g. accuracy, detection limit).

PROV-O

This W3C ontology provides a set of classes, properties, and restrictions that can be used to represent and interchange provenance information generated in different systems and under different contexts. It can also be specialized to create new classes and properties to model provenance information for different applications and domains.

EngMath

Ontology for mathematical modeling. Mostly used by engineers.

UCUM (Unified Code for Units of Measure)

This code system includes units of measures being contemporarily used in international science and engineering. UCUM is based on ISO 80000:2009 and is used e.g. for electronical data interchange protocols.

OM (Ontology of Units of Measure and Related Concepts)

This ontology was developed by the Wageningen University with strong focus on units, quantities and dimensions, including conversion factors. Modeled in OWL 2.

RDFS – Resource Description Framework Schema

Was published by the W3C in 1998 and includes several classes with certain properties using the RDF extensible representation data model, providing basic elements for the description of ontologies.

3.5.2 Conflicts and solutions

The AGROVOC thesaurus is widely accepted and appreciated within the agricultural science community. However, it was found that terms in soil science are often inadequately described or lacking as assigned for the objectives of the BonaRes Program. Contact to the editors exists to improve these existing weaknesses.

3.5.3 Recommendations for the BonaRes Program

As already stated in the BonaRes proposal, the common thesauri AGROVOC (FAO) and GEMET (EIO-NET) will be implemented as common thesauri in the data portal.

In case of unit translation the freely available ontologies OM (Wageningen University) and QUDT (NASA, under development) are recommended.

4 Appendix

4.1 Code Lists

Code lists are useful tools for expressing longer lists of potential values and help to organize and harmonize data bases. Whenever an universal accepted code exists for a certain parameter, it is recommended extend the data base with a code column.

Soil survey

In the Tables 11-16 the most important code lists for field soil survey, description and classification, as parts of national and international standards, are listed:

Table 10: Overview of code lists on soil data survey

Standard	**Code list**
German Soil Survey Guideline (KA5)	*see Table 11*
DIN 4220:2008-11	*see* Table 12
Guideline Soil assessment	*see Table 13*
FAO Guidelines for Soil description	*see Table 14*
ISO 25177:2008	*see Table 15*
INSPIRE Code List, e.g. WRB for Reference Soil Groups, Qualifiers and Specifiers	*see Table 16*

For the German Soil Survey Guideline all parameters for field soil description provided with code lists are given in Table 11. The number of the field in the official form for soil scientific profile description, where a certain soil parameter has to be documented is also listed in the table. The accessibility of code lists is given by the corresponding page number in the guideline, number and title of code list. Code lists for deduction of soil parameters are not mentioned in this overview, because they are not relevant for field soil description.

Table 12 gives an overview of parameters in the German standard **DIN 4220** for soil feature designation and classification as provided by code lists. Code lists used for deduction of soil parameters are not listed, as they are not required for field soil description.

Table 11: Parameters for field soil description provided with code lists in German Soil Survey Guideline (Bodenkundliche Kartieranleitung KA5, 5th edition, 2005)

Parameter (EN)	**Parameter (D)**	**field**	**p.**	**Cl-Nr.**	**Code list name**
sampling type	Beprobung Entnahmeart	-	40	Tab. 2	Entnahmeart und Definition der Probenahme
exploration type	Aufschlussart	9	56	List 2	Aufschlussart/Aufnahmeintensität/Probenahme
acquisition intensity	Aufnahmeintensität	9	56	List 2	
slope gradient class	Hangneigungsstufe	11	58	Tab. 6	Einstufung der Hangneigung
exposition	Exposition	12	59	Abb. 5	Windrose zur Kennzeichnung der Exposition
curvature	Wölbung	13	60	Tab. 7	Einstufung der Wölbungsstärke
relief type (simple)	einfacher Reliefformtyp	14	63 64 65 65	List 3 List 4 List 5 List 6	Reliefformtypen Untergliederung des Kulminationsbereichs Untergliederung des Tiefenbereichs Untergliederung des Hanges
relief type (complex)	komplexer Reliefformtyp	14	66 66 67	List 7 List 8 List 9	Komplexe Reliefformtypen Erhebung Geschlossene Hohlform
micro relief	Mikrorelief	16	69	List 10	Rauhigkeit R der Reliefoberfläche
position in relief	Lage im Relief	17	69	List 11	Lage im Relief
denudation/ accumulation processes	Abtrags/Auftragsvorgänge	18	70	List 12	Abtrags-/Auftragsvorgänge und deren Erscheinungen
denudation/accumulation phenomena	Abtrags/Auftragserscheinungen	18	70	List 12	
land use/ surface sealing	Nutzung/ Versiegelung	19	72	List 13	Nutzungsart/Versiegelung
vegetation	Vegetation	20	73	List 14	Vegetation
weather	Witterung	21	74	Tab. 9	Kennzeichnung der Witterungsverhältnisse
anthropogenic changes	anthropogene Veränderungen	22	75	List 15	Anthropogene Veränderungen
lumbricids lifeform type	Lumbricidae Lebensformtyp	23	77 77	Tab. 10 Tab. 11	Lebensformtypen und Abundanzklassen der Lumbriciden
remarks (acquisition conditions)	Bemerkungen (zur Aufnahmesituation)	24	79	List 16	Flächen mit Sonderbestimmungen
lower horizon boundary form	Horizontuntergrenze Form	26	80	Abb. 11a	Form (Gestalt) der Horizontgrenze
lower horizon boundary position	Horizontuntergrenze Lage	26	81	Abb. 11b	Lage (Neigung) der Horizontgrenze zur Oberfläche
lower horizon boundary sharpess	Horizontuntergrenze Schärfe	26	81	List 17	Schärfe (Deutlichkeit) der Horizontgrenzen

horizon symbols	Horizontsymbole	27	86ff	Tab. 12	Vorgesehene Kombinationen von Haupt- und Zusatzsymbolen
color (without color-charts)	Farbe (ohne Fabtafeln)	28	110	List 18	Farbbezeichnungen
humus content	Humusgehalt	29	112	Tab. 15	Einstufung des Humusgehaltes (organische Substanz) von Böden
hydromorphology oxidative	Hydromorphie oxidativ	30	113	Tab. 16	Erscheinungsarten horizont-differenzierender Fe- und Mn-Verbindungen in hydromorphen Böden
hydromorphology reductive	Hydromorphie reduktiv	31	113	Tab. 16	
soil moisture	Bodenfeuchte	32	115	Tab. 17	
Consistency	Konsistenz	33	115	Tab. 17	Konsistenz bindiger Böden, Konsistenz-grenzen und zugehörige Bodenfeuchte
other pedogenic features	sonstige pedogene Merkmale	34	114	-	Organische Merkmale, Mineralische Merkmale
soil structure form	Gefügeform	35	117 118 118 119	List 19 List 20 List 21 List 22	Grundgefüge Makrogrobgefüge Makrofeingefüge Gefügefragmente
compactness	Lagerungsart	36	121	List 23	Lagerungsart
porosity	Porenanteil	38	124	Abb. 13	Bestimmung des Makroporenanteils
tubes, channels	Röhren, Gänge	39	123	List 24	Röhren, Gänge
bulk density	Lagerungsdichte	40	125	Tab. 20	Bestimmungsschlüssel für die Ansprache der effektiven Lagerungsdichte
substance vol. (for peaty soil)	*Substanzvolumen* (bei Moorböden)	40	127	Tab. 22	Ansprache des Substanzvolumens SV bei Moorböden
degree of peat decomposition	Zersetzungsstufe (bei Torf)	40	128	Tab. 23	Bestimmung der Zersetzungsstufen und des Zersetzungsgrades von Torfen
root density	Durchwurzelungsintensität	41	129	Tab. 24	Einstufung der Durchwurzelungsintensität
fine root density	Feinwurzeldichte	41a	129	Tab. 24	
coarse root density	Grobwurzeldichte	41b	129	Tab. 24	
rootable depth class	Durchwurzelbarkeit	41	130	Tab. 25	Einstufung der Durchwurzelungbarkeit (physiologische Gründigkeit)
substrate genesis	Substratgenese	43	137	Tab. 137	Gliederung der Substratgenese auf den verschiedenen Niveaus
soil type	Bodenart	44a	144	Tab. 30	Definition der Feinbodenarten nach Fraktionen, Schlüssel zur Bestimmung der Bodenart im Gelände (Fingerprobe)
sand soil type	Sandbodenart	44a	148	Tab. 31	Kornfraktionen Bodenart „reiner Sand“ Ss
coarse soil fraction	Grobbodenfraktion	44b	150 150	Tab. 32 Tab. 33	Untergliederung + Kornfraktionen des Grobbodens Einstufung des Grobbodens
peat type	Torfart	44a	161	Tab. 36	Botanische Gliederung verbreiteter Torfe und ihre Zuordnung zu den bodenkundlichen Torfartengruppen
gyttja	Mudde	44a	164	List 25	Mudden

carbon content (substrate)	Kohlenstoffgehalt (Substrat)	45	166	Tab. 38	Einteilung des Kohlenstoffgehaltes bei der Substratartenansprache im Feld 42
carbonate content	Carbonatgehalt	46	169	Tab. 40	Kennzeichnung des Carbonatgehaltes des Feinbodens und bei der Substratartenansprache im Feld 42
parent rock	Bodenausgangsgestein	47a	174	Tab. 43	Bodenausgangsgesteine
periglacial position	Periglaziäre Lagen	47b	181	List 26	Periglaziäre Lagen
coarse soil components	Grobbodenkomponenten	47c	174	Tab. 43	Bodenausgangsgesteine
substantial inhomogeneity	Substanzielle Inhomogenitäten	47d	183	List 27	Substanzielle Inhomogenitäten
structural inhomogeneity	Strukturelle Inhomogenitäten	47e	184	List 28	Strukturelle Inhomogenitäten (sofern nicht substanziell differenzierbar)
stratigraphy	Stratigrafie	48	187	List 29	Stratigrafische Einheiten
remarks (horizon)	Bemerkungen (zum Horizont)	49	190	List 30	Geruch
soil type	Bodentyp	50	199	List 31	Bodensystematische Abteilungen, Klassen und Typen mit Horizontfolgen
humus form	Humusform	50	264	Tab. 46	Kriterien und diagnostische Horizontmerkmale der Varietäten
ground water level	Grundwasserstufe	53a	311	Tab. 59	Einstufung der Grundwasserstände
level of soil wetness	Vernässungsgrad	54	315	Tab. 61	Ermittlung des Vernässungsgrades für Grund-, Stau- und Haftnässeböden
level of erosion	Erosionsgrad	55	316	Tab. 62	Erosionsgrad und bodensystematische Ansprache

Table 12: Parameters for field soil description provided with code lists in DIN 4220:2008-11

Parameter (EN)	**Parameter (D)**	**p.**	**Table**	**Code list name**
soil and site characteristics	Boden- und Standorteigenschaften	10	1	Einstufung von Boden- und Standorteigenschaften
size and scale of features	Größen und Skalenbereich von Erscheinungsformen	11	2	Einstufung von Größen, Einteilung in Mikro-, Meso-, Makroskala
area percentage of features	Flächenanteil von Erscheinungsformen	11	3	Flächenanteil von Erscheinungsformen in Böden
soil type (fine soil)	Bodenart (Feinboden)	12	4	Kornfraktionen des Feinbodens
soil type (coarse soil)	Bodenart (Grobboden)	12	5	Kornfraktionen des Grobbodens (Bodenskelett)
soil type-main group, soil type-group	Bodenarten-Hauptgruppe, Bodenarten-Gruppe	13	6	Bodenarten (Gruppierung, Benen-nung, Kurzzeichen, Kornfraktionen)
sand soil type	Sandbodenart	14	7	Unterteilung der Bodenart reiner Sand (0-5% Ton, 0-10% Schluff)
coarse soil additives	Grobboden Beimengungen	15	8	Einteilung Gemengeanteile Grobboden
humus content	Humusgehalt	16	9	Einstufung Humusgehaltes (organische Substanz) von Böden
rootable depth class	Durchwurzelbarkeit	17	10	Einstufung Durchwurzelbarkeit (physiologische Gründigkeit)
Root density	Durchwurzelungsintensität	17	11	Einstufung Durchwurzelungsintensität
dry bulk density	Trockenrohdichte	18	12	Einstufung Trockenrohdichte
ground water level	Grundwasserstufe	18	13	Grundwasserstufen in Abhängigkeit mittl. Grundwasserflurabständen
capillary space	Kapillarraum	19	14	Einstufung geschlossener Kapillarraum
field capacity	Feldkapazität	20	16	Einstufung Feldkapazität
plant available water	nutzbare Feldkapazität	20	17	Einstufung nutzbare Feldkapazität
soil porosity	Luftkapazität	21	18	Einstufung der Luftkapazität
dead water	Totwasser	21	19	Einstufung des Totwassers
total pore volume	Gesamtporenvolumen	21	20	Einstufung Gesamtporenvolumens und Porenziffer
water permeability	Wasserdurchlässigkeit	22	21	Einstufung Wasserdurchlässigkeit
air permeability	Luftdurchlässigkeit	22	22	Einstufung Luftdurchlässigkeit
soil reaction	Bodenreaktion (pH-Wert)	23	23	Einstufung Bodenreaktion
redox potential	Redoxspotenzial	23	24	Einstufung Redoxbedingung
CEC	KAK	24	25	Einstufung potentieller KAK
base saturation	Basensättigung	24	26	Einstufung Basensättigung und Zuordnung von pH-Wert-Bereichen
peat type	Torfart	25	27	Botanische Gliederung von Torfen
substance volume	Substanzvolumen	26	28	Einstufung Substanzanteils von Moorböden
slope gradient level	Hangneigungsstufe	27	29	Einstufung Hangneigung

The *Guidelines for Soil Assessment* (*Bundesministerium der Finanzen 1996*) includes code lists for several soil parameters (Table 13). Symbols and class definitions of these code lists deviate conspicuously from other national standards (KA5 or DIN 4220) with the exception of the code lists for horizon symbols, which is taken from the German Soil Survey Guideline, 4th edition (KA4).

Table 13: Parameters for field soil description provided with code lists in the Guidelines for Soil Assessment

Parameter (EN)	**Parameter (D)**	**page**	**section**	**Code list name**
soil moisture	Bodenfeuchtigkeit	8	1.4	Feuchtigkeitszustand des Bodens
position in relief	Lage im Relief	9	2.1	Lage des Grablochs
exposition	Exposition	9	2.2	Hangrichtung des Grablochs
special cultivation type, characteristic water conditions	Sonderkulturarten und Besonderheiten der Wasserverhältnisse	10	2.8	Erläuterungen zum Kataster
cultivation type	Kulturart	11	2.9	Kulturart
soil type	Bodenart	11	2.10.1	Bodenarten nach dem Schätzungsrahmen, Misch- und Übergangsbodenarten bei Acker- und Grünland, Schichtbodenarten bei Mineralboden, Schichtwechsel Mineral-/Moorboden bei Acker- und Grünland
soil genesis	Bodenentstehung	12	2.10.3	Entstehungsart
particularities	Besonderheiten	13	2.12	Besonderheiten, Abrechnungen (%)
remarks	Bemerkungen	15	2.16	Bemerkungen
humus content	Humusgehalt	18	3.2.1	Humus
carbonate content	Kalkgehalt	18	3.2.2	Kalk
soil color	Bodenfarbe	18	3.2.3	Farbe
iron compounds	Eisenverbindungen	19	3.2.4	Eisen
soil moisture	Bodenfeuchte	20	3.2.5	Feuchte
further soil features	sonstige Bodeneigenschaften	20	3.2.6	Sonstiges
main soil type - fine soil	Hauptbodenarten - Feinboden	21	3.2.7	Hauptbodenarten - Feinboden
main soil type - coarse soil	Hauptbodenarten - Grobboden			Hauptbodenarten - Grobboden (Bodenskelett)
soil type - weathering soil	Bodenart - Verwitterungsböden			Verwitterungsböden
special soil type	besondere Bodenarten			besondere Bodenarten
subordinate soil type - fine soil	Nebenbodenarten - Feinboden			Nebenbodenarten - Feinboden
subordinate soil type - coarse soil	Nebenbodenarten - Grobboden			Nebenbodenarten - Grobboden
additional information on	Ergänzende Angaben zur Boden-			Ergänzende Angaben zur Bodenart

soil type	art			
soil systematic unit - terrestrial soils	Bodensystematische Einheit - terrestrische Böden	26	4.1.1	Abteilung der terrestrischen Böden
soil systematic unit - semiterrestrial soils	Bodensystematische Einheit - semiterrestrische Böden	29	4.1.2	Abteilung der semiterrestrischen Böden
soil systematic unit - peat soils	Bodensystematische Einheit - Moore	31	4.1.4	Abteilung der Moore
horizon symbols - organic horizons	Horizontsymbole - organische Horizonte	33	4.2.1	Organische Horizonte
horizon symbols - mineral horizons	Horizontsymbole - mineralische Horizonte	34	4.2.2	Mineralische Horizonte

The FAO Guidelines for soil description contain a huge number of code lists for numerous soil parameters (Table 14). In many cases several code lists are given for a distinct parameter describing different aspects of the parameter.

Table 14: Parameters provided with code lists in FAO Guidelines for soil description (4th edition, 2006)

Parameter	**page**	**Table**	**Code list name**
weather	9	2	Codes for weather conditions (Schoeneberger et al., 2012)
	9	2	Former weather conditions (Ad-hoc-AG-Boden, 2005)
soil climate	10	3	Soil temperature and moisture regime codes
landform (relief)	11	4	Hierarchy of major landforms
	11	5	Subdivisions for complex landforms
slope form	12	6	Classification of slope forms
slope gradient	12	7	Slope gradient classes
land use	14	8	Land use classification
cultivation	15	9	Crop codes
anthropogenic influence	15	10	Recommended codes for human influence
vegetation	16	11	Vegetation classification
parent material	18	12	Hierarchy of lithology
age of land surface	19	13	Provisional coding for age of land surface
rock outcrops	21	14	Recommended classification of rock outcrops
coarse surface fragments	22	15	Classification of coarse surface fragments
erosion	22	16	Classification of erosion, by category
	22	17	Classification of total area affected by erosion /deposition
	22	18	Classification of erosion, by degree
	23	19	Classification of erosion, by activity
surface sealing	23	20	Classification of attributes of surface sealing
surface cracks	24	21	Classification of surface cracks

Table 15: Parameters provided with code lists in ISO 25177:2008, Soil description in the field

Parameter (EN)	**Parameter (D)**	**p.**	**Cl-Nr.**	**Code list name**
precipitation	Niederschlag	7	-	Vorangegangene Niederschlagsereignisse
land use	Flächennutzung	8	-	Flächennutzung (ausführliche Felduntersuchung) auf Plottebene
nature of the water	Grundwasserbeschaffenheit	11	-	Beschaffenheit des Wassers
percentage of rock outcrops or non-natural materials	Flächenanteil von Gesteinsaufschlüssen oder „nicht natürlichen“ Oberflächen	11	-	Prozentualer Anteil von Gesteinsaufschlüssen oder „nicht natürlichen“ Oberflächen
erosion and soil accumulation	Erosion und Bodenauftrag	12	-	Anzeichen von Erosion
abundance of mottles	Flächenanteil von Flecken	14	-	Häufigkeit von Flecken
organic matter content	Gehalt an org. Substanz	15	-	Geschätzter Gehalt org. Substanz
abundance of coarse elements	Grobbodenanteil	15	-	Grobboden, Auftreten (als Volumenanteil in Prozent)
maximum grain size of coarse elements	Maximale Korngröße Grobboden	16	-	Max. Korngröße häufig auftretender Bestandteile des Grobbodens
carbonate content	Carbonatgehalt	16	-	Intensität des Aufbrausens
carbonate distribution	Carbonatverteilung	17	-	Auftreten des Aufbrausens
soil structure	Bodengefüge	17	-	Hauptkategorien des Bodengefüges
		39	Fig. F.1	Bodengefügeformen
compactness	Festigkeit	18	-	Festigkeit
porosity	Porenanteil	18	-	Geschätzte Gesamtporosität
root diameter	Wurzeldurchmesser	18	-	Dicke (Durchmesser) der am häufigsten auftretenden Wurzeln
root density	Durchwurzelungsintensität	19	-	Häufigkeit von Wurzeln
density of worm channels	Wurmgangdichte	19	-	Dichte von Wurmgängen
lower horizon boundary form	Horizontuntergrenze Form	19	-	Kontur der unteren Horizontbegrenzung
Reference Soil Groups	Referenzbodengruppen	21	Tab. B.1	Referenzbodengruppen der WRB (FAO, ISRIC und ISSS, 2006)
fine soil fractions	Feinbodenfraktionen	35	Tab. D.1	Richtwerte für die Einteilung mineralischer Böden mit Korngrößenbereichen

Table 16: INSPIRE Code List register for soil parameter (selected)

Content/Definition	Name
master part of the horizons	FAO Horizon Master Value
subordinate distinctions/features within master horizons/layers which are based on profile characteristics observable in the field and are applied during the description of the soil at the site	FAO Horizon Subordinate Value
connotes the master horizon symbol of the lower of 2 or 3 (prime, double prime) horizons with identical Arabic-numeral prefixes & letter combinations	FAO Prime Value
values indicating the placement of the Qualifier with regard to the WRB reference soil group (RSG).	WRB Qualifier Place Value
possible qualifiers of the WRB for Soil Resources	WRB Qualifier Value
possible RSG (i.e. first level of classification of the WRB for Soil Resources). RSG are distinguished by the presence/ absence of specific diagnostic horizons, properties and/or materials	WRB Reference Soil Group Value
possible specifiers	WRB Specifier Value
gives an idea whether current non-pedogenic processes affect the soil or not	Layer Genesis Process State Value
layer classification	Layer Type Value
properties that can be observed to characterize the profile element	Profile Element Parameter Name Value
properties that can be derived from soil data	Soil Derived Object Parameter Name Value
status of contaminating activity	Contaminating Activity Presence Value
possible values indicating reasons for conducting a survey	Soil Investigation Purpose Value
terms specifying on what plot observation is made	Soil Plot Type Value
properties observations to characterize soil profiles	Soil Profile Parameter Name Value
properties observations to characterize soil sites	Soil Site Parameter Name Value
trigger to have site or future investigations	Investigation Trigger Value
status risk assessment	Risk Assessment Stage Value
entities exposed to pollutants at the site.	Risk Receptor Value
indicates restrictions on the site as a consequence of the current situation	Soil Contamination Specialized Zone Type Code

Crops, agriculture, land use

- The **International Code Council** (ICC) develops affordable code lists for global markets, agriculture and science.
- Within its World Program for the Census of Agriculture 2010, the **FAO** published an "Alphabetic List of Crops with Botanical Names and Crop Codes" (FAO, 2005).
- The Indicative Crop Classification (**ICC-**FAO) lists crop codes. The 2-4 digits codes do not differ between varieties and sowing dates (e.g. winter wheat).
- A code list for crops is provided by the **Clemson University** (2008).
- In Germany crop types and varieties are described and coded by the Federal Plant Variety Office (**BSA**, Bundessortenamt). It provides descriptive variety lists e.g. for cereals, maize, oil and fiber plants.
- Within the extended **BBCH-scale** phenological development stages are described and coded for all kinds of agricultural plants and products (Hack, 1992).
- Based on the EU-regulation 1305/2013 (in Germany "InVeKoS") code lists on different crop types and culture codes, 3 digits were established (Flächennutzungsnachweis, **FNN**).
- In the United States, fertilizers are listed in the **UFTRS Code List** (Uniform Fertilizer Tonnage Reporting System, 3 digits).
- The Federal Office of Consumer Protection and Food Security (**BVL**) provides code lists on land use (1 letter), plant protection (active substances, 4 digits), function (1 letter), authorization holders (3-4 characters), and type of formulation (2 letters).
- The **EPPO-Code** (European and Mediterranean Plan Protection Organization) contains plants, pests and pathogens in the frame of agriculture and crop protection.
- Land use classes are coded in the CORINE Land Cover (**CLC**) including a 3-level nomenclature. Agricultural areas start with number "2".

Metadata

There are 33 code lists in **ISO 19115-1ff** (including references to other ISO standards e.g. language code**- ISO 639-2**). Code lists of **ISO 19115-1:2003, ISO 19115-2:2003** and **ISO/DIS 19119:2015** are used in INSPIRE and GDI-DE metadata schema as data type for several metadata elements e.g. CI_RoleCode, MD_CharacterSetCode, MD_ClassificationCode, MD_keywordTypeCode, MD_RestrictionCode, MD_TopicCategoryCode etc.

While the standard **EN ISO 19108:2005** deals with geographic information and a temporal schema, **ISO 8601:2004** contains data elements and interchange formats and representats date and times. Both have been implemented for INSPIRE.

Identifiers of **ORCID** (Open Researcher and Contributor ID) and **ISNI** (International Standard Name Identifier) are used as name lists for creator and contributor name in **DataCite**, while **W3CDTF** and **RKMS-ISO 8601** standards are depicting date ranges.

IETF BCP 47 and **ISO 639-1** are associated with language codes, DOI is using for Identifier, and ARK, arXiv, bibcode, EAN13, EISSN, Handle, ISBN, ISSN, ISTC, LISSN, LSID, PMID, PURL, UPC, URL and URN have been associated with relatedIdentifier name in DataCite.

RFC 4646: tags for identifying languages, **RFC 3986,** Uniform Resource Identifier, TGN (Getty Thesaurus of Geographic Names) for coverage and DCMI Type Vocabulary [DCIM-TYPE], to describe nature or genre of the resource have been using in Dublin Core.

The **INSPIRE Metadata Regulation 1205/2008/EC** (JRC 2007) mandate the presence of at least one keyword. This can be associated with a controlled vocabulary which in ISO standard is referred to as “Thesaurus”.

Further code lists and glossaries (summarized)

Table 17: Further BonaRes relevant code lists

Feature	**Publisher/Standard**
air quality, exchange of data	ISO 7168-1:1999
coordinate reference systems	EPSG-Codes
countries	ISO 3166-1:2013
culture codes, crop types	InVeKoS-FNN (Flächen-und Nutzungsnachweis)
date and time	ISO 8601:2004
languages	DIN 2335:2014-07
SI units	EN ISO 80000-1ff series
soil data formats	ISO 28258:2013; INSPIRE DS Soil
sprayers	*ISO10627-2:1996*
vegetation survey (homogeneity, species, abundance)	*Braun-Blanquet-Scale (Relevé method)*

Table 18: Glossaries and vocabularies

Feature	**Publisher/Standard**
access panels in market, opinion, social research	ISO 26362:2009
castors and wheels	EN 12526:1998
earth-moving machinery	ISO 6165:2012
equipment for crop protection	ISO/DIS 5681:2014
equipment of harvesting	ISO 6689-1:1997
forage harvester	ISO 8909-1:1994
grain species	ISO 5527:2015
market, opinion and social research	ISO 20252:2006
meteorology (data aggregation)	VDI 3786-1:2013
quality management	EN ISO 9000:2005
soil quality	ISO 11074:2015
soil tillage, ploughing	ISO 8910:1993
soil water	ISO 15709:2002
statistics (terms, symbols)	ISO 3534-1:2006 and -2:2006
tractors and self-propelled machines	ISO 14269-1:1997
tractors - symbols for operators	ISO 3767-2:2008
wheels and tyres	EN 12526:1998
water quality	ISO 6107 (1-9)

4.2 Web Links

(checked: September 2017)

ADM guidelines: www.adm-ev.de/index.php?id=richtlinien

ADM quality standards: www.adm-ev.de/qualitaetsstandards/?L=1%27

ADM ICC/ESOMAR Kodex: www.adm-ev.de/index.php?id=kodex

AGRIS: agris.fao.org/content/agris-your-link-world%E2%80%99s-agricultural-information

AGROVOC: aims.fao.org/vest-registry/vocabularies/agrovoc-multilingual-agricultural-thesaurus

AIMRO: www.aimro.ie/sites/default/files/documents/basic-page/QUALITY%20STANDARDS.pdf

AIMS: aims.fao.org/

ASI: www.asi-ev.org/

Attribution License: opendatacommons.org/licenses/by/

Better Regulations Guidelines: ec.europa.eu/smart-regulation/guidelines/toc_guide_en.htm

BGR: www.bgr.bund.de/

BonaRes Data Guideline: doi.bonares.de/BonaRes-E1AZ-ETD7/BonaRes-E1AZ-ETD7.html

BVL: biosicherheit-bch.de/SharedDocs/Downloads/04_Pflanzenschutzmittel/psm_uebersichtsliste.pdf?__blob=publicationFile&v=33

CAP: ec.europa.eu/agriculture/cap-overview/index_en.htm

Copernicus Publications: www.earth-system-science-data.net/

CORINE Land Cover: www.eea.europa.eu/publications/COR0-landcover

Creative Commons: creativecommons.org/

Data journals (TRAC list): proj.badc.rl.ac.uk/preparde/blog/DataJournalsList

Data License Germany: www.govdata.de/lizenzen

DDI Data Documentation Initiative: www.ddialliance.org/alliance/structure

DESTATIS:

www.destatis.de/DE/Methoden/DemografischeRegionaleStandards/Standards.html

www.destatis.de/DE/Methoden/DemografischeRegionaleStandards/DemografischeStandardsInfo.html?nn=173768

www.destatis.de/DE/Methoden/Klassifikationen/Klassifikationsserver_012014.pdf?__blob=publicationFile

www.destatis.de/DE/Publikationen/StatistikWissenschaft/Band16_AnonymisierungEinzeldaten_1030816109004.pdf?__blob=publicationFile

www.destatis.de/DE/Publikationen/StatistikWissenschaft/Band18_MethodenGeheimhaltung030818109004.pdf?__blob=publicationFile

www.destatis.de/DE/Publikationen/StatistikWissenschaft/Band10_Berichterstattung1030810079004.pdf?__blob=publicationFile

www.destatis.de/DE/Publikationen/StatistikWissenschaft/Band15_Tabellengestaltung1030815109004.pdf?__blob=publicationFile

Digigtal Curation Centre (DCC): www.dcc.ac.uk/resources/metadata-standards/list

ecoinvent: www.ecoinvent.org/

Ecological Society of America: esapubs.org/archive/

EngMath (Ontology): www.ksl.stanford.edu/knowledge-sharing/papers/engmath.html

EPPO Plant Protection Thesaurus (EPPT): eppt.eppo.org/search.php

EPSG Codes: www.epsg-registry.org/

ESeC: www.iser.essex.ac.uk/archives/esec/user-guide

EUROVOC: eurovoc.europa.eu/drupal/?q=de/node

F1000 Research Ltd: f1000research.com/

FAO-ICC: www.fao.org/fileadmin/templates/ess/documents/world_census_of_agriculture/appendix4_r7.pdf

FNN: www.stmelf.bayern.de/mam/cms01/agrarpolitik/dateien/a6_codierung_fnn.pdf

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